Physics

LEVEL 4	15 TCE CREDIT POINTS
COURSE CODE	PHY415115
COURSE SPAN	2015 — 2024
READING AND WRITING STANDARD	NO
MATHEMATICS STANDARD	YES
COMPUTERS AND INTERNET STANDARD	NO

This course was delivered in 2019. Use A-Z Courses to find the current version (if available).

Physics is a fundamental science that endeavours to explain all the natural phenomena that occur in the universe using the method of experiment and observation and the method of mathematical reasoning

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. 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 physics will enable learners 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.

Rationale

Knowledge and understanding of science, scientific literacy and scientific methods are necessary for learners to develop the skills to resolve questions about their natural and constructed world.

The purpose of science education is to develop scientific literacy, helping learners: to be interested in, and understand, the world around them; to engage in discourse about the scientific and technological aspects underlying global and local issues; to be sceptical and questioning of claims made by others about scientific matters; to be able to identify questions, draw evidence-based conclusions and discuss their validity; and to form opinions, that are reasoned and informed, about the environment, about their own health and well-being and about the role and impact of science on society.

Physics is a fundamental science that endeavours to explain all the natural phenomena that occur in the universe using the method of experiment and observation and the method of mathematical reasoning. 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.

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Aims

Physics aims to develop learners':

- interest in and appreciation of physics and its usefulness in helping to explain physical phenomena and solve problems encountered in their ever-changing world
- understanding of concepts, models and theories that may be used to explain, analyse and make predictions about natural phenomena
- understanding of how physics knowledge is used in a wide range of contexts, and that it has significant impacts on society and implications for decision making
- investigative skills, including conducting investigations to explore physical phenomena and solve problems, collection and analysis of qualitative and quantitative data, and 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, formats and language.

Learning Outcomes

On successful completion of this course, learners will be able to:

1. identify principles of physics concepts, models and theories, related to Newtonian mechanics including gravitational fields, electromagnetism, wave motion, the wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear
2. identify ways in which knowledge of physics interacts with social, economic, cultural and political considerations in a range of contexts
3. use physics principles, outlined in the course content, to identify and predict physical phenomena
4. identify the uses and limitations of knowledge of physics in a range of contexts
5. analyse and interpret physics data to draw valid conclusions and make generalisations
6. solve physics problems through quantitative analysis
7. have practical skills in the use of scientific techniques and equipment relating to physics
8. use scientific inquiry skills to develop, perform, analyse and evaluate physics experiments and their design
9. communicate physics understanding using qualitative and quantitative information in appropriate representations and formats, following accepted conventions and terminology
10. have discriminating research skills
11. be self-directing; be able to plan study; be organised to complete tasks and meet deadlines; have cooperative working skills related to the study of Physics.

Access

Learners are required to be able to work as directed in practical situations as potentially dangerous materials and equipment may be used in this course.

It is highly recommended that learners studying Physics have successfully completed Physical Sciences Level 3 and, as a minimum, have studied or are currently studying General Mathematics Level 3 or equivalent.

Pathways

The successful completion of *Physical Sciences* Level 3, provides an essential preparation for the study of Physics Level 4.

Studying senior secondary science provides learners with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. An understanding of physics provides learners with a suite of skills and understandings that are valuable in a wide range of further study and careers. An understanding of *Physics* Level 4 is relevant and provides a foundation for a range of careers, including those in: astronomy; biomechanics; engineering; energy creation and management; forensic science; computer game design; meteorology; oceanography; quantum computing; space science; and sport science.

Resource Requirements

This course requires a suitably equipped laboratory and resources to conduct experiments. Learners need to be able to access a wide range of reliable sources of information about the uses and applications of science within the wider community.

Refer to *'What can I take to my exam?'* for the current TASC Calculator Policy that applies to Level 3 courses.

Course Size And Complexity

This course has been assessed as having a complexity level of 4.

In general, courses at this level provide theoretical and practical knowledge and skills for specialised and/or skilled work and/or further learning, requiring:

- broad factual, technical and some theoretical knowledge of a specific area or a broad field of work and learning
- a broad range of cognitive, technical and communication skills to select and apply a range of methods, tools, materials and information to:
  - complete routine and non-routine activities
  - provide and transmit solutions to a variety of predictable and sometimes unpredictable problems
- application of knowledge and skills to demonstrate autonomy, judgement and limited responsibility in known or changing contexts and within established parameters.

This Level 4 course has a size value of 15.

Course Content

For the content areas of Physics, the three (3) interrelated strands - Science Inquiry Skills; Science as a Human Endeavour; and Science Understanding - build on learners' learning in F-10 *Australian Curriculum: Science*. In the practice of science, the three strands are closely integrated: the work of scientists reflects the nature and development of science; it is built around scientific inquiry; and it seeks to respond to and influence society. These three strands will be integrated into the study of four (4) physics topics:

- Newtonian mechanics including gravitational fields
- Principles and theories of electricity and magnetism
- General principles of wave motion
- The wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear processes.

Each physics topic is **compulsory**, however the order of delivery is not prescribed. These topics relate directly to Criteria 5 – 8. Criteria 1 – 4 apply to all four topics of physics.

This course has a design time of 150 hours. It is recommended that approximately 40 hours be spent engaged in practical activities, including hands-on experiments and demonstrations.

SCIENCE INQUIRY SKILLS

- Identify, research, construct and refine questions for investigation, proposing mechanisms and predicting possible outcomes.
- Plan physics experiments, including the procedure to be followed, the materials required and the type and amount of primary and/or secondary data to be collected; observing risk assessments; and considering research ethics.
- Conduct physics experiments safely, competently and methodically for the collection of valid and reliable data.
- Use Système Internationale Units (SI), scientific notation, standard notation and significant figures.
- Represent physics data in meaningful and useful ways, including: using graphic representations, and understanding the significance of slopes of tangents and areas under graphs; organising and analysing data to identify trends, patterns and relationships; identifying sources of random and systematic error, including uncertainty in measurements (simple treatment only); identifying anomalous data; selecting, synthesising and using evidence to make and justify conclusions.
- Evaluate models, interpret a range of scientific 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, electromagnetic and gravitational field diagrams and nuclear equations, to communicate conceptual understanding, solve problems and make predictions.
- Select, use and interpret appropriate mathematical representations, including analysis of vectors to any angle and trigonometric applications of sine rule, cosine rule and components of vectors, to solve problems and make predictions.
- Communicate information or findings to others through selecting and constructing appropriate language, nomenclature, text types and modes, including scientific reports.

SCIENCE AS A HUMAN ENDEAVOUR

- Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility.
- Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power.
- Advances in science understanding in one field can influence other areas of science, technology and engineering.
- The acceptance of scientific knowledge can influence, and be influenced by, the social, economic and cultural context in which it is considered.
- The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences.
- Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question.

Support materials only that illustrate some possible contexts for exploring *Science as a Human Endeavour* concepts in relation to *Science Understanding* content are found in Appendix 1.

SCIENCE UNDERSTANDING

The physics content of Physical Sciences (PSC315114) that forms the basis for the development of Physics (PHY315114), *Science Understanding*, will be included in this section as revision.

Newtonian mechanics including gravitational fields **(*Criterion 5*)**

This section enlarges on mechanical and Newtonian ideas of forces and motion, extending the ideas to the first of the natural forces - gravity.

Motion

- Displacement and distance:
    - solve displacement problems to any angled analysis
- Speed and average velocity:
  $$\text{speed}_{av} = \frac{\text{total distance}}{\text{total time}}, \text{velocity}_{av} = \frac{\text{total displacement}}{\text{total time}}$$
- Acceleration:
  $a = \frac{\Delta v}{\Delta t} = \frac{v-u}{\Delta t}$
- Graphical treatment of accelerated motion:
    - construct and interpret constant acceleration cases of s-t graphs, v-t graphs and a-t graphs
    - construct v-t and a-t graphs using data from the slopes of s-t and v-t graphs respectively
    - calculation of displacement and/or distance from v-t graph
- Uniformly accelerated motion, including vertical motion under gravity:
    - solve problems using equations of motion for constant straight line acceleration, including gravity cases
      ($a_g = 9.81 \quad \text{ms}^{-2}$)
      $$v = u + at,\ \ s = ut + \frac{1}{2}at^2,\ v^2 = u^2 + 2as$$
    - understand terminal velocity
- Projectile motion including projection and landing at different levels and/or heights:
    - determine the vertical and horizontal components of velocity (and hence velocity) at any point of the path
    - determine time of flight
    - determine horizontal and vertical displacement.

