Government of Western Australia
School Curriculum and Standards Authority

Physics

ATAR course

Year 11 syllabus

IMPORTANT INFORMATION

This syllabus is effective from 1 January 2017.

Users of this syllabus are responsible for checking its currency.

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

Content

Rationale

Physics is a fundamental science that endeavours to explain all the natural phenomena that occur in the universe. Its power lies in the use of a comparatively small number of assumptions, models, laws and theories to explain a wide range of phenomena, from the incredibly small to the incredibly large. Physics has helped to unlock the mysteries of the universe and provides the foundation of understanding upon which modern technologies and all other sciences are based.

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. In this course, students gather, analyse and interpret primary and secondary data to investigate a range of phenomena and technologies using some of the most important models, laws and theories of physics, including the kinetic particle model, the atomic model, electromagnetic theory, and the laws of classical mechanics.

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

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

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

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 that provide a reliable basis for action
- understanding of the ways in which matter and energy interact in physical systems across a range of scales
- understanding of the ways in which models and theories are refined and new models and theories are developed in physics; and how physics knowledge is used in a wide range of contexts and informs personal, local and global issues
- investigative skills, including the design and conduct of investigations to explore phenomena and solve problems, the collection and analysis of qualitative and quantitative data, and the interpretation of evidence
- ability to use accurate and precise measurement, valid and reliable evidence, and scepticism and intellectual rigour to evaluate claims
- ability to communicate physics understanding, findings, arguments and conclusions using appropriate representations, modes and genres.

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 – Thermal, nuclear and electrical physics

Students investigate energy production by considering heating processes, radioactivity and nuclear reactions, and investigate energy transfer and transformation in electrical circuits.

Unit 2 – Linear motion and waves

Students describe, explain and predict linear motion, and investigate the application of wave models to sound phenomena.

Each unit includes:

- a unit description – a short description of the focus of the unit
- learning outcomes – a set of statements describing the learning expected as a result of studying the unit
- unit content – the content to be taught and learned.

Organisation of content

Science strand descriptions

The Physics ATAR course has three interrelated strands: Science Inquiry Skills, Science as a Human Endeavour and Science Understanding, which build on students' learning in the Year 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 their predictions and explanations are continually re-assessed through new evidence, often through the application of new technologies. This review process involves a diverse range of scientists working within an increasingly global community of practice and can involve the use of international conventions and activities such as peer review.

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

Science Understanding

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

The Science Understanding content in each unit develops students' understanding of the key concepts, models and theories that underpin the course, and of 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 in relation to the health and safety of all students and that school practices meet the requirements of the *Work Health and Safety Act 2011*, 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 8th edition 2013* (www.nhmrc.gov.au/guidelines/publications/ea28).

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 8th edition 2013*, in addition to relevant State guidelines.

Mathematical skills expected of students studying the Physics ATAR course

This course requires students to use the mathematical skills they have developed through the Year 7–10 Mathematics curriculum, in addition to the numeracy skills they have developed through the Science Inquiry Skills strand of the 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, $\approx$, $\surd$, $\leq$, $\geq$, $\sum$
- 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 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 curve.

Progression from the Year 7–10 curriculum

This syllabus continues to develop student understanding and skills from across the three strands of the Year 7–10 Science curriculum. In the Science Understanding strand, the course may draw 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, that is, that forces affect the behaviour of objects, and that 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 assist students to live and work successfully in the twenty-first century. Teachers may find opportunities to incorporate the capabilities into the teaching and learning program for Physics. The general capabilities are not assessed unless they are identified within the specified unit content.

Literacy

Literacy is important in students' development of Science Inquiry Skills and their understanding of content presented through the Science Understanding and Science as a Human Endeavour strands. Students gather, interpret, synthesise and 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. They communicate processes and ideas logically and fluently and structure evidence-based arguments, selecting genres and employing appropriate structures and features to communicate for specific purposes and audiences.

Numeracy

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

Information and communication technology capability

Information and communication technology (ICT) capability is a key part of Science Inquiry Skills. Students use a range of strategies to locate, access and evaluate information from multiple digital sources; to collect, analyse and represent data; to model and interpret concepts and relationships; and to communicate and share science ideas, processes and information. Through exploration of Science as a Human Endeavour concepts, students assess the impact of ICT on the development of science and the application of science in society, particularly with regard to collating, storing, managing and analysing large data sets.

