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## Summary of syllabus amendments January 2014

The following table outlines the amendments made to Physics Senior Syllabus 2007. These amendments are a consequence of the directions of the Minister as outlined in the *Queensland Government Response to the Education and Innovation Committee Report No. 25: The assessment methods used in senior mathematics, chemistry and physics in Queensland schools.*

<table>
<thead>
<tr>
<th>Syllabus section</th>
<th>2014 update</th>
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<tbody>
<tr>
<td><strong>Section 2: Rationale</strong></td>
<td>Studying Physics provides students with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. It 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 subject 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.</td>
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<tr>
<td><strong>Section 7.4: Assessment techniques</strong></td>
<td><strong>Modes of assessment</strong>&lt;br&gt;Assessment techniques may be presented in a variety of modes, e.g. written, spoken/signed and multimodal. An assessment response is communicated to an audience for a particular purpose, which may influence the type of text, language features and other textual features used in the response. Purposes may include analysing; persuading; arguing; informing; presenting investigative, experimental or field-based findings; creating; performing; showcasing; reviewing a text or situation; completing calculations or solving problems. Referencing conventions must be followed regardless of the mode of assessment. <strong>Written responses</strong>&lt;br&gt;Written responses require students to communicate a written assessment response to an audience for a particular purpose. <strong>Spoken responses</strong>&lt;br&gt;Spoken responses require students to present a spoken assessment response to a live or virtual audience (i.e. through the use of technology) for a particular purpose. <strong>Multimodal responses</strong>&lt;br&gt;A multimodal response uses a combination of at least two modes to communicate an assessment response to a live or virtual audience for a particular purpose. Modes include:&lt;br&gt;• written&lt;br&gt;• spoken/signed&lt;br&gt;• nonverbal, e.g. physical, visual, auditory. Each of the selected modes contributes significantly to the multimodal response. Different technologies may be used in the creation or presentation of the response. Replication of a written document into an electronic or digital format does not constitute a multimodal response. When making judgments about multimodal responses, teachers apply the standards to the entire response — that is, to all modes used to communicate the response.</td>
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Supporting evidence

Supporting evidence is required to substantiate decisions made on spoken and multimodal responses for monitoring, verification and exit purposes. Evidence to support spoken or multimodal responses may include:

- research/data analyses
- notes or annotations
- summary of findings
- journal entries or log book
- seminar brief or conference paper
- a recording of the response (as appropriate).

Section 7.4.1: Category 1: Extended experimental investigations (EEI)

An extended experimental investigation may run for a minimum of four weeks, or across the unit of work, and includes laboratory or field-based learning.

The outcome of an extended experimental investigation is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria.

In each year of the course, no more than two EEIs may be undertaken.

The assessment conditions in the table below refer to discussion, conclusions, evaluation and recommendations.

[Conditions provided for each mode. See p. 22.]

Teachers can provide the research question or it may be initiated by the student. …and familiarising students with assessment expectations.

Section 7.4.3: Category 3: Extended response tasks (ERT)

The outcome of extended response tasks is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria.

[Conditions provided for each mode. See p. 25.]

Section 7.4.8 Authentication of student work

It is essential that judgments of student achievement be made on genuine student assessment responses. Teachers must take reasonable steps to ensure that each student’s work is their own, particularly where students have access to electronic resources or when they are preparing responses to collaborative tasks.

The QSA’s A–Z of Senior Moderation contains a strategy for authenticating student work (<www.qsa.qld.edu.au/10773.html>). This provides information about various methods teachers can use to monitor that students’ work is their own. Particular methods outlined include:

- teachers seeing plans and drafts of student work
- student production and maintenance of evidence for the development of responses
- student acknowledgment of resources used.

Teachers must ensure students use consistent, accepted conventions of in-text citation and referencing, where appropriate.

Section 7.8: Requirements for verification folio

- assessment instruments, demonstrating a range of techniques, that includes:
  - at least one, but no more than two extended experimental investigation
  - at least one supervised assessment
1. A view of science and science education

Science is a social and cultural activity through which explanations of natural phenomena are generated. It incorporates ways of thinking that are both creative and critical. Scientists have a deep conviction that the universe is understandable.

Explanations of natural phenomena may be viewed as mental constructions based on personal experiences and result from a range of activities including observation, experimentation, imagination and discussion. The evolution of scientific understandings has occurred in definable episodes, with chance sometimes playing an important role.

Accepted scientific concepts, theories and models may be viewed as shared understandings that the scientific community perceive as viable in light of current available evidence. Scientific knowledge is subject to questioning by the scientific community and may be reconfirmed, challenged, modified or replaced. New understandings are continually arising and this is an essential characteristic of science.

Science education should help students envisage alternative futures and make informed decisions about science and its applications. It should help them make decisions that will influence the wellbeing of themselves, other living things and their environment.

Science education should:
- build on students’ understandings of science and challenge these where necessary
- provide excitement, motivation and empowerment
- encourage a thirst for and a willingness to incorporate new and existing knowledge
- encourage critical reflection
- develop creative thinking skills
- provide a lens through which to view the world.
2. Rationale

The development of understanding of physical phenomena occurs in physics by means of methods of inquiry that have been refined over the past three hundred years. A culture of physics has emerged that values methods of precise measurement, reproducible experimentation and powerful mathematical relationships. Today, these methods continue to contribute to the development and provision of new information, ideas and theories to explain observations and experiences.

As a result, physics has become one of the most deeply conceptualised of the sciences, founded on physical concepts that have been developed into predictive theories expressed in mathematics.

The knowledge and concepts of physics are a set of explanations shared by the physics community that viably accounts for an extensive range of phenomena. At times these explanations conflict with everyday understandings, but they are distinguished by their utility in explaining observed physical phenomena and, most importantly, they predict new phenomena as yet unobserved. The explanations remain tentative and open to modification in the light of new evidence.

Thus, two clear reasons emerge for the study of Physics at senior level. First, it is the study of the universe and how it works, and second, its applications have produced and continue to produce benefits to our society. Participating in a course of study derived from the Physics syllabus will immerse students in both the practical and the contextual aspects of the discipline. It will facilitate the growth of student awareness of the construction of physical understandings from personal, social and global perspectives. A course developed from this syllabus embraces the intrinsic “hands on” nature of the subject and provides students with opportunities to develop the key competencies* in contexts that arise naturally from the subject matter.

The study of Physics gives students a means of enhancing their understanding of the world around them, a way of achieving useful knowledge and skills, and a stepping stone for further study. An understanding of Physics adds to and refines the development of students’ scientific literacy. Participating in a course of study derived from the Physics syllabus, working scientifically and enacting scientific inquiries, investigations and experiments will immerse students in both the practical and the conceptual aspects of the discipline.

This syllabus presents a framework to guide teachers as they construct units of work that develop students’ understanding and appreciation of physics in the real world. It will encourage students to think creatively and rationally about physics. Students will be challenged to understand and act responsibly on physics-related issues and to communicate effectively in a range of modes.

Studying Physics provides students with a suite of skills and understandings that are valuable to a wide range of further study pathways and careers. It 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 subject 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.

* KC1: collecting, analysing and organising information; KC2: communicating ideas and information; KC3: planning and organising activities; KC4: working with others and in teams; KC5: using mathematical ideas and techniques; KC6: solving problems; KC7: using technology.
3. Global aims

The global aims are statements of the long-term achievements, attitudes and values that are developed by students through studying Physics but that are not directly assessed by the school. The overarching aim of studying any course in science, thereby including Physics, should be to develop in students an ongoing ability to extend their scientific literacy.

