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

PHYSICS

ATAR course

Year 11 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 laws of classical mechanics, the kinetic particle model, wave theory, and the atomic and nuclear models.

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, collect and analyse qualitative and quantitative data, and interpret 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 11 syllabus is divided into two units, each of one semester duration, which are typically delivered as a pair. The notional time for each unit is 55 class contact hours.

Unit 1 – Motion, forces and energy

Students describe, explain and predict linear motion and mechanical and thermal energy.

Unit 2 – Waves, nuclear and electrical physics

Students investigate the application of wave models to sound phenomena, radioactivity and nuclear reactions, and investigate energy transfer and transformation in electrical circuits.

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 Science Inquiry Skills, Science as a Human Endeavour and Science Understanding have been written so that this integration is possible in each unit.

Science Inquiry Skills

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

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

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 select and integrate 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 to calculate one quantity and check the dimensional consistency of such calculations
- solve simple algebraic equations
- comprehend and use the symbols/notations $<$, $>$, Δ, $\approx$, $\surd$, $\leq$, $\geq$, $\sum$
- translate information between graphical, numerical and algebraic forms

- distinguish between discrete and continuous data and then select appropriate forms, variables and scales for constructing graphs
- interpret frequency tables and diagrams, pie charts and histograms
- describe and compare data sets using range, mean and median
- interpret the gradient 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.

Progression from the Years 7–10 curriculum

This syllabus continues to develop student understanding and skills from the Years 7–10 Science curriculum. In the Science Understanding strand, this course draws on knowledge and understanding from across the four sub-strands of Biological, Physical, Chemical, and Earth and Space Sciences.

In particular, the course continues to develop the key concepts introduced in the Physical Sciences sub-strand, namely:

- forces affect the behaviour of objects
- energy can be transferred and transformed from one form to another.

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 11 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 1 – Motion, forces and energy

Unit description

Students develop an understanding of motion, forces, and mechanical and thermal energy, which can be used to describe, explain and predict a wide range of phenomena. Students describe linear motion in terms of position and time data, and examine the relationships between force, momentum and energy for interactions in one dimension.

Contexts that may be investigated in this unit include technologies, such as accelerometers and motion detectors, and related areas of science and engineering, such as sports science and car and road safety.

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

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

Unit content

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

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

- safety for motorists and other road users has been substantially increased through application of Newton's laws and conservation of momentum by the development and use of passive safety devices, e.g. helmets, seatbelts, crumple zones, airbags, collapsible steering columns and safety barriers
- the operation of a refrigerator and a reverse-cycle air conditioner is based on thermal energy transfer

Science Understanding

Motion and forces

- distinguish between vector and scalar quantities
- addition and subtraction of vectors in one and two dimensions
- resolution of vectors into components and manipulation (addition and subtraction) of components
- change (final – initial) in a variable is represented by the symbol Δ, e.g. $\Delta t = t_f - t_i$
- displacement is defined as the change in position of an object, including applying the relationship

  $$s = \Delta x = x_f - x_i$$

- velocity is defined as the rate of change in displacement of an object, including applying the relationship

  $$v = \frac{s}{\Delta t} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

- uniformly accelerated motion (a is constant) is described in terms of relationships between measurable scalar and vector quantities, including displacement, velocity and time, including applying the relationships

  $a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$ $\quad v_f = v_i + a\Delta t$ $\quad s = v_i\Delta t + \frac{1}{2}a\Delta t^2$ $\quad {v_f}^2 = {v_i}^2 + 2as$

- motion can be represented graphically to describe linear motion including determination and manipulation and use of gradients of curves and areas under graphs of
  - displacement–time
  - velocity–time
  - acceleration–time
- vertical motion is analysed by assuming the acceleration due to gravity is constant near Earth's surface
- momentum is a property of moving objects; it is conserved in a closed system and may be transferred from one object to another when a force acts over a time interval, including applying in one dimension the relationships

  $p = mv \quad \Sigma mv_i = \Sigma \mathrm{m}v_f$

- Newton's three laws of motion describe the relationship between the force or forces acting on an object, modelled as a point mass, and the motion of the object due to the application of the force or forces
- free body diagrams show the forces acting on objects, from descriptions of real-life situations involving forces acting in one or two dimensions
- the acceleration acting on an object can be determined from the summation (ΣF) of the forces (net force) acting on the object and mass of the object, including applying the relationship