Critical and creative thinking

Critical and creative thinking is particularly important in the science inquiry process. Science inquiry requires the ability to construct, review and revise questions and hypotheses about increasingly complex and abstract scenarios and to design related investigation methods. Students interpret and evaluate data; interrogate, select and cross-reference evidence; and analyse processes, interpretations, conclusions and claims for validity and reliability, including reflecting on their own processes and conclusions. Science is a creative endeavour and students devise innovative solutions to problems, predict possibilities, envisage consequences and speculate on possible outcomes as they develop Science Understanding and Science Inquiry Skills. They also appreciate the role of critical and creative individuals and the central importance of critique and review in the development and innovative application of science.

Personal and social capability

Personal and social capability is integral to a wide range of activities in the Physics ATAR course, as students develop and practise skills of communication, teamwork, decision-making, initiative-taking and self-discipline with increasing confidence and sophistication. In particular, students develop skills in both independent and collaborative investigation; they employ self-management skills to plan effectively, follow procedures efficiently and work safely; and they use collaboration skills to conduct investigations, share research and discuss ideas. In considering aspects of Science as a Human Endeavour*,* students also recognise the role of their own beliefs and attitudes in their response to science issues and applications, consider the perspectives of others, and gauge how science can affect people's lives.

Ethical understanding

Ethical understanding is a vital part of science inquiry. Students evaluate the ethics of experimental science, codes of practice, and the use of scientific information and science applications. They explore what integrity means in science, and they understand, 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.

Intercultural understanding

Intercultural understanding is fundamental to understanding aspects of Science as a Human Endeavour, as students appreciate the contributions of diverse cultures to developing science understanding and the challenges of working in culturally diverse collaborations. They develop awareness that raising some debates within culturally diverse groups requires cultural sensitivity, and they demonstrate open-mindedness to the positions of others. Students also develop an understanding that cultural factors affect the ways in which science influences and is influenced by society.

Representation of the cross-curriculum priorities

The cross-curriculum priorities address contemporary issues which students face in a globalised world. Teachers may find opportunities to incorporate the priorities 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 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 Asia region in such areas as medicine, communication technologies, transportation, sports science and energy security. They could consider collaborative projects between Australian and Asian scientists and the contribution these make to scientific knowledge.

Sustainability

The cross-curriculum priority of Sustainability provides authentic contexts for exploring, investigating and understanding the function and interactions of physical systems. 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 – Thermal, nuclear and electrical physics

Unit description

An understanding of heating processes, nuclear reactions and electricity is essential to appreciate how global energy needs are met. In this unit, 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 heating processes, apply the nuclear model of the atom to investigate radioactivity, and learn how nuclear reactions convert mass into energy. They 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, thermal, or geothermal energy, the greenhouse effect, electrical energy production, large-scale power systems, radiopharmaceuticals, and electricity in the home; and related areas of science, such as nuclear fusion in stars and the Big Bang theory.

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 heating processes, nuclear reactions and electrical circuits. They develop their inquiry skills through primary and secondary investigations, including analysing heat transfer, heat capacity, radioactive decay and a range of simple electrical circuits.

Learning outcomes

By the end of this unit, students:

- understand how the kinetic particle model and thermodynamics concepts describe and explain heating processes
- understand how the nuclear model of the atom explains radioactivity, fission, fusion and the properties of radioactive nuclides
- understand how charge is involved in the transfer and transformation of energy in electrical circuits
- understand how scientific models and theories have developed and are applied to improve existing, and develop new, technologies
- use science inquiry skills to design, conduct and analyse safe and effective investigations into heating processes, nuclear physics and electrical circuits, and to communicate methods and findings
- use algebraic and graphical representations to calculate, analyse and predict measurable quantities associated with heating processes, nuclear reactions and electrical circuits
- evaluate, with reference to empirical evidence, claims about heating processes, nuclear reactions and electrical technologies

- communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

Unit content

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

Science Inquiry Skills

- identify, research, construct and refine questions for investigation; propose hypotheses; and predict possible outcomes
- design investigations, including the procedure(s) to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics
- conduct investigations, including using temperature, current and potential difference measuring devices, safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate Système Internationale (SI) units and symbols, and significant figures; organise and analyse data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; identify anomalous data and calculate the measurement discrepancy between experimental results and a currently accepted value, expressed as a percentage; and select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
- select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, flow diagrams, nuclear equations and circuit diagrams, to communicate conceptual understanding, solve problems and make predictions
- select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

Heating processes

The development of heating technologies that use conduction, convection, radiation and latent heat have had, and continue to have, significant social, economic and environmental impacts. These technologies include:

- passive solar design for heating and cooling of buildings
- the development of the refrigerator over time
- the use of the sun for heating water

- engine cooling systems in cars.