Accordingly, through a course of study in Physics, students should develop:

- the capacity to work scientifically in physics contexts
- the skills to engage in informed scientific inquiry and safe investigation techniques beyond the school context to solve physics problems
- an ability to use technology productively in physics
- an ability to understand and appreciate the physics encountered in everyday life
- a capacity to work as part of a team engaging in cooperative activity
- an ability to communicate understandings of physics
- an appreciation of the issues and impacts of physics.
4. General objectives

The general objectives are a summary of what students should be able to achieve as a result of completing the course. They stem from a view of science and science education, the rationale and the global aims.

The objectives of the syllabus are categorised in the following dimensions:

- Knowledge and conceptual understanding
- Investigative processes
- Evaluating and concluding
- Attitudes and values.

The general objectives represent aspects of Physics that help students develop their scientific literacy. As students engage with the objectives in conjunction with each other, they also hone their abilities in working scientifically. Progress in all dimensions should occur concurrently. Students become critically aware of the complexity and interconnectedness of physics and human influences on the planet. They develop an understanding of the historical influences of physics, current developments and implications for physics in the future.

Progress in all dimensions should occur concurrently. Progress in any one dimension at times may be dependent on the qualities and skills developed in another. The complexity and sophistication of learning experiences in all dimensions must increase over the duration of the course.

The general objectives within the dimension Attitudes and values relate to the affective elements that the course aims to encourage. They are not directly assessed for the awarding of exit levels of achievement.

Knowledge and conceptual understanding

Students should acquire knowledge and construct understanding of facts, theories, concepts and principles of physics. To work scientifically, students need to have an understanding of underlying scientific knowledges, including the associated mathematical skills. They need to engage with the processes and phenomena observed in Physics through characteristics of data analysed. Students need to make informed judgments based on sound reasoning in order to direct them in their scientific endeavours and to engage with problem solving.

By the end of this course, students should be able to:

- **recall and interpret concepts, theories and principles of Physics** — this includes the abilities to remember, reproduce and interpret subject matter such as facts, definitions, formulas, terminology, concepts, theories, principles, laws, procedures, sequences, events, diagrams, symbols, figures, systems and patterns

- **describe and explain processes and phenomena of Physics** — this includes the abilities to compare and classify the concepts, theories and principles being explored, based on primary and secondary data

- **link and apply algorithms, concepts, theories and schema of Physics** — this includes the abilities to adapt, translate and reconstruct understandings in order to find solutions.
Investigative processes

Students need to recognise the methodologies available to them to investigate scientifically. They need to be able to judge the worth of quantitative and qualitative data and interpret and apply the outcomes of such data. Students require the skills to manipulate and review data and scientific techniques so that they may improve their scientific knowledge. They need to synthesise the research that they have generated and be able to discuss the outcomes in relation to their initial purpose.

By the end of this course, students should be able to:

• **conduct and appraise Physics research tasks** — this includes the abilities to formulate questions, hypothesise, plan, manage, evaluate, refine and justify decisions made during investigations, as well as the critical reflection required to fulfil research goals

• **operate scientific equipment and technology safely** — this includes the abilities to safely select, adapt and apply technological, laboratory and fieldwork equipment, and consider its limitations; it also incorporates the ability to do this individually and in groups

• **use primary and secondary data** — this includes the abilities to analyse and extrapolate from data, and to identify relationships, patterns and anomalies in primary and secondary data.

Evaluating and concluding

Students who are working scientifically need to be able to make decisions about the knowledge they have gained and generated. They need to distinguish between a plausible conclusion and one based on pure supposition. Students need to be able to synthesise their thoughts and the thinking of others into a coherent whole, from which they can make judgments and propose future possibilities. They need to reach conclusions and explain the world in which they live, using science. They need to be able to adhere to communication and scientific conventions in communicating their decisions to selected audiences.

By the end of this course, students should be able to:

• **determine, analyse and evaluate the interrelationships involved in applications of Physics** — this includes the abilities to identify the physics involved, to determine the simple and complex relationships that exist between concepts, principles, theories and schema and then to critically examine the associated implications

• **predict outcomes and justify conclusions and recommendations** — this includes the abilities to explore scenarios and consider possible outcomes, and then to provide justifications of conclusions and recommendations

• **communicate information in a variety of ways** — this includes the abilities to select, use and present data and ideas to convey meaning, an argument or a case to selected audiences in a range of formats.

Attitudes and values

Students should incorporate physics into their view of the world, and realise the impacts of physics on it. They should envision possible, probable and preferred futures and take responsibility for their own actions and decisions to promote ethical practices.

By the end of the course, students should be able to:

• retain openness to new ideas, and develop intellectual honesty, integrity, collegiality, cooperation and respect for evidence and ethical conduct

• develop a level of sensitivity to the implications of physics for individuals and society and understand that physics is a human endeavour with consequent limitations

• develop a thirst for knowledge, become flexible and persistent learners and appreciate the need for lifelong learning.
5. Course organisation

5.1 Organising principles

The syllabus provides a framework on which courses of study in Physics are constructed. The organising principles are:

- range of complexity
- accommodation of individual and group differences
- sequencing and development of key concepts and key ideas.

5.1.1 A range of complexity

Increasing complexity in both depth and scope of subject matter should be developed over the course of study in Physics. The increasing complexity will be reflected in the teaching and learning experiences and the assessment program developed by the school.

*Depth* refers to the development of knowledge and understandings from simple through to complex within and across the key concepts.

*Scope* refers to the development of the key concepts across at least two units of work. Where possible, the development of key concepts should also range from specific to general. This may occur within a unit of work or across units of work.

5.1.2 Accommodation of individual and group differences

Each student will bring to Physics particular attitudes, knowledge and understandings based on their own experiences and culture. In developing courses, schools should take into consideration the needs of individuals and class groups; the school context; the availability and selection of resources, both physical and human; teachers’ special areas of expertise and interest; learning experiences and teaching styles; assessment instrument design and educational equity.

5.1.3 Sequencing and development of key concepts and key ideas

To ensure effective sequencing of the key concepts, they should be mapped across the two-year course of study. The sequencing of the key concepts in the course of study should develop in complexity, scope and depth over the two years. Key concepts need to be explored in at least two different units of work, preferably one in Year 11 and one in Year 12. Some key concepts may be included on more occasions than this, but when a key concept is not a significant aspect of a unit of work it should not be the focus for assessment.

The associated key ideas should also be considered when structuring the units of work.
5.2 Course structure

5.2.1 Organisers
“Forces”, “Energy” and “Motion” are the organisers for grouping the key concepts.

5.2.2 Key concepts
The key concepts are accepted broad scientific (physical) understandings.

5.2.3 Key ideas
The key ideas are statements that illustrate the depth and scope of the key concepts.

The possible depth of subject matter is indicated in Appendix 3, where suggestions are provided under the organisers.

The following pages show the relationships between the organisers, key concepts and key ideas.
Organiser 1: Forces

Understandings of ideas of forces are powerful tools that can be used to describe and predict the phenomena of motion. The revolutionary insights of Sir Isaac Newton into the connection between movement and force laid the foundations for our current understanding of how matter interacts. All interactions involve one or more of the four fundamental forces — gravity, electromagnetism, and strong and weak nuclear forces. These forces act upon matter and determine the way in which it behaves.