Momentum and Newton's Laws

- Momentum and conservation of momentum:
    - determine momentum
      $p = mv$
    - apply the law of conservation of momentum to one and two dimensional problems at any angle, either collision or explosion formats
      $\sum p_i = \sum p_f$
- Newton's Laws of Motion:
    - identify forces in a free body diagram
    - identify whether forces are balanced or unbalanced in 2 dimensional situations including
        - inclined slopes
        - many force situations (up to 4 forces)
    - apply and illustrate the operation of Newton's First Law
    - apply Newton's Second Law to numerical and non-numerical problems including weight problems and the solution of motion problems
      $F_{unbalanced} = ma = \frac{m(v-u)}{\Delta t} = \frac{\Delta p}{\Delta t}$
    - apply Newton's Second Law both when velocity changes and in simple mass change situations, e.g. ion drives, water from a hose
    - apply and illustrate Newton's Third Law of Motion
    - relate forces and momentum together in force – time graphs and momentum – time graphs
    - 2 dimensional momentum changes and forces.

Circular Motion as an example of Newton's Second Law

- Tangential speed and velocity:
  $v = \dfrac{2\pi r}{T}$
- Centripetal acceleration and centripetal force as changes in velocity and momentum in time:
  $F_c = \dfrac{mv^2}{r}, \quad a_c = \dfrac{v^2}{r}$
- Application to horizontal circular motion.

Work, Energy and Power

- Develop the concepts of energy and work done to Force – distance graphical interpretations
  (Work Done = area under force – distance curves)
- Examine Work Done when the applied force and subsequent displacement are not colinear $WD = Fs\cos\theta$ where F is the applied force, s is the displacement and θ the angle between the two vectors
- Continued development of:
    - gravitational potential energy $E_p = mg\Delta h$
    - kinetic energy $E_k = \dfrac{1}{2}mv^2$
- Conservation of energy:
    - apply the law of conservation of energy to numerical problems
    - quantitatively determine whether a situation is elastic or inelastic based on E_k calculations
    - apply power to numerical problems
      $P = \dfrac{\Delta E}{t} = \dfrac{W}{t}$.

Gravity and Gravitational Fields

- Universal Law of Gravitation – gravitational force between two masses:
  $F_g = \dfrac{GM_1M_2}{r^2}$
  $\mathrm{G} = 6.67 \times 10^{-11} \quad \textbf{units } (\mathrm{Nm^2kg^{-2}})$
- Weight as the gravitational force on a body
  $F_g = mg$.
- Masses produce a gravitational field in the space that surrounds them; field theory attributes the gravitational force on a point mass or massive body to the presence of a gravity field.
- Gravitational Field Strength definition:
  $g^{def} = \dfrac{F_g}{m}$
- Qualitative description of fields.
- Gravitational Field Strength near a single mass:
  $g = \dfrac{GM}{r^2}$
- Sum of two individual gravitational field strengths in 2 dimensions.
- Sketch qualitative gravitational fields around single and double masses.
- Kepler's Third Law in both Newtonian and ratio form:
  $T^2 = \dfrac{4\pi^2 r^3}{GM}$
  $\left(\dfrac{T_1}{T_2}\right)^2 = \left(\dfrac{r_1}{r_2}\right)^3$
- Circular orbiting satellites including geosynchronous (geostationary) satellites.
- 'Weightlessness' as a sensation when only gravity is operating on a body.

***Principles and theories of electromagnetism* (*Criterion 6*)**

An underlying principle to be conveyed across the study of electromagnetism is the following:

- Stationary charges lead to electrostatic effects
- Moving charges lead to magnetic effects

- Accelerating charges lead to electromagnetic radiation. In particular, vibrating (oscillating) charges lead to the emission of continuous electromagnetic waves of frequency equal to the oscillation frequency. (New content not studied in PHY315114.)

Static Electricity

- Two forms of charge exist, positive and negative based on the electronic charge that is held by electrons and protons
- Macroscopic objects can be charged in various ways including friction. (New content not studied in PHY315114.)
- Electrostatically charged objects exert a force on one another; the magnitude of this force can be calculated using Coulomb's Law:
  $F_E = \frac{k_E Q_1 Q_2}{r^2}$
  $k_E = 9 \times 10^9 \ \ \textbf{units} \ (\mathrm{Nm^2C^{-2}})$
- Solve problems based on the above equations using methods such as free body diagrams, vector diagrams, graphing techniques and other techniques where applicable
- Point charges produce an electric field in the space that surrounds them; field theory attributes the electrostatic force on a point charge or charged body to the presence of an electric field
- Definition of electric field strength as the force on a small positive charge, q, placed at that point per unit charge:
  $E^{def} = \frac{F_E}{q}$
- Calculate quantitative descriptions of the total electric field strength in the vicinity of a single point charge and two point charges. These will involve 2 D diagrams:
  $E = \frac{k_E Q}{r^2}$
- Sketch qualitative electrostatic fields around single and double point charges
- Understand that electric fields cannot enter closed conducting hollow objects (Faraday cages). (New content not studied in PHY315114.)
- When a charged body moves or is moved from one point to another in an electric field, its potential energy changes and work is done on or by the field
- Potential Difference between two points in an electric field is defined:
  $\text{Pot Diff} = V = \frac{\text{Work Done}}{q} = \frac{\Delta\text{Energy}}{q}$
- Potential Difference is related to the Electric Field Strength:
  $E = \frac{V}{d}$
- Movement of a charged particle across a Potential Difference (e.g. Electron Gun)
- Movement of charged particles in uniform electric fields in the direction of the field, perpendicular to the field and at an angle to the field
- Millikan's Oil Drop experiment, balancing electric and gravitational forces.

Magnetic Fields

- Magnetic effects are caused by the movement of charges even in metal magnets.
- Qualitative description of magnetism including north and south poles, temporary magnets, permanent magnets and electromagnets. Direction of a magnetic field defined by a compass.
- Earth's magnetic field including 'angle of dip'.
- Basic phenomenon of currents attracting and repelling each other:
  $F_B = \frac{k_B I_1 I_2 l}{r}$
  $k_B = 2 \times 10^{-7} \ \ \textbf{units} \ (\mathrm{NA^{-2}})$. (New content not studied in PHY315114.)
- Magnetic field in the vicinity of a single wire carrying a current and use a suitable rule to give the direction
- Definition of Magnetic Flux Density, B, in terms of a test current in a wire creating a force:
  $B^{def} = \frac{F_B}{I_T l \sin\theta}$
- Magnetic force on a current in a magnetic field including the direction as given by a suitable rule to give the direction:
  $F_B = BIl\sin\theta$
- Application of the above to simple currents in wires and simple rotating DC motors
- Application of definition to create the Magnetic Flux Density equation for a single current in a straight wire:
  $B = \frac{k_B I}{r}$
- Use the above to calculate Magnetic Flux Density for single and pairs of currents parallel and at right angles to each other
- Sketch qualitative B field lines around one wire or two parallel wires with currents in either direction
- Magnetic force on moving charges including the direction. Subsequent circular or helical motion should be understood and contexts may include the van Allen Belts and similar:
  $F_B = qvB\sin\theta,\ r = \frac{mv\sin\theta}{qB}$

- Bainbridge mass spectrometer, including the velocity filter combination of Electric and Magnetic Flux Density and determination of the radius of an ion's path:
  $r = \dfrac{mv}{qB}$
- Balanced forces in crossed electric and magnetic fields such as the velocity filter:
  $v = \dfrac{E}{B}$.