Science Understanding

Heating processes

- the kinetic particle model describes matter as consisting of particles in constant motion, except at absolute zero
- all substances have internal energy due to the motion and separation of their particles
- temperature is a measure of the average kinetic energy of particles in a system
- provided a substance does not change state, its temperature change is proportional to the amount of energy added to or removed from the substance; the constant of proportionality describes the heat capacity of the substance

  This includes applying the relationship
  $Q = mc\Delta T$
- change of state involves separating particles which 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

  This includes 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
- a system with thermal energy has the capacity to do mechanical work [to apply a force over a distance]; when work is done, the internal energy of the system changes
- because energy is conserved, the change in internal energy of a system is equal to the energy added by heating, or removed by cooling, plus the work done on or by the system
- heat transfer occurs between and within systems by conduction, convection and/or radiation
- energy transfers and transformations in mechanical systems always result in some heat loss to the environment, so that the usable energy is reduced and the system cannot be 100 percent efficient

  This includes applying the relationship

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

Science as a Human Endeavour

Ionising radiation and nuclear reactions

Qualitative and quantitative analyses of relative risk (including half-life, absorbed dose, dose equivalence) are used to inform community debates about the use of radioactive materials and nuclear reactions for a range of applications and purposes, including:

- 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, moderators, cooling systems and radiation monitors
- the management of nuclear waste is based on the knowledge of the behaviour of radiation.

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
- each species of radionuclide has a half-life which indicates the rate of decay

  This includes 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

  This includes applying the relationships

  $$\text{absorbed dose} = \frac{E}{m}, \qquad \text{dose equivalent} = \text{absorbed dose} \times \text{quality factor}$$

- Einstein's mass/energy relationship relates the binding energy of a nucleus to its mass defect

  This includes applying the relationship

  $$\Delta E = \Delta m\, c^2$$

- 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

  This includes applying the relationship

  $$\Delta E = \Delta m\, c^2$$

- 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

Science as a Human Endeavour

Electrical circuits

The supply of electricity to homes has had an enormous impact on society and the environment. An understanding of electrical circuits informs the design of effective safety devices for the safe operation of:

- lighting
- power points
- stoves
- other household electrical devices.

Science Understanding

Electrical circuits

- there are two types of charge that exert forces on each other
- electric current is carried by discrete charge carriers; charge is conserved at all points in an electrical circuit

  This includes applying the relationship

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

- energy is conserved in the energy transfers and transformations that occur in an electrical circuit
- the energy available to charges moving in an electrical circuit is measured using electric potential difference, which is defined as the change in potential energy per unit charge between two defined points in the circuit

  This includes applying the relationship

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

- energy is required to separate positive and negative charge carriers; charge separation produces an electrical potential difference that drives current in circuits
- power is the rate at which energy is transformed by a circuit component; power enables quantitative analysis of energy transformations in the circuit

This includes applying the relationship

$$P = \frac{W}{t} = V\ I$$

- resistance depends upon the nature and dimensions of a conductor
- resistance for ohmic and non-ohmic components is defined as the ratio of potential difference across the component to the current in the component

This includes applying the relationship

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

- circuit analysis and design involve calculation of the potential difference across the current in, and the power supplied to, components in series, parallel, and series/parallel circuits

This includes applying the relationships

series components, I = constant, $V_t = V_1 + V_2 + V_3$ ....

$R_t = R_1 + R_2 + R_3$ ....

parallel components, V = constant, $I_t = I_1 + I_2 + I_3$ ....

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} ...$$

- 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
- 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

Unit 2 – Linear motion and waves

Unit description

Students develop an understanding of motion and waves 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.

Students investigate common wave phenomena, including waves on springs, and water, sound and earthquake waves.