In our everyday context, most interactions and many common phenomena can be explained by considering gravity and electromagnetism, but by considering the manifestations of the four fundamental forces students can move beyond everyday phenomena related to motion, structures and materials to include topics such as satellite motion, thermal properties of matter, atomic structure and radioactive decay.

**Key concept**

**F1**
The nature of a force

**Key ideas**

F1.1 — A force is an interaction between two objects.
F1.2 — The four fundamental forces observed in nature are: gravitational force, electromagnetic forces, strong and weak nuclear forces.
F1.3 — Forces are vector quantities whose interactions can be analysed using vector algebra and/or graphical methods.
F1.4 — Forces occur in pairs which are equal in magnitude and opposite in direction.

**F2**
Forces that act on objects influence their state of equilibrium.

**Key ideas**

F2.1 — Systems of forces may be balanced or unbalanced.
F2.2 — Vector methods can be used to determine the resultant force for given situations.
F2.3 — A net external force is required to change the velocity of an object and its momentum.
F2.4 — The acceleration of an object is directly proportional to the net force causing it and inversely proportional to the mass of the object.

**F3**
Forces are able to influence the motion and shape of objects.

**Key ideas**

F3.1 — The everyday motion of objects can be analysed through the application of Newton's Laws.
F3.2 — Forces (e.g. gravity) between objects influence their relative motions.
F3.3 — The motion of particles can be described and analysed using principles of dynamics.
F3.4 — At the macroscopic level, forces applied to matter may cause irreversible structural changes.

**F4**
The forces that act on objects influence their internal energy.

**Key ideas**

F4.1 — External forces can change the internal energy of an object.
F4.2 — Kinetic theory suggests that matter is made up of atoms that are in continuous random motion. Concepts related to pressure, volume and temperature may be linked to this motion.
F4.3 — Strong nuclear force is a force of attraction acting between nucleons.
F4.4 — Weak nuclear forces become apparent in certain types of radioactive decay.
Organiser 2: Energy

The world is made up of objects that interact with each other and in doing so energy is usually transferred. This theme develops the concepts of energy and momentum that culminate in the laws of conservation of these two quantities. These two conservation laws, particularly when used in combination, facilitate powerful and elegant solutions to a wide range of problems. This organiser also has social significance in that it reinforces the student's appreciation that production of a particular form of energy is at the expense of other forms of energy.

**Key concept**

**E1**

Energy may take different forms originating from forces between, or relative motion of, particles or objects.

**Key ideas**

**E1.1** — Energy is the capacity to do work.

**E1.2** — Energy manifests itself in various forms, including: potential energy associated with gravitational, electric and magnetic fields; kinetic energy related to the motion of matter; and nuclear energy, which links to the concept of mass–energy equivalence.

**E1.3** — Energy can be described and measured in terms of an object's position and motion within gravitational, electric and magnetic fields.

**E1.4** — Colour, pitch and temperature are measurable quantities that can be used to distinguish between energy levels for observable physical phenomena.

**E1.5** — Momentum is linked to the motion of matter and, by association, related to its kinetic energy.

**E1.6** — Physicists use models to explain and reconcile observed energy phenomena.

**E2**

Energy is conserved.

**Key ideas**

**E2.1** — The total amount of energy within a closed system remains constant.

**E2.2** — Exchanges or transformations of energy during an interaction do not change the total energy of a closed system.

**E2.3** — When energy is converted from one form to another there is a reduction in the amount of useful energy available to do work in the system.

**E2.4** — The transference of energy within or between systems can be explained using the laws of thermodynamics.

**E2.5** — The laws of conservation of energy and momentum can be used to examine the interactions between objects in simple and complex situations.

**E2.6** — Concepts associated with mass–energy equivalence can be demonstrated through nuclear interactions and transformations.

**E3**

Energy transfer processes provide us with different ways of using and dealing with energy and radiation and these have different social consequences and applications.

**Key ideas**

**E3.1** — Energy transformations and associated applications have social and environmental consequences.

**E3.2** — Rational discussion of energy transformations in present-day society requires an understanding of the underlying physics concepts and ideas.

**E3.3** — Knowledge of underlying physics concepts and ideas can be used to provide a reasoned argument about the viability of alternative energy transformation processes.

**E3.4** — Energy has applications in medical, industrial and commercial fields, e.g. radiation, electronics and alternative technologies.

**E3.5** — Energy in solid-state systems (e.g. semiconductors).
Organiser 3: Motion

Motion is common to most of our everyday experiences. This is formalised mathematically in kinematics, which is the study of how objects move. Students should be reminded that the types of motion are highly idealised and may seem to have little to do with the real world as we observe it. However, it is essential that students first investigate these simple and idealised motions and their descriptions to obtain a firm understanding of the basis of kinematics. Once this goal has been achieved, they are in a position to apply their knowledge to the more complex real-world situations, and study phenomena in the quantum realm, which is outside our everyday experiences.

**Key concept**

- **M1** Motion can be described in different ways.

**Key ideas**

- M1.1 — Changes in motion result from unbalanced forces.
- M1.2 — Scalar, vector and graphical methods can be used, as appropriate, to describe motion.
- M1.3 — The collection of data used to describe motion can be accomplished using a range of technologies.
- M1.4 — Primary and secondary data can be analysed, manipulated and presented in a variety of formats to provide alternative descriptions of motion.

- **M2** Motion can be analysed in different ways.

**Key ideas**

- M2.1 — The relationship between force, mass and acceleration can be analysed qualitatively and quantitatively using algorithms and graphical techniques.
- M2.2 — The directional relationship between acceleration and net force can be analysed using vector diagrams.
- M2.3 — The laws of conservation of energy and momentum can be used to analyse and describe motion of objects in simple and complex situations.
- M2.4 — An understanding of the nature of fields (gravitational, magnetic and electric) and their interactions with matter can be used to analyse and predict the motion of an object.
- M2.5 — Relative rates of change are useful measures when analysing the motion of an object.

- **M3** Motion can be described using various models and modern theories.

**Key ideas**

- M3.1 — The propagation of light demonstrates the concepts of wave–particle duality, quantisation of energy and probability waves.
- M3.2 — Classical and relativistic theories are used to describe motion in different circumstances.
5.3 **Time allocation**

The minimum number of hours of timetabled school time, including assessment, for a course of study developed from this syllabus is 55 hours per semester. A course of study will usually be completed over two years (220 hours).

5.4 **Planning a course of study**

In developing a course of study, teachers should refer to the global aims and the general objectives and should incorporate and apply the organising principles.

A course of study in Physics is to be constructed by developing between six and 12 units of work. Through the units of work all the key concepts and key ideas will be progressively developed.

A substantial unit of work is at least 20 hours of timetabled school time. At least two substantial units, one in Year 11 and one in Year 12, must identify and demonstrate a context-based approach (see Appendix 2). Other units of work should be between 10 hours and a semester in length. They may draw upon a variety of approaches, including context-based, expository, demonstrative, problem solving, or inquiry.

A planned, cohesive sequence of units of work provides the means for students to explore systematically the key concepts of Physics. The sequencing of learning and associated units of work ensures that the course of study develops in complexity, scope and depth over the two years. A unit of work needs to allow students the opportunity to develop a depth of understanding through the exploration of the key concepts and associated key ideas. When key concepts and key ideas are substantially revisited, the depth and sophistication of understanding and/or the complexity should be increased.