Induction by Magnetic Fields

- Induction of electrical effects such as induced E fields, Potential Differences and currents
- Faraday's Law quantitatively limited to moving conductors in B fields:
  Electromotive Force (EMF) = theoretical potential difference when no current is produced
  $emf = vlB\sin\theta$
- Induction of potential differences, and currents when connected to a resistor, in a simple conductor drawn through a B field and rotating AC generator (do not include internal resistance of generator) (do not extend to DC motors operating as generators)
- Qualitative induction effects when B changes, qualitative accounts of transformers, eddy currents and similar
- Lenz's Law to predict induced currents caused by an applied changing magnetic field
- Transfer of energy in induction processes from external source seen as an opposing force to the motion of the conductor.

***General principles of wave motion* (*Criterion 7*)**

This section introduces learners to waves as a physical phenomenon. It covers many general properties and looks at how waves can produce effects that cannot be explained through particulate ideas.

Wave Interactions

- Waves are periodic oscillations that transfer energy from one point to another
- Transverse and longitudinal waves are distinguished by the relationship between the directions of oscillation to the direction of the wave velocity. Qualitative connections to Simple Harmonic Motion as the basic oscillation of waves.
- Sound and light as examples of waves. Sound is a mechanical longitudinal wave; the other is an electromagnetic wave with transverse qualities and can travel through a vacuum.
- Wavelength λ, frequency f, period T, amplitude and velocity v, of a wave:
  $v = \lambda f$, $f = \dfrac{1}{T}$
- Reflection and transmission of waves at boundaries both fixed and free in 1 Dimension. Phase change occurring during reflection at fixed ends.
- Reflection in 2 Dimensions:
  $\theta_i = \theta_r$
- Refraction across boundaries of two media and relative refractive index. Snell's Law:
  $\dfrac{\sin\theta_i}{\sin\theta_r} = n_{2,1} = \dfrac{v_1}{v_2} = \dfrac{\lambda_1}{\lambda_2}$
- Absolute refractive index for light (refractive index of a medium relative to a vacuum). Snell's Law becomes:
  $n_1\sin\theta_1 = n_2\sin\theta_2$
- Applying Snell's Law across a variety of boundaries to include internal reflection and critical angle (when the wave moves from a low velocity to a high velocity medium).

Wave Interference

- Principle of Superposition including 1 dimensional pulse diagrams
- Beats as an example of the superposition of two waves of similar frequency:
  $f_1 - f_2 = \pm f_B$
- Resonance as a phenomenon whereby energy builds up when it is driven at one of its natural frequencies of oscillation. Energy is efficiently transferred into systems under these conditions.
- Transverse and longitudinal standing waves are a result of the superposition of two waves. Applications of standing wave theory to musical string and wind instruments and other situations:
  - identification of the location of nodes and antinodes in closed and open pipes and strings
  - harmonics, overtones

- Quantitative calculations of frequencies of the above situations including to stretched wires of known tension and linear density:
  $v = \sqrt{\frac{T}{\mu}}$
  T = tension, μ = linear density

- Quantitative treatment of two dimensional two source interference and its application to light and sound at a large distance from the sources:
  - coherence, “pinhole” wavefront sources as a necessary condition for a clear observation of interference effects (or the equivalent, e.g. a laser like source)
  - path difference, the difference in distance from each source to a point of interest as a means of quantitative analysis
  - band width from node to node given by
    $W = \frac{\lambda x}{d}$
    W = band width, distance between nodes, λ = wave length, d = source separation,
    x = distance along axis from sources to pattern.
- Qualitative treatment of diffraction. The greater the wavelength, the more diffraction occurs:
  - diffraction around corners or objects. When the target is comparable to the wavelength, diffraction is most obvious
  - implications for communication, for example, microwaves for mobile phones
  - implications regarding image resolution for microscopes
  - illumination of a single slit with coherent light produces interference effects due to path differences from within the finite slit called a Diffraction Interference pattern. (Not to be treated in any great depth, largely observational)
- Qualitative treatment of polarisation and partial polarisation of mechanical transverse waves and electromagnetic waves. Discussion of polarisation of EM by the processes of reflection, transmission and scattering. Examples include, light reflecting from water or glass, the transmitted light through water or glass or ‘Polaroid’ filter, scattering by air.

The wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear processes **(*Criterion 8*)**

This section introduces learners to the changes in the interpretation of the physical world that took place at the end of the nineteenth century into the present era. The purpose is to give learners an insight into the basics of wave-particle duality and a very elementary idea of the electron “cloud” model of the atom. It also introduces a more formal discussion of mass-energy and the applications to nuclei of atoms.

Particle Nature of Light

- The issue of why hot objects produce a continuous spectrum. The failure of classical physics to resolve the issue of the intensity of the continuous spectrum. The resolution of this by Planck with studies of ‘Black Bodies’, that is, bodies that completely absorb or emit all wavelengths of light, and cavity radiators:
  - Wien’s Law
    $\lambda_{peak} = \frac{0.002898}{T}$
    λ_{peak} = peak wavelength, T = absolute temperature (New content not studied in PHY315114.)
  - photon energy, $E = hf$

- The issue of the Photoelectric Effect discovered by Hertz and the failure of classical physics to explain the phenomenon. Einstein’s subsequent explanation:
  $E_k(\max) = eV = hf - W$, W = work function
  - link of the equation to Millikan’s experimental arrangement involving Stopping Voltages
  - introduction of the term, “electron-volt”
  - quantitative use of the above equation in graphical, numerical or tabular form

- Production of X-rays. Einstein’s explanation of potential difference based maximum frequencies:
  $hf_{\max} = eV$
  - X-Ray tube construction
  - types of X-rays: continuous and characteristic X-rays
  - maximum frequency of photons are independent of tube current

- Allocation of momentum to individual photons and Compton scattering of X-Rays with electrons obeying momentum rules. Simple collision interpretations between X-Rays and electrons
  $p = \frac{h}{\lambda} = \frac{E}{c}$

- De Broglie’s completion of wave/particle duality by his allocation of a wavelength to particles and the implications in terms of interference of electrons and other so called particles. Qualitative discussion can then lead to the interpretation of this as

Quantum Mechanics by Schrodinger:

$p = mv = \frac{h}{\lambda}$

- quantitative calculations of electron and other particles’ wavelengths
- wave-particles are more particle like as their momenta/energy increases and more wavelike as their momenta/energy decreases
- electrons and other small particles can exhibit the wave like properties of interference and diffraction similar to X-Rays. Very limited quantitative discussions (typical dimensions to see these effects). (At this point teachers may wish to raise discussions on the “true” nature of reality)
- EM spectrum ranging from very wavelike radio waves to very particle like γ-rays.

Energy Levels of Atoms, Atomic Structure

- Description of emission and absorption line spectra of atoms. Failure of classical physics to explain the cause of these spectra.
- Qualitative discussion of Bohr-Rutherford atom
- Description of the production of line spectra by both electron and photon bombardment:
    - recognition of energy levels of electrons within atoms
    - transition of electrons between energy levels is associated with photon absorption or production
    - quantitative evaluation of photon energies, frequencies and wavelengths as a result of transitions
    - excitation of atoms by electron bombardment either through heat, electrically or other means
    - excitation of atoms by photons, ionisation of atoms by high energy photons
    - characteristic X-Ray spectra are due to electron energy changes typically to $n = 1$ ($\mathbf{K}$ Lines) or $n = 2$ ($\mathbf{L}$ Lines) for heavy elements

- Qualitative description of electron standing wave patterns applied to the Bohr-Rutherford atom. (New content not studied in PHY315114.)