Contexts that can be investigated in this unit include technologies such as accelerometers, motion detectors, global positioning systems (GPS), energy conversion buoys, music, hearing aids, echo locators, and related areas of science and engineering, such as sports science, car and road safety, acoustic design, noise pollution, seismology, bridge and building design.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from a range of disciplines and many individuals, and the development of ICT and other technologies have contributed to developing understanding of motion and waves 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 and wave phenomena through laboratory investigations. They develop skills in relating graphical representations of data to quantitative relationships between variables, and they continue to develop skills in planning, conducting and interpreting the results of primary and secondary investigations.

Learning outcomes

By the end of this unit, students:

- understand that Newton's Laws of Motion describe the relationship between the forces acting on an object and its motion
- understand that waves transfer energy and that a wave model can be used to explain the behaviour of sound
- understand how scientific models and theories have developed and are applied to improve existing, and develop new, technologies
- use science inquiry skills to design, conduct and analyse safe and effective investigations into linear motion and wave phenomena, and to communicate methods and findings
- use algebraic and graphical representations to calculate, analyse and predict measurable quantities associated with linear and wave motion
- evaluate, with reference to evidence, claims about motion and sound related phenomena and associated technologies
- communicate physics understanding using qualitative and quantitative representations in appropriate modes and genres.

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 investigations, including the manipulation of devices to measure motion and sound safely, competently and methodically for the collection of valid and reliable data
- represent data in meaningful and useful ways, including using appropriate Système Internationale (SI) units and symbols, and significant figures; organise and analyse data to identify trends, patterns and relationships; identify sources of random and systematic error and estimate their effect on measurement results; identify anomalous data and calculate the measurement discrepancy between the experimental results and a currently accepted value, expressed as a percentage; and select, synthesise and use evidence to make and justify conclusions
- interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
- select, construct and use appropriate representations, including text and graphic representations of empirical and theoretical relationships, vector diagrams, free body/force diagrams, wave diagrams and ray diagrams, to communicate conceptual understanding, solve problems and make predictions
- select, use and interpret appropriate mathematical representations, including linear and non-linear graphs and algebraic relationships representing physical systems, to solve problems and make predictions
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Science as a Human Endeavour

Linear motion and force

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 devices, including:

- helmets
- seatbelts
- crumple zones
- airbags
- safety barriers.

Science Understanding

Linear motion and force

- distinguish between vector and scalar quantities, and add and subtract vectors in two dimensions
- uniformly accelerated motion is described in terms of relationships between measurable scalar and vector quantities, including displacement, speed, velocity and acceleration

  This includes applying the relationships

  $$v_{av} = \frac{s}{t}, \qquad a = \frac{v - u}{t}, \qquad v = u + at, \qquad s = ut + \tfrac{1}{2}at^2, \qquad v^2 = u^2 + 2as$$

- representations, including graphs, vectors, and equations of motion, can be used qualitatively and quantitatively to describe and predict linear motion
- vertical motion is analysed by assuming the acceleration due to gravity is constant near Earth's surface
- Newton's three Laws of Motion describe the relationship between the force or forces acting on an object, modelled as a point mass, and the motion of the object due to the application of the force or forces
- free body diagrams show the forces and net force acting on objects, from descriptions of real-life situations involving forces acting in one or two dimensions

  This includes applying the relationships

  $$\text{resultant } F = ma, \qquad F_{weight} = mg$$

- 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

  This includes applying the relationships

  $$p = mv, \qquad \sum mv_{before} = \sum mv_{after}, \qquad mv - mu = \Delta p = F\,\Delta t$$

- energy is conserved in isolated systems and is transferred from one object to another when a force is applied over a distance; this causes work to be done and changes the kinetic (E_k) and/or potential (E_p) energy of objects

  This includes applying the relationships

  $$E_k = \tfrac{1}{2}mv^2, \qquad E_p = mg\,\Delta h, \qquad W = Fs, \qquad W = \Delta E$$

- collisions may be elastic and inelastic; kinetic energy is conserved in elastic collisions

  This includes applying the relationship

  $$\sum \tfrac{1}{2}mv^2_{before} = \sum \tfrac{1}{2}mv^2_{after}$$

- power is the rate of doing work or transferring energy

  This includes applying the relationship

  $$P = \frac{W}{t} = \frac{\Delta E}{t} = F\,v_{av}$$

Science as a Human Endeavour

Waves

Application of the wave model has enabled the visualisation of imaging techniques. These can include:

- medical applications, such as ultrasound
- geophysical exploration, such as seismology.