5.4.1 **Course organisation summary**

- Six to 12 units of work should be completed over the two-year course of study.
- At least one substantial unit of work in Year 11 and one in Year 12 should be developed using a contextualised approach (at least 20 hours per unit of work).
- Each key concept is to be incorporated in at least two different units of work.
- The physical and human resources of the school should be considered.

5.5 **Planning and developing a unit of work**

A unit of work provides a detailed structure to facilitate the delivery of the key concepts and related key ideas which are being developed. It provides opportunities for students to apply and reinforce scientific investigation, scientific techniques and their knowledge and conceptual understandings through the selected learning experiences. It relates the learning experiences selected to earlier and later learning experiences, builds on students’ prior learning and conceptualisation and provides the basis for further development.

The structure and delivery of the unit of work reflects the integrated nature of the learning experiences with the assessment techniques. The assessment technique should fit structurally with the organisation of the unit of work.
In planning and developing a unit of work, teachers should include the following in their consideration of the unit:

- general objectives being developed
- key concepts and key ideas to be developed
- assessment technique (and instrument) for the unit
- time available
- selection of learning experiences best suited to the development of:
  - identified key concepts and key ideas
  - skills, abilities and knowledge the students require to effectively participate in the unit
  - assessment requirements of the unit
- learning environment and approach, e.g. individual, small-group and whole-class activities, workshops, tutorial sessions, guest speakers, real-life situations, access to available resource centres
- specific resources to be used.

5.6 Composite classes

In some schools, it may be necessary to combine students into a composite Year 11 and 12 class. This syllabus provides teachers with an opportunity to develop a course of study that caters for a variety of circumstances such as combined Year 11 and 12 classes, combined campuses, or modes of delivery involving periods of student-directed study.

The multilevel nature of such classes can prove advantageous to the teaching and learning process because:

- it provides opportunities for peer teaching
- it allows teachers to maximise the flexibility of the syllabus
- it provides opportunities for a mix of multilevel group work, and for independent work on appropriate occasions
- learning experiences and assessment can be structured to allow both Year 11 and Year 12 students to consider the key concepts and ideas at the level appropriate to the needs of students within each year level.

The following guidelines may prove helpful in designing a course of study for a composite class:

- The course of study could be written in a Year A/Year B format, if the school intends to teach the same unit of work to both cohorts.
- Place a unit of work at the beginning of each year that will allow new Year 11 students easy entry into the course.
- Learning experiences and assessment instruments need to cater for both year levels throughout the course. Even though techniques may be similar for both year levels, we recommend that a more extended and/or complex instrument be used with Year 12 students.
5.7 Work program requirements

A work program is the school’s plan of how the course will be delivered and assessed, based on the school’s interpretation of the syllabus. It allows for the special characteristics of the individual school and its students.

The school’s work program must meet all syllabus requirements and must demonstrate that there will be sufficient scope and depth of student learning to meet the general objectives and the exit standards.

The requirements for work program approval can be accessed on our website, <www.qsa.qld.edu.au>. This information should be consulted before writing a work program. Updates of the requirements for work program approval may occur periodically.
6. Learning experiences

Learning experiences are action-oriented learning opportunities intended to contribute to the attainment of the general objectives and are devised in consideration of the purposeful context for learning.

6.1 Teaching Physics

Effective learning in science requires a variety of teaching approaches, from direct instruction to student-centred learning, designed to make a particular aspect of science accessible to each particular group of learners (Shulman 1986; Goodrum, Hackling & Rennie 2001). The best outcomes are achieved when learners feel supported in their learning, where their views are listened to and respected and where they are encouraged and feel confident to take risks within the learning process.

Students will be required to build upon or challenge their understandings when they study Physics. Providing a context in which they can do this better facilitates learning.

6.2 Guidelines for learning experiences

Learning experiences should draw on a range of pedagogical approaches, for example, guided discovery, inquiry, cooperative learning, individualised instruction and direct instruction.

Learning experiences should be presented in a supportive environment where:

- students are encouraged to learn and their opinions and views are respected and listened to
- academic risk-taking is supported through scaffolding of thinking skills
- open communication is encouraged
- students are encouraged to learn by defining their own directions and setting goals for themselves
- students are encouraged to learn through intrinsic and extrinsic motivation.

Learning experiences should encompass elements across all the objectives over the two years, extending understandings through an increasing depth of study.

Learning experiences should progress developmentally from simple to more complex as the course of study progresses. Learning experiences should be constructed to facilitate or be in response to the:

- quantity and complexity of information that students must use
- skills required for information-gathering and sorting
- technological and safety skills required
- cognition required, especially the complexity or depth of the analysis, application, synthesis and evaluation of the information
- communication skills required.

The cognitive skills that support the general objectives of this syllabus should be specifically taught and embedded in the learning experiences throughout the course so students may demonstrate what they know and can do.
Where possible, learning experiences should be based in real-world contexts to which students can relate. Learning experiences should extend beyond the classroom and, where possible, beyond the school. Learning experiences should encourage active learning.

Learning experiences and assessment are not mutually exclusive. The process of assessment is a learning experience and should be treated as such. Assessment can be the culmination of a series of learning experiences. It could be a large and extended single learning experience worked on over time or a mechanism that generates independent, out-of-classroom, personalised and unique learning.

Assessment instruments should be scaffolded and supported by learning experiences that provide direction and the specific knowledge and abilities to fulfil instrument requirements. Learning experiences should encompass the requirements and modelling of assessment techniques that will be required in future summative assessment opportunities.

In selecting learning experiences, teachers have many opportunities to deal with the key employment competencies, some of which are essential to the study of Physics, especially:

- collecting, analysing and organising information
- communicating ideas and information
- planning and organising activities
- working with others and in teams
- solving problems.

Ideas for generic learning experiences that may be useful include:

- researching from primary and secondary sources
- accessing and using computers, including internet research
- undertaking national science initiatives
- developing decision-making skills
- interpreting data from wide-ranging sources including media
- analysing current strategies or policies of the issue being investigated
- analysing strategies and evaluating effectiveness or improvements
- applying the principles of research ethics
- formulating hypotheses and testing them through fieldwork, experiments, interviews and research
- synthesising ideas in a variety of forms, e.g. oral, written, practical
- practising assessment instrument requirements, e.g. genre writing
- predicting impact of recommendations
- proposing and/or implementing strategies for improvement
- solving problems
- engaging in active research projects, independently and with groups and teams
- participating in forum discussions and debates
- sharing information mutually beneficial to the group
- advocating for change.
6.3 Workplace health and safety

In Physics, a significant amount of the course should be devoted to practical experiences in the laboratory. These practical experiences expose students to a variety of hazards from corrosive and poisonous substances, and to injury from glass and hot objects. Besides a teacher’s duty of care that derives from the Education (General Provisions) Act 1989, there are other legislative and regulatory requirements, for example the Workplace Health and Safety Act 1995, that will influence the nature and extent of practical work.

Practical laboratory experiences should be selected and conducted with student safety in mind. A significant component of the course should allow students to gain knowledge about the dangers of laboratory procedures used. All practical work must be organised with students’ safety in mind. Some common hazards in the Physics laboratory include:

- electric shock from power supplies, motors and other mains voltage equipment
- eye damage from lasers or bright lights
- crush injury from heavy weights
- ionizing radiation from radioactive sources or cathode ray tubes
- burns from hotplates and flames
- cuts from broken glassware
- hazardous chemicals such as radioactive salts, mercury and alcohol.