  $\Sigma F = ma$

- a change in momentum is caused by a force acting over a period of time and is referred to as impulse, including applying in one dimension the relationship

  $\Delta p = mv_f - mv_i = F\Delta t$

- the weight of an object near to the Earth's surface, where acceleration due to gravity is constant, is given by

  $F_{weight} = mg$

- friction is a contact force between two surfaces which opposes motion. Friction is proportional to the normal force (FN) and the coefficient of friction between the surfaces. Friction can be classified as static or kinetic, depending on the relative motion between surfaces, including applying the relationship

  $F_f = \mu F_N$ where μ is the coefficient of static or kinetic friction

- 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, including friction

Mechanical and thermal energy

- energy is associated with the motion of objects and their position relative to the surface of the Earth, including applying the relationships

  $E_k = \frac{1}{2}mv^2$ $\quad$ $E_p = mg\Delta h$
- total energy is conserved in isolated systems, including applying the relationship

  $\Sigma E_i = \Sigma E_f$
- energy is transferred from one object to another when a force is applied over a distance; this causes work to be done and changes the kinetic (Ek) and/or potential (Ep) energy of objects, including applying the relationships

  $W = Fs$ $\quad$ $W = \Delta E$
- collisions may be elastic and inelastic; kinetic energy is conserved in elastic collisions, including applying the relationship

  $\Sigma \frac{1}{2}mv_i^2 = \Sigma \frac{1}{2}mv_f^2$
- power is the rate of doing work or transferring energy, including applying the relationships

  $P = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$
- kinetic theory describes matter as consisting of particles in continuous motion, except at the temperature of absolute zero
- all substances have internal energy due to the motion and separation of their particles
- temperature is a measure of the average translational kinetic energy of particles in a system
- provided a substance does not change state, its temperature change is proportional to the amount of energy added to or removed from the substance; the constant of proportionality describes the heat capacity of the substance, including applying the relationship

  $Q = mc\Delta T$
- change of state involves separating particles that exert attractive forces on each other; latent heat is the energy required to be added to, or removed from, a system to change the state of the system, including applying the relationship

  $Q = mL$
- two systems in contact transfer energy between particles so that eventually the systems reach the same temperature; that is, they are in thermal equilibrium. This may involve changes of state as well as changes in temperature

Unit 2 – Waves, nuclear and electrical physics

Unit description

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

Contexts that can be investigated in this unit include technologies related to nuclear energy, radiopharmaceuticals, seismic waves, musical instruments and electricity in the home; and related areas of science, such as nuclear fusion in stars.

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

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

Unit content

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

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

Waves

- concepts of standing waves and resonance are applied in musical instruments
- ultrasound is used as a diagnostic and cleaning tool in a variety of industries

Science Understanding

Waves

- waves are periodic oscillations that transfer energy from one point to another
- mechanical waves transfer energy through a medium; longitudinal and transverse waves are distinguished by the relationship between the directions of oscillation of particles relative to the direction of the wave velocity
- waves may be represented by displacement/time and displacement/distance wave diagrams and described in terms of relationships between measurable quantities, including period, amplitude, wavelength, frequency and velocity, including applying the relationships

$$v = f\lambda \qquad T = \frac{1}{f}$$

- the mechanical wave model can be used to explain phenomena related to reflection and refraction, including echoes and seismic phenomena

- the superposition of waves in a medium may lead to the formation of standing waves and interference phenomena, including two parallel coherent speakers, standing waves in pipes and stretched strings and observation of beats, including applying the relationships for

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

  pipes closed at one end $\lambda = \frac{4\ell}{n}$

  where n = the number of the appropriate harmonic

  beat frequency $f_{beat} = |f_2 - f_1|$

- a mechanical system resonates when it is driven at one of its natural frequencies of oscillation; energy is transferred efficiently into systems under these conditions

Science as a Human Endeavour

Ionising radiation and nuclear reactions

- radioisotopes are used as diagnostic tools and for tumour treatment in medicine
- nuclear power stations employ a variety of safety mechanisms to prevent nuclear accidents, including shielding, cooling systems and radiation monitors
- the management of nuclear waste is based on the knowledge of the behaviour of radiation
- international research teams are developing Generation IV fission reactors and fusion reactors as long-term solutions to meeting the world's energy needs