Nuclear Physics

<u>Radioactivity and its detection</u>

- Discovery of nucleus by the Rutherford team in 1909
- Definition of radioactivity and properties of alpha, beta and gamma radiation
    - alpha radiation being associated with large nuclei
    - beta radiation due to decay of protons or neutrons in unstable nuclei
- Positrons, neutrinos, antineutrinos and neutrons
- Background radiation – ionising radiation not associated with the source being investigated. Sources of background radiation.
- The unit of radioactive decay, activity A, the Becquerel (Bq).

<u>Radioactive decay</u>

- Isotopes and the radioisotope
- Transmutations, parent nuclei and daughter nuclei, decay series
- Decay equations for alpha and beta decay including gamma radiation and neutrinos
- Half-life of radioisotopes:
    - half-life of a radioisotope
    - definition of activity and decay constant
      $A = -\frac{dN}{dt} = \lambda N,\ \lambda = \frac{0.693}{T_{\frac{1}{2}}}$
    - calculations involving half-life including exponential treatment
      $\frac{N}{N_0} = \frac{A}{A_0} = \frac{m}{m_0} = e^{-\lambda t} = 2^{-\frac{t}{T_{\frac{1}{2}}}}$

- Atomic number, mass number, atomic mass unit (Dalton)
- Strong nuclear force and its basic properties:
    - very short range
    - only acts on protons and neutrons.
      (Some new content not studied in PHY315114.)

- The equivalence of mass and energy. Law of conservation of mass-energy in all equations: $E = mc^2$
- Mass Defect calculations, Binding Energy and stability of nuclei
- Mass difference calculations applied to nuclear reactions and subsequent energy release or requirements
- Interpretations of BE/nucleon curve - Fusion reactions on one side, fission reactions on the other side of maximum. (Some new content not studied in PHY315114.)
- Fission including chain reaction, critical mass and the basic components of a fission reactor, particularly moderator, control rods and heat exchange
- Qualitative description of the Standard Model – quarks, colour charge and gluons. Discussion limited to protons and neutrons – up and down quarks. No discussion of mesons. (New content not studied in PHY315114.)

<u>The theory of relativity and the Standard Model of particle physics</u> (New content not studied in PHY315114.)

A qualitative discussion of the theory of relativity and the Standard Model may be achieved through a focus on *Science as a Human Endeavour*.

The following dot-points are qualitative, and internally assessed (*only*):

- Enlargement of Standard Model:
    - the Standard Model recognises that there are different gauge bosons; gluons that carry the strong force, W and Z bosons that carry the weak force and photons which carry the electromagnetic force.
- Special relativistic effects at high velocities:
    - observations of objects travelling at very high speeds cannot be explained by Newtonian physics, for example, the dilated half-life of high-speed muons created in the upper atmosphere, and the momentum of high speed particles in particle accelerators
    - Einstein's special theory of relativity predicts significantly different results to those of Newtonian physics for velocities approaching the speed of light
    - the special theory of relativity is based on two postulates: that the speed of light in a vacuum is an absolute constant, and that all inertial reference frames are equivalent
    - motion can only be measured relative to an observer; length and time are relative quantities that depend on the observer's frame of reference
    - relativistic momentum increases at high relative speed and prevents an object from reaching the speed of light
    - the concept of mass-energy equivalence emerged from the special theory of relativity and explains the source of the energy produced in nuclear reactions.

Assessment

Criterion-based assessment is a form of outcomes assessment that identifies the extent of learner achievement at an appropriate end-point of study. Although assessment – as part of the learning program – is continuous, much of it is formative, and is done to help learners identify what they need to do to attain the maximum benefit from their study of the course. Therefore, assessment for summative reporting to TASC will focus on what both teacher and learner understand to reflect end-point achievement.

The standard of achievement each learner attains on each criterion is recorded as a rating 'A', 'B', or 'C', according to the outcomes specified in the standards section of the course.

A 't' notation must be used where a learner demonstrates any achievement against a criterion less than the standard specified for the 'C' rating.

A 'z' notation is to be used where a learner provides no evidence of achievement at all.

Providers offering this course must participate in quality assurance processes specified by TASC to ensure provider validity and comparability of standards across all awards.To learn more, see TASC's quality assurance processes and assessment information.

Internal assessment of all criteria will be made by the provider. Providers will report the learner's rating for each criterion to TASC.

TASC will supervise the external assessment of designated criteria which will be indicated by an asterisk (*). The ratings obtained from the external assessments will be used in addition to internal ratings from the provider to determine the final award.

Quality Assurance Process

The following processes will be facilitated by TASC to ensure there is:

- a match between the standards of achievement specified in the course and the skills and knowledge demonstrated by learners
- community confidence in the integrity and meaning of the qualification.

Process – TASC gives course providers feedback about any systematic differences in the relationship of their internal and external assessments and, where appropriate, seeks further evidence through audit and requires corrective action in the future.

External Assessment Requirements

The external assessment for this course will comprise:

- a written examination assessing criteria: 5, 6, 7 and 8.

For further information, see the current external assessment specifications and guidelines for this course available in the Supporting Documents below.

Criteria

The assessment for Physics Level 4 will be based on the degree to which the learner can:

1. demonstrate personal skills to plan, organise and complete activities
2. develop, interpret and evaluate physics experiments
3. collect, process and communicate information
4. demonstrate understanding of the application and impact of physics in society
5. identify and apply principles of Newtonian mechanics including gravitational fields*
6. identify and apply principles and theories of electricity and magnetism*
7. identify and apply general principles of wave motion*
8. identify and apply principles of the wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear processes*

* = denotes criteria that are both internally and externally assessed

Standards

Criterion 1: demonstrate personal skills to plan, organise and complete activities

The learner:

Rating A	Rating B	Rating C
uses techniques and equipment related to physics investigations safely, competently and methodically, applying them to unfamiliar contexts	uses techniques and equipment related to physics investigations safely, competently and methodically	uses familiar techniques and equipment related to physics investigations safely and competently
follows instructions accurately and methodically, adapting to new circumstances	follows instructions accurately and methodically to complete the task	follows instructions accurately to complete the task
reflects – orally and/or in writing – on progress towards meeting goals and timelines; critically evaluates progress to plan future actions	reflects – orally and/or in writing – on progress towards meeting goals and timelines; analyses progress to plan future actions	reflects – orally and/or in writing – on progress towards meeting goals and timelines, articulating some ways in which goals may be met in the future
performs tasks, modifies own contribution and guides others in their contribution to the successful completion of group activities.	performs tasks and modifies own contribution to the successful completion of group activities.	performs tasks to effectively contribute to the completion of group activities.

Criterion 2: develop, interpret and evaluate physics experiments

Related to experiments in Physics, the learner:

Rating A	Rating B	Rating C
expresses a plausible and readily testable scientific idea that explains all experimental observations	expresses a plausible scientific idea that explains all experimental observations	expresses a scientific idea that explains some experimental observations
critically analyses and interprets data to draw a valid conclusion that relates to the purpose of the experiment	analyses and interprets data to draw a valid conclusion that relates to the purpose of the experiment	based on experimental results, draws a conclusion that relates to the purpose of the experiment and has some validity
discusses significant limitations and sources of error in experimental design, with reference to theory and/or evidence	identifies significant limitations and sources of error in an experimental design	identifies some limitations and sources of error in an experimental design
critically evaluates an experimental design and provides an evidence-based critique and discussion on valid improvements and alternatives.	analyses an experimental design and describes a number of possible valid improvements.	identifies a valid improvement in an experimental design.

Criterion 3: collect, process and communicate information

The learner:

Rating A	Rating B	Rating C
uses a variety of relevant resources to collect information, and critically evaluates	uses a variety of relevant resources to collect information, and evaluates their	uses a variety of relevant resources to collect information

their reliability	reliability	
collects a wide range of relevant experimental data, and records it methodically in a format that allows analysis	collects experimental data and records it in a format that allows analysis	collects and records experimental data
clearly identifies the information, images, ideas and words of others used in the learner's work	clearly identifies the information, images, ideas and words of others used in the learner's work	differentiates the information, images, ideas and words of others from the learner's own
clearly identifies sources of the information, images, ideas and words that are not the learner's own. Referencing conventions and methodologies are followed with a high degree of accuracy.	clearly identifies sources of the information, images, ideas and words that are not the learner's own. Referencing conventions and methodologies are followed correctly.	identifies the sources of information, images, ideas and words that are not the learner's own. Referencing conventions and methodologies are generally followed correctly.
creates appropriate, well structured reference lists/bibliographies	creates appropriate, structured reference lists/bibliographies	creates appropriate reference lists/bibliographies
selects and uses appropriate scientific formats for effective and accurate communication of information for specific audiences and purposes.	uses an appropriate scientific format for clear and accurate communication of information for specific audiences and purposes.	uses an appropriate scientific format for communication of information.