It is important that equipment in use is safe and, in the case of 240 V AC equipment, that it is tested and tagged and is operated on circuits protected by a residual current device (RCD).

The science safety requirements relating to teachers of science are explained in Aspects of Science Management: A reference manual for schools (Education Queensland, 1999) and in Workplace Health and Safety Guidelines — Curriculum — Core Module (Education Queensland, 1999), on the following website:


It is the school’s responsibility to ensure that its practices meet current guidelines.
7. Assessment

The purposes of assessment are to provide feedback to students and parents about learning that has occurred and to provide information on which to base judgments about how well students meet the general objectives of the course. In designing an assessment program, it is important that the assessment instruments, conditions and criteria are compatible with the general objectives and the learning experiences. Assessment, then, is an integral aspect of a course of study. It can be formative or summative. The distinction between formative and summative assessment lies in the purpose for which that assessment is used.

Formative assessment is used to provide feedback to students, parents and teachers about achievement over the course of study. This enables students and teachers to identify the students’ strengths and weaknesses so students may improve their achievement and better manage their own learning. The formative techniques used should be similar to summative assessment techniques, which students will meet later in the course. This provides students with experience in responding to particular types of instruments, under appropriate conditions. Feedback on any early assessment tasks may be used in a formative sense to assist students’ preparation for later assessment tasks.

Summative assessment, while also providing feedback to students, parents and teachers, provides cumulative information on which levels of achievement are determined at exit from the course of study. It follows, therefore, that it is necessary to plan the range of assessment techniques and instruments to be used, when they will be administered, and how they contribute to the determination of exit levels of achievement. Students’ achievements are matched to the standards of exit criteria, which are derived from the general objectives of the course. Thus, summative assessment provides the information for certification at the end of the course.

7.1 Underlying principles of exit assessment

The policy on exit assessment requires consideration to be given to the following principles when devising an assessment program for the two-year course of study:

- Information is gathered through a process of continuous assessment.
- Balance of assessments is a balance over the course of study and not necessarily a balance over a semester or between semesters.
- Exit achievement levels are devised from student achievement in all areas identified in the syllabus as being mandatory.
- Assessment of a student’s achievement is in the significant aspects of the course of study identified in the syllabus and the school’s work program.
- Selective updating of a student’s profile of achievement is undertaken over the course of study.
- Exit assessment is devised to provide the fullest and latest information on a student’s achievement in the course of study.

These principles are to be considered together and not individually in the development of an assessment program. Exit assessment must satisfy concurrently the six principles associated with it.
7.1.1 Continuous assessment

The major principle is “continuous assessment”. The process of continuous assessment is the basis for the other five principles of balance, mandatory aspects of the syllabus, significant aspects of the course, selective updating, and fullest and latest information to exist and operate.

Continuous assessment is the means by which assessment instruments are administered at suitable intervals and by which information on student achievement is collected. It involves a continuous gathering of information and the making of judgments in terms of the stated criteria and standards throughout a two-year course of study.

Decisions about levels of achievement are based on information gathered, through the process of continuous assessment, at points in the course of study appropriate to the organisation of the learning experiences. Levels of achievement must not be based on students’ responses to a single assessment instrument at the end of a course or instruments set at arbitrary intervals that are unrelated to the developmental course of study.

7.1.2 Balance

Balance of assessments is a balance over the course of study and not necessarily a balance within a semester or between semesters.

Within the two-year course for Physics it is necessary to establish a suitable balance in the general objectives, assessment techniques, conditions, and across the criteria. The exit criteria are to have equal emphasis across the range of summative assessment. The exit assessment program must ensure an appropriate balance over the course of study as a whole.

7.1.3 Mandatory aspects of the syllabus

Judgment of student achievement at exit from a two-year course of study must be derived from information gathered about student achievement in those aspects stated in the syllabus as being mandatory, namely

- the general objectives of Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding
- the key concepts.

The exit criteria and standards stated in Sections 7.6 and 7.9 must be used to make the judgment of student achievement at exit from a two-year course of study.

7.1.4 Significant aspects of the course of study

Significant aspects refer to those areas in the school’s course of study selected from the choices permitted by the syllabus. Significant aspects can complement mandatory aspects or be in addition to them. They will be determined by the context of the school and the needs of students at that school, and should provide a choice of learning experiences appropriate to the location of the school, the local environment and the resources available.

The significant aspects must be consistent with the general objectives of the syllabus and complement the developmental nature of learning in the course over two years.

7.1.5 Selective updating

In conjunction with the principle of fullest and latest information, information on student achievement should be selectively updated throughout the course.

Selective updating is related to the developmental nature of the course of study and operates within the context of continuous assessment. As subject matter is treated at increasing levels of
complexity, assessment information gathered at earlier stages of the course may no longer be representative of student achievement. The information therefore should be selectively and continually updated (not averaged) to accurately reflect student achievement.

The following conceptions of the principle of selective updating apply:

- A systemic whole subject-group approach in which considerations about the whole group of students are made according to the developmental nature of the course and, in turn, the assessment program. In this conception, developmental aspects of the course are revisited so that later summative assessment replaces earlier formative information.

- An act of decision-making about individual students — deciding from a set of assessment results the subset which meets syllabus requirements and typically represents a student’s achievements, thus forming the basis for a decision about a level of achievement. In the application of decisions about individual students, the set of assessment results does not have to be the same for all students. However, the subset which represents the typical achievement of a student must conform to the parameters outlined in the school’s work program.

Selective updating must not involve students reworking and resubmitting previously graded assessment instruments. Opportunities may be provided for students to complete and submit additional responses. Such responses may provide information for making judgments where achievement on an earlier instrument was unrepresentative or atypical, or there was insufficient information upon which to base a judgment.

### 7.1.6 Fullest and latest information

Judgments about student achievement made at exit from a school course of study must be based on the fullest and latest information available. This information is recorded on a student profile. “Fullest” refers to information about student achievement gathered across the range of general objectives. “Latest” refers to information about student achievement gathered from the most recent period in which the general objectives are assessed. As the assessment program in Physics is developmental, fullest and latest information will most likely come from Year 12.

Information recorded on a student profile will consist of the latest assessment data on mandatory and significant aspects of the course, which includes the data gathered in the summative assessment program that is not superseded.

### 7.2 Planning an assessment program

At the end of Year 12, judgments are made about how students have achieved in relation to the standards stated in the syllabus for each of the criteria. These summative judgments are based on achievement in each of the general objectives.

When planning an assessment program, schools must consider:

- general objectives (see Section 4)
- the learning experiences (see Section 6)
- the underlying principles of assessment (see Section 7.1)
- a variety of assessment techniques over the two-year course (see Section 7.4)
- conditions under which the assessment instrument is implemented
- the exit criteria and standards (see Sections 7.6 and 7.9)
- verification folio requirements (see Section 7.8).

Students should be conversant with the assessment techniques and have some knowledge of the criteria to be used in assessment instruments.
7.3 The assessment program

The assessment program must incorporate the underlying principles stated in Section 7.1 and is to consist of a balance of assessment techniques demonstrating the general objectives of Knowledge and conceptual understanding, Investigative processes, and Evaluating and concluding. Assessment techniques must be appropriate to the learning experiences and allow students to demonstrate achievement. Instruments are to be designed so that teachers are able to make valid judgments on students’ achievements of the general objectives and so gather information on which to base judgments about students’ exit achievement. These judgments must be consistent with the standards described in the exit criteria.