Science Understanding

Ionising radiation and nuclear reactions

- the nuclear model of the atom describes the atom as consisting of an extremely small nucleus which contains most of the atom's mass, and is made up of positively charged protons and uncharged neutrons surrounded by negatively charged electrons
- nuclear stability is the result of the strong nuclear force which operates between nucleons over a very short distance and opposes the electrostatic repulsion between protons in the nucleus
- some nuclides are unstable and spontaneously decay, emitting alpha, beta (+/-) and/or gamma radiation over time until they become stable nuclides
- protons and neutrons are made of fundamental particles called quarks
- beta minus (b-) and beta plus (b+) decay can be explained by the transformation of quarks in the nucleus
- in nuclear reactions, energy, momentum and charge are conserved; one example is through the emission of neutrinos or antineutrinos in beta plus (b+) and beta minus (b-) decay
- each species of radionuclide has a half-life which indicates the rate of decay, including applying the relationship

  $$N = N_0 \left(\frac{1}{2}\right)^n$$

- alpha, beta and gamma radiation have different natures, properties and effects

- the measurement of absorbed dose and dose equivalence enables the analysis of health and environmental risks, including applying the relationships

  $\text{absorbed dose} = \frac{E}{m}$ $\text{dose equivalent} = \text{absorbed dose} \times \text{quality factor}$
- Einstein's mass/energy relationship relates the binding energy of a nucleus to its mass defect, (Δm) including applying the relationship

  $\mathit{\Delta}E = \Delta mc^2$
- Einstein's mass/energy relationship also applies to all energy changes and enables the energy released in nuclear reactions to be determined from the mass change in the reaction, including applying the relationship

  $\Delta E = \Delta mc^2$
- alpha and beta decay are examples of spontaneous transmutation reactions, while artificial transmutation is a managed process that changes one nuclide into another
- neutron-induced nuclear fission is a reaction in which a heavy nuclide captures a neutron and then splits into smaller radioactive nuclides with the release of energy
- a fission chain reaction is a self-sustaining process that may be controlled to produce thermal energy, or uncontrolled to release energy explosively if its critical mass is exceeded
- nuclear fusion is a reaction in which light nuclides combine to form a heavier nuclide, with the release of energy
- more energy is released per nucleon in nuclear fusion than in nuclear fission because a greater percentage of the mass is transformed into energy
- the early universe was composed mostly of hydrogen, and all other elements that are present in today's universe, including the human body, were created via nuclear processes inside stars and during the destruction of stars

Science as a Human Endeavour

Electrical forces and energy

- there is an inherent danger involved with the use of electricity that can be reduced by using various safety devices, including fuses, residual current devices (RCD), circuit breakers, earth wires and double insulation

Science Understanding

Electrical forces and energy

- there are two types of electric charge, positive and negative
- the energy available to charges moving in an electrical circuit is measured using electric potential difference (ΔV), which is defined as the change in potential energy per unit charge between two defined points in the circuit, including applying the relationship

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

- energy is required to separate positive and negative charge carriers; charge separation produces an electrical potential difference that drives current in circuits
- electric current is carried by discrete charge carriers; charge is conserved at all points in an electrical circuit, including applying the relationship

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

- energy is conserved in the energy transfers and transformations that occur in an electrical circuit
- electrical circuits enable electrical energy to be transferred and transformed into a range of other useful forms of energy, including thermal and kinetic energy and light
- power is the rate at which energy is transformed by a circuit component; power enables quantitative analysis of energy transformations in the circuit, including applying the relationship

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

- resistance is defined as the ratio of potential difference across the component to the current in the component, including applying the relationship

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

- conductors can be classified as ohmic or non-ohmic
- circuit analysis and design involve calculation of the potential difference across the current in, and the power supplied to, components in series, parallel, and compound circuits, including applying the relationships

$$\text{series components: } I = \text{constant} \qquad V_t = V_1 + V_2 + V_3 \ldots$$
$$R_t = R_1 + R_2 + R_3 \ldots$$

$$\text{parallel components: } V = \text{constant} \qquad I_t = I_1 + I_2 + I_3 \ldots$$
$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$$

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 weightings for the Physics ATAR Year 11 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 11

Type of assessment	Weighting
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.	20%
Test Tests typically consist of questions requiring short answers, extended answers and problem solving. This assessment type is conducted in supervised classroom settings.	40%
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. In preparation for Unit 3 and Unit 4, the examination should reflect the examination design brief included in the ATAR Year 12 syllabus for this course. This assessment type is conducted in supervised classroom settings.	40%

Teachers are required to use the assessment table to develop an assessment outline for the pair of units (or for a single unit where only one is being studied).