Criterion 4: demonstrate understanding of the application and impact of physics in society

Related to the study of Physics, the learner:

Rating A	Rating B	Rating C
explains the relevance of identified science background to an issue	describes relevant science background to an issue	identifies relevant science background to an issue
explains significant components of an issue, and presents a detailed and balanced discussion	describes components of an issue, and presents a balanced discussion	identifies the key components of an issue, and presents a discussion
clearly describes and critically evaluates the tensions and connections between an issue and all significant relevant influences (ethical, political, cultural, social, economic)	clearly describes the tensions and connections between an issue and most of the relevant influences (ethical, political, cultural, social, economic)	identifies connections between an issue and some of the relevant influences (ethical, political, cultural, social, economic)
analyses and evaluates to present a complex argument related to the benefits of the use of scientific knowledge, and any harmful or unintended consequences	describes the benefits of the use of scientific knowledge, and any harmful or unintended consequences	identifies the benefits of the use of scientific knowledge, and any harmful or unintended consequences
argues a reasoned conclusion, linking it to relevant evidence. Assesses the impact of the application of the decision in society.	argues a reasoned conclusion, articulating links to relevant evidence.	presents a reasoned conclusion, using some relevant evidence.

Criterion 5: identify and apply principles of Newtonian mechanics including gravitational fields

This criterion is both internally and externally assessed.

Related to the study of Newtonian mechanics, including gravitational fields, the learner:

Rating A	Rating B	Rating C

explains fundamental principles	describes fundamental principles	identifies fundamental principles
selects, applies and manipulates appropriate formulae to solve complex numerical problems, and analyses the validity of the solution	selects, applies and manipulates appropriate formulae to solve numerical problems involving several steps	selects, applies and manipulates appropriate formulae to solve straight forward numerical problems
analyses and evaluates data in graphical and tabular form, generates additional data and information, and makes generalisations	analyses data in graphical and tabular form to generate additional data and information	interprets data in graphical and tabular form
applies principles to interpret complex problems, and makes reasoned, plausible predictions in unfamiliar, including real-world, contexts.	applies principles to interpret problems, and makes plausible predictions in unfamiliar, including real-world, contexts.	interprets problems, and makes predictions in familiar, including real-world, contexts.

Criterion 6: identify and apply principles and theories of electricity and magnetism

This criterion is both internally and externally assessed.

Related to the study of electricity and magnetism, the learner:

Rating A	Rating B	Rating C
explains fundamental principles and theories	describes fundamental principles and theories	identifies fundamental principles and theories
selects, applies and manipulates appropriate formulae to solve complex numerical problems, and analyses the validity of the solution	selects, applies and manipulates appropriate formulae to solve numerical problems involving several steps	selects, applies and manipulates appropriate formulae to solve straight forward numerical problems
analyses and evaluates data in graphical and tabular form, generates additional data and information, and makes generalisations	analyses data in graphical and tabular form to generate additional data and information	interprets data in graphical and tabular form
applies principles to interpret complex problems, and makes reasoned, plausible predictions in unfamiliar, including real-world, contexts.	applies principles to interpret problems, and makes plausible predictions in unfamiliar, including real-world, contexts.	interprets problems, and makes predictions in familiar, including real-world, contexts.

Criterion 7: identify and apply general principles of wave motion

This criterion is both internally and externally assessed.

Related to the study of wave motion, the learner:

Rating A	Rating B	Rating C
explains general principles	describes general principles	identifies general principles
selects, applies and manipulates appropriate formulae to solve complex numerical problems, and analyses the validity of the solution	selects, applies and manipulates appropriate formulae to solve numerical problems involving several steps	selects, applies and manipulates appropriate formulae to solve straight forward numerical problems
analyses and evaluates data in graphical and tabular form, generates additional data and information, and makes generalisations	analyses data in graphical and tabular form to generate additional data and information	interprets data in graphical and tabular form

applies principles to interpret complex problems, and makes reasoned, plausible predictions in unfamiliar, including real-world, contexts.	applies principles to interpret problems, and makes plausible predictions in unfamiliar, including real-world, contexts.	interprets problems, and makes predictions in familiar, including real-world, contexts.

Criterion 8: identify and apply principles of the wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear processes

This criterion is both internally and externally assessed.

Related to the study of the wave-particle nature of light, atomic and nuclear physics, and models of the nucleus and nuclear processes, the learner:

Rating A	Rating B	Rating C
explains fundamental principles	describes fundamental principles	identifies fundamental principles
selects, applies and manipulates appropriate formulae to solve complex numerical problems, and analyses the validity of the solution	selects, applies and manipulates appropriate formulae to solve numerical problems involving several steps	selects, applies and manipulates appropriate formulae to solve straight forward numerical problems
analyses and evaluates data in graphical and tabular form, generates additional data and information, and makes generalisations	analyses data in graphical and tabular form to generate additional data and information	interprets data in graphical and tabular form
applies principles to interpret complex problems, and makes reasoned, plausible predictions in unfamiliar, including real-world, contexts.	applies principles to interpret problems, and makes plausible predictions in unfamiliar, including real-world, contexts.	interprets problems, and makes predictions in familiar, including real-world, contexts.

Qualifications Available

Physics Level 4 (with the award of):

EXCEPTIONAL ACHIEVEMENT

HIGH ACHIEVEMENT

COMMENDABLE ACHIEVEMENT

SATISFACTORY ACHIEVEMENT

PRELIMINARY ACHIEVEMENT

Award Requirements

The final award will be determined by the Office of Tasmanian Assessment, Standards and Certification from the 12 ratings (8 from the internal assessment, 4 from the external assessment).

The minimum requirements for an award in Physics Level 4 are as follows:

EXCEPTIONAL ACHIEVEMENT (EA)
10 ‘A’ ratings, 2 ‘B’ ratings (3 ‘A’ ratings, 1 ‘B’ rating from external assessment)

HIGH ACHIEVEMENT (HA)
4 ‘A’ ratings, 5 ‘B’ ratings, 3 ‘C’ ratings (1 ‘A’ rating, 2 ‘B’ ratings and 1 ‘C’ rating from external assessment)

COMMENDABLE ACHIEVEMENT (CA)
6 ‘B’ ratings, 5 ‘C’ ratings (2 ‘B’ ratings, 2 ‘C’ ratings from external assessment)

SATISFACTORY ACHIEVEMENT (SA)
10 ‘C’ ratings (3 ‘C’ ratings from external assessment)

PRELIMINARY ACHIEVEMENT (PA)
6 ‘C’ ratings

A learner who otherwise achieves the ratings for a CA (Commendable Achievement) or SA (Satisfactory Achievement) award but who fails to show any evidence of achievement in one or more criteria (‘z’ notation) will be issued with a PA (Preliminary Achievement) award.

Course Evaluation

The Department of Education’s Curriculum Services will develop and regularly revise the curriculum. This evaluation will be informed by the experience of the course’s implementation, delivery and assessment.

In addition, stakeholders may request Curriculum Services to review a particular aspect of an accredited course.

Requests for amendments to an accredited course will be forwarded by Curriculum Services to the Office of TASC for formal consideration.

Such requests for amendment will be considered in terms of the likely improvements to the outcomes for learners, possible consequences for delivery and assessment of the course, and alignment with Australian Curriculum materials.