A student may be required to undertake assessment instruments individually or as a member of a group. Schools are to develop procedures and strategies to demonstrate individual authorship when responses to assessment instruments are generated from group activities.

7.4 Assessment techniques

Assessment techniques in this syllabus are grouped under categories. The categories do not present an exhaustive list of techniques.

Modes of assessment

Assessment techniques may be presented in a variety of modes, e.g. written, spoken/signed and multimodal. An assessment response is communicated to an audience for a particular purpose, which may influence the type of text, language features and other textual features used in the response. Purposes may include analysing; persuading; arguing; informing; presenting investigative, experimental or field-based findings; creating; performing; showcasing; reviewing a text or situation; completing calculations or solving problems.

Referencing conventions must be followed regardless of the mode of assessment.

Written responses

Written responses require students to communicate a written assessment response to an audience for a particular purpose.

Spoken responses

Spoken responses require students to present a spoken assessment response to a live or virtual audience (i.e. through the use of technology) for a particular purpose.

Multimodal responses

A multimodal response uses a combination of at least two modes to communicate an assessment response to a live or virtual audience for a particular purpose.

Modes include:
- written
- spoken/signed
- nonverbal, e.g. physical, visual, auditory.

Each of the selected modes contributes significantly to the multimodal response.

Different technologies may be used in the creation or presentation of the response. Replication of a written document into an electronic or digital format does not constitute a multimodal response.
When making judgments about multimodal responses, teachers apply the standards to the entire response — that is to all modes used to communicate the response.

**Supporting evidence**

Supporting evidence is required to substantiate decisions made on spoken and multimodal responses for monitoring, verification and exit purposes. Evidence to support spoken or multimodal responses may include:

- research/data analyses
- notes or annotations
- summary of findings
- journal entries or log book
- seminar brief or conference paper
- a recording of the response (as appropriate).
7.4.1 Category 1: Extended experimental investigations (EEI)

What is an extended experimental investigation?

Within this category, instruments are developed to investigate a hypothesis or to answer a practical research question. The focus is on planning the extended experimental investigation, problem solving and analysis of primary data generated through experimentation by the student. Experiments may be laboratory or field based. An extended experimental investigation may run for a minimum of four weeks, or across the unit of work, and includes laboratory or field-based learning.

The outcome of an extended experimental investigation is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria.

In each year of the course, no more than two EEIs may be undertaken.

What must a student do to complete an extended experimental investigation?

- Develop a planned course of action.
- Articulate the hypothesis or research question clearly and provide a statement of purpose for the investigation.
- Provide descriptions of the experiment.
- Show evidence of modifications or student design.
- Provide evidence of primary and secondary data collection and selection.
- Execute the experiment(s).
- Analyse data.
- Discuss the outcomes of the experiment(s).
- Evaluate and justify conclusion(s).
- Present information in a mode determined by the school.

The assessment conditions in the table below refer to discussion, conclusions, evaluation and recommendations.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Year 11</th>
<th>Year 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written</td>
<td>800–1000 words</td>
<td>1000–1500 words</td>
</tr>
<tr>
<td>Spoken</td>
<td>3–4 minutes</td>
<td>4–5 minutes</td>
</tr>
<tr>
<td>Multimodal</td>
<td>3–5 minutes</td>
<td>5–7 minutes</td>
</tr>
</tbody>
</table>

What do teachers do when planning and implementing an extended experimental investigation?

The teacher suggests topics/issues and provides some stimulus to trigger student interest.

Teachers can provide the research question or it may be initiated by the student. In those instances teachers should negotiate with students to ensure safety and the possibility of success. It is more likely that students will be able to generate their own research questions the further they progress in the course of study.

Teachers must allow some class time and provide some supervision at times for students to be able to effectively undertake each component of the extended experimental investigation. Teachers may allow elements of the extended experimental investigation to be conducted in small groups or pairs. However, independent student time will probably be required to complete the extended experimental investigation.
Teachers must implement strategies to ensure authentication of student work. Some strategies are annotated notes in response to issues that emerged during research (e.g. journals, experimental logs), teacher observation sheets, research checklists, and referencing and reference list.

Teachers must consult, negotiate and provide feedback before and during the research process to help ensure occupational health and safety requirements are followed, to provide ethical guidance and to monitor student work. Feedback and assistance should be provided judiciously, gradually being reduced with the development of student experience and confidence.

Scaffolding must be provided. When an extended experimental investigation is undertaken for the first time, the scaffolding should help students complete the assessment by modelling the extended experimental investigation process and familiarising students with assessment expectations. However, the scaffolding provided should not specify the physics, or lead the student through a series of steps dictating a solution. Scaffolding should be reduced from Year 11 to Year 12 to allow the student to better demonstrate independence in the research process. When an extended experimental investigation is revisited (most likely in Year 12) the scaffolding should be reduced and could be a series of generic questions.
7.4.2 **Category 2: Supervised assessments (SA)**

<table>
<thead>
<tr>
<th>What is a supervised assessment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The supervised assessment is an instrument that is written and conducted under supervised conditions to ensure authentication of student work.</td>
</tr>
<tr>
<td>Supervised assessments may draw on one, two or three of the criteria.</td>
</tr>
<tr>
<td>A supervised assessment could be constructed using one or more of the following four item types:</td>
</tr>
<tr>
<td>1. <strong>Short items</strong></td>
</tr>
<tr>
<td>Multiple-choice questions or items requiring single word, sentence or short paragraph (up to 50 words) responses</td>
</tr>
<tr>
<td>2. <strong>Practical exercises</strong></td>
</tr>
<tr>
<td>Using graphs, tables, diagrams, data or the application of algorithms</td>
</tr>
<tr>
<td>3. <strong>Paragraph responses</strong></td>
</tr>
<tr>
<td>These are used when explanation of a greater complexity is required and should be between 50 and 150 words.</td>
</tr>
<tr>
<td>4. <strong>Responses to seen or unseen stimulus materials</strong></td>
</tr>
<tr>
<td>These may take the form of a series of short items, practical exercises and paragraph responses (see above) or more extended pieces of writing, such as essays. If an extended piece of writing is chosen, it is probably best if it is the only item on the supervised test, as this will better allow students to demonstrate the full range of standards.</td>
</tr>
<tr>
<td>Some considerations when the item is an extended piece of writing:</td>
</tr>
<tr>
<td>• extended pieces of writing should be in response to a question or statement and supplied sources</td>
</tr>
<tr>
<td>• the question or statement is not provided before the test (unseen) and should focus on asking the students to evaluate and justify</td>
</tr>
<tr>
<td>• perusal times may be required</td>
</tr>
<tr>
<td>• stimulus materials should be succinct enough to allow students to engage with them in the time provided for the supervised test or, if the stimulus materials are lengthy, they may need to be shared with students before the administration of the written task.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year 11</th>
<th>Year 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended time: 1–1½ hours.</td>
<td></td>
</tr>
<tr>
<td>For extended pieces of writing as responses to seen or unseen stimulus materials, 500–600 words is recommended.</td>
<td></td>
</tr>
<tr>
<td>Recommended time: 1½–2 hours.</td>
<td></td>
</tr>
<tr>
<td>For extended pieces of writing as responses to seen or unseen stimulus materials, 600–800 words is recommended.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What do teachers do when planning a supervised assessment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The teacher should:</td>
</tr>
<tr>
<td>• construct questions that are unambiguous</td>
</tr>
<tr>
<td>• format the paper to allow for ease of reading and responding</td>
</tr>
<tr>
<td>• consider the language needs of the students</td>
</tr>
<tr>
<td>• ensure the questions allow students to demonstrate the full range of standards.</td>
</tr>
</tbody>
</table>
7.4.3 Category 3: Extended response tasks (ERT)

What is an extended response task?