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 11 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 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 based on a pre-determined range of marks (cut-offs).

Appendix 1 – Grade descriptions Year 11

A	**Understanding and applying concepts** Applies models and principles to explain systems and processes in detail, illustrating responses with diagrams where appropriate. Clearly links multiple concepts to accurately explain complex phenomena and relationships in detail. Accurately applies scientific understanding to explain unfamiliar contexts or examples. Interprets and evaluates scientific information from a variety of sources to solve problems or to support an argument. Consistently selects and manipulates equations to solve complex problems. Performs multiple-step calculations accurately using correct units and significant figures.
	Science inquiry skills Formulates a testable hypothesis that states the relationship between dependent and independent variables. Plans investigations to identify and control appropriate variables, describes the experimental method in detail and accurately collects data. Processes data accurately and presents it logically in a range of forms, including graphs and tables, to identify patterns and relationships. Comprehensively explains trends using numerical data and uses evidence to draw conclusions that relate to the hypothesis. Evaluates experimental method and provides specific relevant suggestions to improve validity and reliability. Communicates detailed information and concepts logically and coherently, using appropriate terminology and conventions.

B	**Understanding and applying concepts** Applies models and principles to accurately explain simple, and some complex, systems and processes, illustrating with diagrams where appropriate. Provides logical explanations of phenomena, with some provision of supporting examples. Applies scientific knowledge to explain unfamiliar contexts or examples, sometimes lacking detail. Selects and evaluates scientific information to solve problems or to support a point of view. Selects and manipulates equations to solve multiple-step calculations. Provides working which is clear and uses correct units and significant figures.
	Science inquiry skills Formulates a testable hypothesis that states the relationship between dependent and independent variables. Plans investigations to identify and control appropriate variables, clearly describes the experimental method and accurately collects data. Processes data correctly and presents data in a range of forms, including graphs, tables and diagrams, to identify patterns and relationships. Evaluates experimental method and provides general suggestions to improve validity and reliability of data. Explains trends and uses evidence to draw conclusions that relate to the hypothesis. Communicates information and concepts logically, using appropriate terminology and conventions.

C	**Understanding and applying concepts** Applies models and principles to explain simple systems and some processes, illustrating with simple diagrams which lack detail. Describes relationships but does not relate to a specific context. Applies scientific knowledge to explain familiar contexts or examples. Develops responses which lack detail and sometimes include irrelevant information. Selects and manipulates equations and data to solve simple problems. Provides working which is limited or unclear with some errors in units and significant figures.
	Science inquiry skills Formulates a testable hypothesis that links dependent and independent variables. Plans investigations to identify and control some variables. Briefly outlines the experimental method and collects data. Processes and presents data using basic tables and graphs. Makes general suggestions for improving the experimental method used. Describes trends in data and draws simple conclusions that may not be linked back to the hypothesis. Communicates information and concepts, without detail, using some correct terminology and appropriate conventions.
D	**Understanding and applying concepts** Incorrectly applies physics principles and models to explain simple systems and processes. Presents diagrams which are incomplete or incorrect. Presents statements of ideas with limited development of an argument and little use of evidence. Inconsistently recalls facts and includes some irrelevant or confused information. Inconsistently applies principles to familiar contexts. Performs simple calculations with errors and omissions. Provides working out which is unclear and lacks the use of appropriate units and significant figures.
	Science inquiry skills Identifies one or more relevant variables without making links between them. Plans investigations which identify a limited number of controlled variables. Does not distinguish between the dependent, independent and controlled variables. Presents a plan of experimental method which lacks detail. Presents data that is unclear, insufficient and lacks appropriate processing. Provides trivial or irrelevant suggestions for improving the validity and reliability of data. Identifies trends in data incorrectly or overlooks trends. Offers simple conclusions that are not supported by data or are not related to the hypothesis. Communicates information with frequent errors using everyday language and lacking appropriate conventions.
E	Does not meet the requirements of a D grade and/or has completed insufficient assessment tasks to be assigned a higher grade.

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.

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.