A course is formally analysed prior to the expiry of its accreditation as part of the process to develop specifications to guide the development of any replacement course.

Expectations Defined By National Standards In Content Statements Developed by ACARA

The statements in this section, taken from documents endorsed by Education Ministers as the agreed and common base for course development, are to be used to define expectations for the meaning (nature, scope and level of demand) of relevant aspects of the sections in this document setting out course requirements, learning outcomes, the course content and standards in the assessment.

Unit 1 – Ionising radiation and nuclear reactions

- Nuclear fusion is a reaction in which light nuclides combine to form a heavier nuclide, with the release of energy (ACSPH035)
- More energy is released per nucleon in nuclear fusion than in nuclear fission because a greater percentage of the mass is transformed into energy. (ACSPH036)

Unit 2 – Waves

- Waves are periodic oscillations that transfer energy from one point to another (ACSPH067)
- Longitudinal and transverse waves are distinguished by the relationship between the direction of oscillation relative to the direction of the wave velocity (ACSPH068)
- Waves may be represented by time and displacement wave diagrams and described in terms of relationships between measurable quantities, including period, amplitude, wavelength, frequency and velocity (ACSPH069)
- Mechanical waves transfer energy through a medium; mechanical waves may oscillate the medium or oscillate the pressure within the medium (ACSPH070)
- The mechanical wave model can be used to explain phenomena related to reflection and refraction (for example, echoes, seismic phenomena) (ACSPH071)
- 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 (ACSPH072)
- 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 (ACSPH073)
- Light exhibits many wave properties; however, it cannot be modelled as a mechanical wave because it can travel through a vacuum (ACSPH074)
- A ray model of light may be used to describe reflection, refraction and image formation from lenses and mirrors (ACSPH075)
- A wave model explains a wide range of light-related phenomena including reflection, refraction, total internal reflection, dispersion, diffraction and interference; a transverse wave model is required to explain polarisation. (ACSPH076)

Unit 3 – Gravity and motion

- The movement of free-falling bodies in Earth's gravitational field is predictable (ACSPH093)
- All objects with mass attract one another with a gravitational force; the magnitude of this force can be calculated using Newton's Law of Universal Gravitation (ACSPH094)
- Objects with mass produce a gravitational field in the space that surrounds them; field theory attributes the gravitational force on an object to the presence of a gravitational field (ACSPH095)
- When a mass moves or is moved from one point to another in a gravitational field and its potential energy changes, work is done on or by the field (ACSPH096)
- Gravitational field strength is defined as the net force per unit mass at a particular point in the field (ACSPH097)
- 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 (ACSPH098)
- Projectile motion can be analysed quantitatively by treating the horizontal and vertical components of the motion independently (ACSPH099)
- When an object experiences a net force of constant magnitude perpendicular to its velocity, it will undergo uniform circular motion, including circular motion on a horizontal plane and around a banked track (ACSPH100)
- Newton's Law of Universal Gravitation is used to explain Kepler's laws of planetary motion and to describe the motion of planets and other satellites, modelled as uniform circular motion. (ACSPH101)

Unit 3 – Electromagnetism

- Electrostatically charged objects exert a force upon one another; the magnitude of this force can be calculated using Coulomb's Law (ACSPH102)

- Point charges and charged objects produce an electric field in the space that surrounds them; field theory attributes the electrostatic force on a point charge or charged body to the presence of an electric field (ACSPH103)
- A positively charged body placed in an electric field will experience a force in the direction of the field; the strength of the electric field is defined as the force per unit charge (ACSPH104)
- When a charged body moves or is moved from one point to another in an electric field and its potential energy changes, work is done on or by the field (ACSPH105)
- Current-carrying wires are surrounded by magnetic fields; these fields are utilised in solenoids and electromagnets (ACSPH106)
- The strength of the magnetic field produced by a current is called the magnetic flux density (ACSPH107)
- Magnets, magnetic materials, moving charges and current-carrying wires experience a force in a magnetic field; this force is utilised in DC electric motors (ACSPH108)
- A changing magnetic flux induces a potential difference; this process of electromagnetic induction is used in (…………) (ACSPH110)
- Conservation of energy, expressed as Lenz's Law of electromagnetic induction, is used to determine the direction of induced current (ACSPH111)
- Electromagnetic waves are transverse waves made up of mutually perpendicular, oscillating electric and magnetic fields (ACSPH112)
- Oscillating charges produce electromagnetic waves of the same frequency as the oscillation; electromagnetic waves cause charges to oscillate at the frequency of the wave. (ACSPH113)

Unit 4 – Special Relativity

- Observations of objects travelling at very high speeds cannot be explained by Newtonian physics (for example, the dilated half-life of high-speed muons created in the upper atmosphere, and the momentum of high speed particles in particle accelerators) (ACSPH129)
- Einstein's special theory of relativity predicts significantly different results to those of Newtonian physics for velocities approaching the speed of light (ACSPH130)
- The special theory of relativity is based on two postulates: that the speed of light in a vacuum is an absolute constant, and that all inertial reference frames are equivalent (ACSPH131)
- Motion can only be measured relative to an observer; length and time are relative quantities that depend on the observer's frame of reference (ACSPH132)
- Relativistic momentum increases at high relative speed and prevents an object from reaching the speed of light (ACSPH133)
- The concept of mass-energy equivalence emerged from the special theory of relativity and explains the source of the energy produced in nuclear reactions. (ACSPH134)

Unit 4 – Quantum theory

- Atomic phenomena and the interaction of light with matter indicate that states of matter and energy are quantised into discrete values (ACSPH135)
- On the atomic level, electromagnetic radiation is emitted or absorbed in discrete packets called photons; the energy of a photon is proportional to its frequency; and the constant of proportionality, Planck's constant, can be determined experimentally (for example, from the photoelectric effect or the threshold voltage of coloured LEDs) (ACSPH136)
- A wide range of phenomena, including black body radiation and the photoelectric effect, are explained using the concept of light quanta (ACSPH137)
- Atoms of an element emit and absorb specific wavelengths of light that are unique to that element; this is the basis of spectral analysis (ACSPH138)
- The Bohr model of the hydrogen atom integrates light quanta and atomic energy states to explain the specific wavelengths in the hydrogen spectrum and in the spectra of other simple atoms; the Bohr model enables line spectra to be correlated with atomic energy-level diagrams (ACSPH139)
- On the atomic level, energy and matter exhibit the characteristics of both waves and particles (for example, Young's double slit experiment is explained with a wave model but produces the same interference pattern when one photon at a time is passed through the slits). (ACSPH140)

Unit 4 – Standard Model

- The Standard Model is based on the premise that all matter in the universe is made up from elementary matter particles called quarks and leptons; quarks experience the strong force, leptons do not (ACSPH141)
- The Standard Model explains three of the four fundamental forces (strong, weak and electromagnetic forces) in terms of an exchange of force-carrying particles called gauge bosons; each force is mediated by a different type of gauge boson (ACSPH142)
- Reactions between particles can be represented by simple reaction diagrams (ACSPH143)
- High-energy particle accelerators are used to test theories of particle physics including the Standard Model (ACSPH146)

- The Standard Model is used to describe the evolution of forces and the creation of matter in the Big Bang theory. (ACSPH147)

Accreditation

The accreditation period for this course has been renewed from 1 January 2022 until 31 December 2024.

During the accreditation period required amendments can be considered via established processes.

Should outcomes of the Years 9-12 Review process find this course unsuitable for inclusion in the Tasmanian senior secondary curriculum, its accreditation may be cancelled. Any such cancellation would not occur during an academic year.

Version History

Version 1 – Accredited on 19 June 2014 for use in 2015 to 2018. This course replaces Physics (PHY315114) that expired on 31 December 2014.

Version 2 – As per TASC decision on 4 February 2015, this course has been assigned Level 4 (not 3) in complexity. The level and complexity section of this course document has been updated and the code changed to PHY415115.

Version 2.a - Amendment to Pathways information. Accreditation renewed on 22 November 2018 for the period 1 January 2019 until 31 December 2021.