The extended response task is an assessment instrument developed in response to a Physics question, circumstance or issue. It is essentially non-experimental, but may draw on primary experimental data. Research and secondary data will often be the focus. The management of the extended response task should be mostly the responsibility of the student. Supervision by the teacher may be necessary at times. The extended response task may last from two weeks to the entirety of the unit of work.

The outcome of extended response tasks is a written, spoken or multimodal response that demonstrates aspects of each of the three criteria.

Modes and types of responses

Written

Report: In the report, the student would make some form of decision regarding the question or issue under investigation and support the decision with logical argument. The report may be in response to observations made and conclusions drawn from a case study or studies, industrial visits, or field trips.

Assignment: Students provide a response to a specific question or issue. The response may be supported by appropriate tables of data, diagrams and flowcharts. The assignment could be a persuasive argument or informative text.

Article: Students create an article that would be suitable for a scientific magazine or publication that would run stories of scientific interest. Documentation of findings should be enhanced by the use of graphics, tables and pictures.

Spoken

For example debates, seminars, lessons, demonstrations.

Multi-modal

For example PowerPoint presentations, webpages, videos, computer simulations.

Spoken and multi-modal presentations would need to be supported by explanatory notes, references, data and diagrams.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Year 11</th>
<th>Year 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Report</td>
<td>800–1000 words (discussions, conclusions and/or recommendations)</td>
<td>1000–1500 (discussions, conclusions and/or recommendations)</td>
</tr>
<tr>
<td>• Assignment</td>
<td>800–1000 words</td>
<td>1000–1500 words</td>
</tr>
<tr>
<td>• Article</td>
<td>800–1000 words</td>
<td>1000–1500 words</td>
</tr>
<tr>
<td>Spoken</td>
<td>3–4 minutes</td>
<td>4–5 minutes</td>
</tr>
<tr>
<td>Multi-modal</td>
<td>3–5 minutes</td>
<td>5–7 minutes</td>
</tr>
</tbody>
</table>
What must a student do to complete an extended response task?

- gather and sort information and data from a variety of sources, demonstrating appropriate referencing
- process information, demonstrating an understanding of processes and phenomena
- interpret, analyse and synthesise data
- explain relationships between concepts, principles, theories and schema
- evaluate information and justify ideas
- communicate ideas.

What do teachers do when planning and implementing an extended response task?

The teacher suggests topics and provides some stimulus to trigger student interest.

Teachers can provide the research question or it may be instigated by the student. In those instances teachers should negotiate with students to ensure safety and the possibility of success. It is more likely that students will be able to generate their own research questions the further they progress in the course of study.

Teachers must allow some class time for students to be able to effectively undertake each component of the extended response task. Teachers may allow elements of the extended response task to be conducted in small groups or pairs. However, independent student time will be required to complete the extended response task.

Teachers must implement strategies to ensure authentication of student work. Some strategies are annotated notes in response to issues that emerged during the extended response task (e.g. journals, experimental logs), teacher observation sheets, research checklists, and referencing and reference lists.

Teachers must consult, negotiate and provide feedback before and during the extended response task to provide ethical guidance and to monitor student work. Feedback and assistance should be provided judiciously, gradually being reduced with the development of student experience and confidence.

Scaffolding must be provided. When an extended response task is undertaken for the first time, the scaffolding should help students complete the assessment by modelling the extended response task process. However, the scaffolding provided should not specify the physics, or lead the student through a series of steps dictating a solution. Scaffolding should be reduced from Year 11 to Year 12 to allow the student to better demonstrate independence in the research process. When an extended response task is revisited (most likely in Year 12) the scaffolding should be reduced and could be a series of generic questions.
7.4.4 **Assessment instruments**

Assessment instruments are developed by the school to provide:

- opportunities for students to demonstrate their understanding of Physics
- a level of challenge suitable for the whole range of students
- information about students’ demonstration of the achievement of the general objectives
- information on which teachers may make judgments about student achievement.

Assessment instruments are accompanied by:

- statements of the conditions of assessment that apply (Section 7.4.6)
- a detailed description of the instrument (Section 7.4.7)
- a detailed criteria sheet (Section 7.4.8)
- details of procedures for authentication of student responses (Section 7.4.9).

7.4.5 **Conditions of assessment**

Across the whole assessment program, teachers should establish a range of conditions. This can be done by systematically varying the factors that are most significant in establishing the conditions for an instrument, namely:

- the time allowed to prepare and complete the response
- access to resources, both material and human, during the preparation for and completion of the instrument.

Every instrument description must include clear statements of the assessment conditions that apply. These may include:

- time available for the preparation and completion of the response
- resources accessible and available (both material and human) during the preparation for and completion of the response
- location for the preparation and completion of the response, e.g. in class, at home
- whether the response is to be an individual or group production
- the strategy used to ensure student authorship, e.g. the degree of teacher supervision and teacher monitoring that will apply.

7.4.6 **Instrument descriptions**

Instrument descriptions are to:

- state all requirements, including the length and the conditions
- be congruent with the general objectives of the syllabus, the standards associated with exit and the school work program; this congruence ensures the essential relationship between learning, teaching and assessment practices.

7.4.7 **Criteria sheets**

Where criteria sheets specific to each instrument are developed, they should be provided to students before undertaking assessment.

These instrument-specific criteria sheets are to:

- be derived from the exit criteria
- describe standards congruent with the exit standards
- provide a clear specification of each of the five standards (A–E)
• inform teaching and learning practice
• be annotated to indicate student achievement
• provide the basis for teacher judgment about student achievement
• provide students with the opportunity to develop self-evaluative expertise.

The extent to which the exit standards are reflected in the criteria sheet will vary according to the general objectives associated with the instrument and according to the stage in the course at which the instrument is undertaken.

7.4.8 Authentication of student work

It is essential that judgments of student achievement be made on genuine student assessment responses. Teachers must take reasonable steps to ensure that each student’s work is their own, particularly where students have access to electronic resources or when they are preparing responses to collaborative tasks.

The QSA’s A–Z of Senior Moderation contains a strategy for authenticating student work <www.qsa.qld.edu.au/10773.html>. This provides information about various methods teachers can use to monitor that students’ work is their own. Particular methods outlined include:

• teachers seeing plans and drafts of student work
• student production and maintenance of evidence for the development of responses
• student acknowledgment of resources used.

Teachers must ensure students use consistent, accepted conventions of in-text citation and referencing, where appropriate.

7.5 Special consideration

Guidance about the nature and appropriateness of special consideration and special arrangements for particular students may be found in the Authority’s Policy on Special Consideration for School-based Assessments in Senior Certification (2006), available from <www.qsa.qld.edu.au/yourqsa/policy/special-c/docs/spec-con.pdf>. This statement also provides guidance on responsibilities, principles and strategies that schools may need to consider in their school settings.

To enable special consideration to be effective for students so identified, it is important that schools plan and implement strategies in the early stages of an assessment program and not at the point of deciding levels of achievement. The special consideration might involve alternative teaching approaches, assessment plans and learning experiences.