Noise pollution comes from a variety of sources and is often amplified by walls, buildings and other built structures. Acoustic engineering, based on an understanding of the behaviour of sound waves, is used to reduce noise pollution. It focuses on absorbing sound waves or planning structures so that reflection and amplification do not occur.

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

  This includes 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 standing waves in pipes and on stretched strings

  This includes 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

  $$\lambda = \frac{4\ell}{(2n-1)}$$

- 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
- the intensity of a wave decreases in an inverse square relationship with distance from a point source

  This includes applying the relationship

  $$I \propto \frac{1}{r^2}$$

School-based assessment

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

Teachers design school-based assessment tasks to meet the needs of students. The table below provides details of the assessment types for the Physics ATAR Year 11 syllabus and the weighting for each assessment type.

Assessment table – Year 11

Type of assessment	Weighting
Science Inquiry There must be at least one experiment, one investigation and one evaluation and analysis completed for each unit. Appropriate strategies should be used to authenticate student achievement on an out-of-class assessment task. **Experiment** Practical tasks designed to develop or assess a range of laboratory related skills and conceptual understanding of physics principles, and skills associated with representing data; organising and analysing data to identify trends and relationships; recognising error, uncertainty and limitations in data; and selecting, synthesising and using evidence to construct and justify conclusions. Tasks can take the form of practical skills tasks, laboratory reports and short in-class tests to validate the knowledge gained. **Investigation** Activities in which ideas, predictions or hypotheses are tested and conclusions are drawn in response to a question or problem. Investigations can involve experimental testing, field work, locating and using information sources, conducting surveys, and using modelling and simulations. Assessment tasks can take the form of an experimental design brief, a formal investigation report requiring qualitative and/or quantitative analysis of the data and evaluation of physical information, or exercises requiring qualitative and/or quantitative analysis of second-hand data. **Evaluation and analysis** Involves interpreting a range of scientific and media texts; evaluating processes, claims and conclusions by considering the accuracy and precision of available evidence; and using reasoning to construct scientific arguments. Assessment tasks can take the form of answers to specific questions based on individual research; exercises requiring analysis; and interpretation and evaluation of physics information in scientific and media texts.	30%
Test Tests typically consist of questions requiring short answers, extended answers and problem solving. This assessment type is conducted in supervised classroom settings.	30%
Examination Examinations require students to demonstrate use of terminology, understanding and application of concepts and knowledge of factual information. It is expected that questions would allow students to respond at their highest level of understanding. 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).

In the assessment outline for the pair of units, each assessment type must be included at least twice. In the assessment outline where a single unit is being studied, each assessment type must be included at least once.

The set of assessment tasks must provide a representative sampling of the content for Unit 1 and Unit 2.

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

Grading

Schools report student achievement in terms of the following grades:

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

The teacher prepares a ranked list and assigns the student a grade for the pair of units (or for a unit where only one unit is being studied). The grade is based on the student's overall performance as judged by reference to a set of pre-determined standards. These standards are defined by grade descriptions and annotated work samples. The grade descriptions for the Physics ATAR Year 11 syllabus are provided in Appendix 1. They can also be accessed, together with annotated work samples, through the Guide to Grades link on the course page of the Authority website at 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.

Appendix 1 – Grade descriptions Year 11

Grade	Description
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.

Grade	Description
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.

Grade	Description
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 confused 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.

Appendix 2 – Glossary

This glossary is provided to enable a common understanding of the key terms in this syllabus.

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 in order 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.
Cultural relativism	The practice of describing the beliefs, customs and practices of another culture from a neutral point of view, rather than from the perspective of the observing individual's own culture.
Data	The plural of datum; the measurement of an attribute, for example, 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.
Ethnocentrism	The practice of describing the beliefs, customs and practices of another culture from the perspective of the observing individual's own culture.
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 (i.e. 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.
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.
Intensity	The average rate of flow of energy per unit area.
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 that is 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, 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.
Newtonian determinism	The philosophical consequence of Newton's Laws of Motion, viz., that it is possible in principle to deduce all consequences of interactions between objects; sometimes referred to as the 'clockwork Universe'.

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.
Reductionism	A philosophical approach that starts by removing all objects from a system, then returning them one-by-one and noting the relationships between them; a process of defining basic concepts and relationships from simplest to more complex.
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.
Resonance	The effect achieved when one system with a natural predisposition to accept energy impacting it and is characterised by a particular frequency or frequencies.
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.
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; is 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.