Version 2.b - Renewal of Accreditation on 14 July 2021 for the period 31 December 2021 until 31 December 2024, without amendments.

Appendix 1

EXAMPLES IN CONTEXT

The following examples in context are sourced from the *Australian Senior Secondary Curriculum: Physics*. These examples have been selected to support the *Science Understanding* content of this course, and may be used to explore *Science as a Human Endeavour* concepts. The list provides a range of contexts in which the physics content related to Criteria 5, 6, 7 and 8 might also be applied to the impact of physics in society (Criterion 4).

The examples in context listed should **not** be taken as an exhaustive list, nor is it intended that all examples be explicitly taught. The examples are support materials and **may** be used to inspire assessment tasks, augment classroom teaching, stimulate discussion, or to simply act as exemplars for teachers.

Possible internal assessment tasks (based on the following or other relevant examples) may include written reports, essays, case studies, portfolios, scientific poster presentations, oral presentations and debates. Principles and concepts in the examples that are not part of *Science Understanding* content of this course will not be examined externally.

Forensic science – projectiles, C5 & C4

Ballistics is the study of the flight of projectiles, especially bullets. The path of a bullet can be predicted by understanding the effects of air resistance and gravity, and by determining the effect of environmental conditions. Scientists study and record the motion of bullets through use of analytical methods such as high-speed video analysis and 3D computer modelling. Databases have been created recording the motion of a variety of bullets from different weapons and computer matching is used to identify weapons used in crimes. Forensic evidence is often used in court though, despite messages in the popular media, forensic science cannot always provide sufficient conclusive evidence to lead to convictions.

Artificial satellites, C5 & C4

Artificial satellites are used for communication, research and observation. Knowledge of orbital heights and speeds allow satellites to be best positioned for observation of weather, natural phenomena, traffic and military movements. Communication via satellite is now used in GPS, satellite phones and television. Orbits and uses of satellites are classified by altitude (Low Earth, Medium Earth or High Earth) and by inclination (equatorial, polar, polar sun-synchronous). Thousands of decommissioned satellites, spent rocket stages and fragments from collisions (collectively called space debris) continue to orbit Earth, causing problems upon collision with functional satellites and posing danger upon re-entry into Earth’s atmosphere. Various strategies including active removal are in place to try to limit an increase in orbiting debris.

Developing understanding of planetary motion, C5 & C4

Ptolemaic astronomy proposed a geocentric model of the solar system that used the idea of epicycles to explain planetary movement. This model was used until Copernicus proposed a heliocentric model of the solar system that was later championed by Galileo, causing conflict with the Catholic Church. Johannes Kepler proposed three laws of planetary motion that form the basis of our modern understanding of orbits. Newton was able to show how these laws were derived from his theory of gravitation.

Medical imaging, C6 & C4

Magnetic Resonance Imaging (MRI) uses the property of nuclear magnetic resonance (NMR) to magnetise nuclei inside the body and create clear and accurate images of internal structures. MRI has many advantages over other imaging techniques such as computed tomography (CT) scans and X-rays, including greater contrast between soft tissues and an ability to take images without the use of ionising radiation. Due to the strong magnetic fields used in these machines, there are many safety procedures that must be followed and the procedure is often unsuitable for people with metallic implants or possible allergies to the contrast agents used.

Superconductivity, C6 & C4

Superconductivity is the phenomena observed when certain materials are cooled below a characteristic temperature, and zero electrical resistance occurs. Superconductors also exhibit the Meissner effect, where all magnetic flux inside is cancelled. Superconductivity was discovered in 1911 when the resistance of mercury was found to drop to zero at very low temperatures. A series of discoveries caused a number of theories to be put forward to explain the phenomena, but it was not until the late 1950s that a complete atomic scale theory of superconductivity was proposed. Since then, the developments of high temperature superconductors and practical applications for them have been the focus of research. Superconductors are used in magnetic levitation, such as in maglev trains, mass spectrometers, and in magnetic imaging (MRI). An extremely powerful and large superconducting magnet has been built for use inside the Large Hadron Collider at CERN.

Development of the wave theory of light, C6, C7 & C4

In the late 17th century, Robert Hooke and Christiaan Huygens published early theories of light as a wave and around 1800 Thomas Young showed through experimentation that light passing through a double slit showed interference and thus wave properties. Young also developed principles of coherence and superposition of light. For many years, the presence of the luminiferous aether was proposed as the medium by which light is propagated, an idea that was later disproved by experiments such as the Michelson-Morley experiment. Later, in the 1860s, James Clerk Maxwell developed a theory of electromagnetism and showed that electromagnetic waves would travel through space at the speed of light, implying light was an electromagnetic wave.

Monitoring earthquakes and tsunamis, C7 & C4

Major catastrophes like the Japanese and Indian Ocean tsunamis and the Christchurch earthquakes have led to an increased need to monitor and record the plate movements that cause these phenomena. Various devices including seismographs and computer modelling are used to detect, determine the location of and predict effects of earthquakes and tsunamis. Knowledge of different types of waves and their motion through the ocean and the continents allows prediction of the possible extent of damage or the timing of a tsunami. Earthquake engineering aims to limit seismic risk through design and construction of structures that are better able to resist the effects of earthquakes. A variety of methods including damping and suspension have been developed to protect buildings.

Noise pollution and acoustic design, C7 & C4

Noise pollution comes from a variety of sources and is often amplified by walls, buildings and other built structures. Acoustical 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 does not occur. When new roads are built, consideration is given to noise barrier design, surface materials and speed control. Buildings can be designed to limit the noise that enters from outside sources like roadways and low flying aircraft. Noise mitigation is also achieved by using particular materials for insulation and designing both the interior and exterior to reflect sound in particular ways. Safety equipment such as ear protection is compulsory and extensively tested for use in industrial situations due to the possible health consequences of exposure to excessive noise.

Radioisotopes and radiometric dating, C8 & C4

Radiometric dating of materials utilises a variety of methods depending on the age of the substances to be dated. The presence of natural radioisotopes in materials such as carbon, uranium, potassium and argon and knowledge about their half-life and decay processes enables scientists to develop accurate geologic timescales and geologic history for particular regions. This information is used to inform study of events such as earthquakes and volcanic eruptions, and helps scientists to predict their behaviour based on past events. Dating of wood and carbon-based materials has also led to improvements in our understanding of more recent history through dating of preserved objects.

Harnessing nuclear power, C8 & C4

Knowledge of the process of nuclear fission has led to the ability to use nuclear power as a possible long term alternative to fossil fuel electricity generation. Nuclear power has been used very successfully to produce energy in many countries but has also caused significant harmful consequences in a number of specific instances. Analysis of health and environmental risks and weighing these against environmental and cost benefits is a scientific and political issue in Australia that has economic, cultural and ethical aspects. The management of nuclear waste is based on knowledge of the behaviour of radiation. Current proposals for waste storage in Australia attempt to address the unintended harmful consequences of the use of radioactive substances.

Nuclear fusion in stars, C8 & C4

Energy production in stars was attributed to gravity until knowledge of nuclear reactions enabled understanding of nuclear fusion. Almost all the energy used on Earth has its origin in the conversion of mass to energy that occurs when hydrogen nuclei fuse together to form helium in the core of the sun. According to the Big Bang Theory, all the elements heavier than helium have been created by fusion in stars. The study of nuclear fusion in the sun has produced insights into the formation and life cycle of stars. An unexpected consequence of early understanding of fusion in stars was its use to inform the development of thermonuclear weapons. Research is ongoing into the use of fusion as an alternative power source.

Development of the quantum model, C8 & C4

Max Planck and Einstein were the first to describe light and energy as being quantised, a finding that led to light being described as spatially quantised photons of energy. The Bohr model of the atom was built on this quantised description of light energy and Rutherford's nuclear model. The Bohr model was a quantum-based modification to Rutherford's model and was rapidly accepted due to its ability to explain the emission lines of atomic hydrogen. Prior to Bohr's model, the Rydberg formula describing the wavelengths of spectral lines of many chemical elements was known but could not be explained. A more elaborate quantum mechanical model of the atom, however, was required to explain other observations made about atoms. The quantum mechanical model of the atom uses quantum theory and describes electron orbitals that can be used to calculate the probability of finding an electron at a specific point.

Black body radiation and the greenhouse effect, C8 & C4

All objects in the universe, including the sun and Earth, emit black body radiation. The natural temperature of Earth can be predicted using the Stefan-Boltzmann black body radiation equation that assumes there is a balance between incoming and outgoing radiation. The true temperature is significantly higher due to the absorption of emitted black body radiation from the surface by molecules in the atmosphere (the greenhouse effect). Models of Earth's energy balance enable scientists to monitor changes in global temperature, assess the evidence for changes in climate due to the enhanced greenhouse effect, and evaluate the risk posed by anthropogenic climate change. Further development of models of Earth's energy dynamics and climate change enables scientists to more accurately predict the scenarios that will result in global warming, the time frames involved, and the likely impacts of these changes.

Development of the special theory of relativity, C8 & C4

Many scientists, including Albert Michelson, Hendrik Lorentz and Henri Poincaré, contributed to the development of the special theory of relativity. Lorentz's Transformation and his ideas about the aether initially explained the Doppler effect. They were improved upon by the next generation of scientists developing theories about electromagnetic mass and ideas about inertial frames of reference and relative motion. Albert Einstein's work on special relativity built upon the work of scientists such as Maxwell and Lorentz, while subsequent studies by Max Planck, Hermann Minkowski and others led to the development of relativistic theories of gravitation, mass-energy equivalence and quantum field theory. The Michelson-Morley and Fizeau experiments provided evidence for the special theory of relativity.

Ring laser gyroscopes and navigation, C8 & C4

Ring laser gyroscopes (RLG) are inertial guidance systems that do not rely on signals from an external source but from instruments on board a moving object. RLGs use small differences in the time it takes light to travel around the ring in two directions, known as the Sagnac effect. RLGs have many advantages over other systems: they are highly accurate, have no moving parts, are compact and lightweight, and do not resist changes to their orientation (ACSPH122). RLGs are commonly used in aircraft for accurate navigation and have military applications in helicopters, ships, submarines and missiles.

Nuclear reactors, C8 & C4

Special relativity leads to the idea of mass-energy equivalence, which has been applied in nuclear fission reactors. Nuclear reactors are most commonly used for power generation, propulsion and scientific research. Research reactors have resulted in advances in areas such as medicine and materials testing and fabrication through provision of nuclear isotopes for industrial and medical applications. Although nuclear reactors provide a range of benefits, there is considerable public concern over safety and security issues (ACSPH124). Data from the nuclear industry indicates that nuclear power reactors pose an acceptable risk to public safety and that much has been done to limit that risk. However, other groups argue that such a risk is not acceptable, and, even if no accidents occur, storage of the radioactive waste produced from nuclear facilities remains a safety concern.

Evidence for the Higgs boson particle, C8 & C4

The Higgs boson particle was predicted in the early 1960s by the Standard Model of particle physics. Evidence for the Higgs boson particle would confirm the existence of the Higgs field and help to explain why fundamental particles have mass. Discovery of the particle would guide other theories and discoveries in this field, including validation of the Standard Model, and insights into cosmic inflation and the cosmological constant problem. Production of the Higgs boson requires an extremely powerful particle accelerator. The Large Hadron Collider at CERN was built to test particle physics theories, and specifically to try to produce and detect the Higgs boson particle. Since the commencement of its operation, previously unobserved particles have been produced and most recently a new particle has been observed that is consistent with the theorised Higgs boson particle.

Particle Accelerators, C8 & C4

Particle accelerators propel charged particles to high speeds using a combination of electric and magnetic fields. High-energy particle accelerators are used in particle physics research to create and observe particles. These machines have gradually increased in size, complexity and in their ability to accelerate particles to higher speeds, thus increasing scientists' ability to observe new particles. More practical uses of particle accelerators include their use in production of radioisotopes for medical treatments and as synchrotron light sources. The construction of the Australian Synchrotron involved collaboration between Australian and New Zealand science organisations, state and federal governments and international organisations and committees including the International Science Advisory Committee and the International Machine Advisory Committee.

The Big Bang Theory, C8 & C4

The Big Bang Theory describes the early development of the universe including the formation of subatomic particles from energy and the subsequent formation of atomic nuclei. There is a variety of evidence that supports the Big Bang Theory including Cosmic Background Radiation, the abundance of light elements and the red shift of light from galaxies that obey Hubble's Law. Alternate theories exist including the Steady State theory, but the Big Bang Theory is the most widely accepted theory today. There is opposition to this theory in both scientific and religious communities due to its inability to explain what came before the singularity and because it cannot explain all aspects of the universe as it exists today.

Appendix 2

GLOSSARY

Analyse
Examine, scrutinise, explore, review, consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences.

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

Communicates
Conveys knowledge and/or understandings to others.

Complex
Consisting of multiple interconnected parts or factors.

Critically analyse
Examine the component parts of an issue or information, for example, identifying the premise of an argument and its plausibility, illogical reasoning or faulty conclusions.

Critically evaluate
Evaluation of an issue or information that includes considering important factors and available evidence in making critical judgement that can be justified.

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.

Demonstrate
Give a practical exhibition as an explanation.

Describe
Give an account of characteristics or features.

Evaluate
Provide a detailed examination and substantiated judgement concerning the merit, significance or value of something.

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.

Explain
Provide additional information that demonstrates understanding of reasoning and/or application.

Familiar
Previously encountered in prior learning activities.

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).

Generalisation
A principle, theory etc. with general application.

Identify
Establish or indicate who or what someone or something is.

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, fieldwork, laboratory experimentation and manipulation of simulations.

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

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.

Primary data
Data collected directly by a person or group.

Primary source
Report of data created by the person or persons directly involved in observations of one or more events, experiments, investigations or projects.

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.

Reasoned
Reasoned argument/conclusion: one that is sound, well-grounded, considered and thought out.

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.

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

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.

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.

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 that imitates a real or idealised situation.

Solve
Work out a correct solution to a problem.

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.

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.

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.

Unfamiliar
Not previously encountered in prior learning activities.

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.

Supporting documents including external assessment material

- PHY415115 Exam Paper 2016.pdf (2017-07-21 01:05pm AEST)
- PHY415115 Assessment Report 2016.pdf (2017-07-25 03:56pm AEST)
- Use Of Calculator Policy 2017.pdf (2017-07-25 04:00pm AEST)
- PHY415115 Exam Paper 2017.pdf (2017-11-23 04:52pm AEDT)
- PHY415115 Assessment Report 2017.pdf (2018-03-02 09:50am AEDT)
- UPDATED Solutions - PHY415115 Physics exam 2017.pdf (2018-11-21 12:07pm AEDT)
- PHY415115 Physics TASC Exam Paper 2018.pdf (2018-12-09 09:59am AEDT)
- PHY415115 - Assessment Panel Report 2018.pdf (2019-02-19 02:54pm AEDT)
- PHY415115 - Solutions 2018 - Combined all parts.pdf (2019-02-27 03:09pm AEDT)
- PHY415115 Physics TASC Exam Paper 2019.pdf (2019-11-21 10:41am AEDT)
- PHY415115 Assessment Report 2019.pdf (2020-02-17 12:29pm AEDT)
- PHY415115 Physics TASC Exam Paper 2020.pdf (2020-12-10 02:53pm AEDT)
- PHY415115 Assessment Report 2020.pdf (2021-01-18 03:23pm AEDT)
- PHY415115 External Assessment Specifications.pdf (2021-02-25 09:18am AEDT)
- PHY415115 Information sheet .pdf (2021-03-22 01:05pm AEDT)
- PHY415115 Physics TASC Exam Paper 2021.pdf (2021-11-18 05:27pm AEDT)