7.6 Exit criteria

The following exit criteria must be used in making judgments about a student’s level of achievement at exit from a course in Physics.

Knowledge and conceptual understanding

This criterion refers to the student’s ability to acquire knowledge about facts, theories, concepts and principles of Physics; to engage with the theories and issues of Physics; to interpret the interrelationships and predict outcomes occurring within Physical contexts.

Investigative processes
This criterion refers to the student’s ability to recognise the methodologies available to them, to conduct experimental processes safely, to judge the worth of qualitative data, and to interpret and apply the outcomes of quantitative data.

**Evaluating and concluding**

This criterion refers to the student’s ability to synthesise their thoughts and the thinking of others, determine interrelationships, propose solutions and justify decisions, and communicate their findings.

All criteria make equal contribution to the determination of levels of exit achievement.

### 7.7 Determining exit levels of achievement

On completion of the course of study, the school is required to award each student an exit level of achievement from one of the five categories:

- Very High Achievement
- High Achievement
- Sound Achievement
- Limited Achievement
- Very Limited Achievement.
The school must award an exit standard for each of the criteria *Knowledge and conceptual understanding*, *Investigative processes*, and *Evaluating and concluding* based on the principles of assessment described in this syllabus. The criteria are derived from the general objectives and are described in Section 4. The standards associated with the three exit criteria are described in the matrix in Section 7.9. When teachers are determining a standard for each criterion, it is not always necessary for the student to have met each descriptor for a particular standard; the standard awarded should be informed by how the qualities of the work match the descriptors overall.

For Year 11, particular standards descriptors may be selected from the matrix and/or adapted to suit the task. These standards are used to inform the teaching and learning process. For Year 12 tasks, students should be provided with opportunities to understand and become familiar with the expectations for exit. The exit standards are applied to the summative body of work selected for exit.

The seven key competencies* referred to in the rationale are embedded in the descriptors in the standards matrix. The descriptors refer mainly to aspects of *Knowledge and conceptual understanding*, *Investigative processes*, and *Evaluating and concluding*.

When standards have been determined in each of the criteria of *Knowledge and conceptual understanding*, *Investigative processes*, and *Evaluating and concluding*, the following table is used to award exit levels of achievement, where *A* represents the highest standard and *E* the lowest. The table indicates the minimum combination of standards across the criteria for each level.

### Awarding exit levels of achievement

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VHA</td>
<td>Standard <em>A</em> in any two criteria and no less than a <em>B</em> in the remaining criterion</td>
</tr>
<tr>
<td>HA</td>
<td>Standard <em>B</em> in any two criteria and no less than a <em>C</em> in the remaining criterion</td>
</tr>
<tr>
<td>SA</td>
<td>Standard <em>C</em> in any two criteria and no less than a <em>D</em> in the remaining criterion</td>
</tr>
<tr>
<td>LA</td>
<td>At least Standard <em>D</em> in any two criteria</td>
</tr>
<tr>
<td>VLA</td>
<td>Standard <em>E</em> in the three criteria</td>
</tr>
</tbody>
</table>

### 7.8 Requirements for verification folio

A verification folio is a collection of a student’s responses to assessment instruments on which the level of achievement is based. Each folio should contain student responses to a variety of assessment instruments demonstrating achievement in the criteria *Knowledge and conceptual understanding*, *Investigative processes*, and *Evaluating and concluding*, over a range of topics. The variety of assessment instruments is necessary to provide a range of opportunities from which students may demonstrate achievement.


Students’ verification folios for Physics must contain:

- student responses to a minimum of four and a maximum of six summative assessment instruments

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* KC1: collecting, analysing and organising information; KC2: communicating ideas and information; KC3: planning and organising activities; KC4: working with others and in teams; KC5: using mathematical ideas and techniques; KC6: solving problems; KC7: using technology.
• assessment instruments, demonstrating a range of techniques, that includes:
  – at least one, but no more than two extended experimental investigations
  – at least one supervised assessment
• at least one assessment instrument that is derived from the Year 12 contextualised unit of work
• a criteria sheet for each assessment instrument which provides evidence of how students meet standards associated with the assessment criterion involved in that instrument
• a student profile that records achievement in the assessment instruments across all assessment criteria used to substantiate the proposed interim level of achievement.

7.8.1 Post-verification assessment

In addition to the contents of the verification folio, there must be subsequent summative assessment in the exit folio. In Physics, at least one instrument must be completed after verification. Preparation for this assessment often commences before fourth term. It is desirable for the assessment instrument to include all criteria.
### 7.9 Standards associated with exit criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Knowledge and conceptual understanding</strong></td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
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<tr>
<td></td>
<td>• reproduction and interpretation of complex and challenging concepts, theories and principles</td>
<td>• reproduction and interpretation of complex or challenging concepts, theories and principles</td>
<td>• reproduction of concepts, theories and principles</td>
<td>• reproduction of simple ideas and concepts</td>
<td>• reproduction of isolated facts</td>
</tr>
<tr>
<td></td>
<td>• comparison and explanation of complex concepts, processes and phenomena</td>
<td>• comparison and explanation of concepts, processes and phenomena</td>
<td>• explanation of simple processes and phenomena</td>
<td>• description of simple processes and phenomena</td>
<td>• recognition of isolated simple phenomena</td>
</tr>
<tr>
<td></td>
<td>• linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex and challenging situations.</td>
<td>• linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex or challenging situations.</td>
<td>• application of algorithms, principles, theories and schema to find solutions in simple situations.</td>
<td>• application of algorithms, principles, theories and schema.</td>
<td>• application of simple given algorithms.</td>
</tr>
<tr>
<td><strong>Investigative processes</strong></td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
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<tr>
<td></td>
<td>• formulation of justified significant questions/hypotheses which inform design and management of investigations</td>
<td>• formulation of justified questions/hypotheses which inform design and management of investigations</td>
<td>• formulation of questions and hypotheses to select and manage investigations</td>
<td>• implementation of given investigations</td>
<td>• guided use of given procedures</td>
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<td></td>
<td>• assessment of risk, safe selection and adaptation of equipment, and appropriate application of technology to gather, record and process valid data</td>
<td>• assessment of risk, safe selection of equipment, and appropriate application of technology to gather, record and process data</td>
<td>• assessment of risk, safe selection of equipment, and appropriate application of technology to gather and record data</td>
<td>• safe use of equipment and technology to gather and record data</td>
<td>• safe directed use of equipment to gather data</td>
</tr>
<tr>
<td></td>
<td>• systematic analysis of primary and secondary data to identify relationships between patterns, trends, errors and anomalies.</td>
<td>• analysis of primary and secondary data to identify patterns, trends, errors and anomalies.</td>
<td>• analysis of primary and secondary data to identify obvious patterns, trends, errors and anomalies.</td>
<td>• identification of obvious patterns and errors.</td>
<td>• recording of data.</td>
</tr>
<tr>
<td>Criterion</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
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<td>-------------------------------------------------------------------</td>
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<tr>
<td>Evaluating and</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
<td>The student work has the following characteristics:</td>
</tr>
<tr>
<td>concluding</td>
<td>• analysis and evaluation of complex scientific</td>
<td>• analysis of complex scientific interrelationships</td>
<td>• description of scientific interrelationships</td>
<td>• identification of simple scientific interrelationships</td>
<td>• identification of obvious scientific interrelationships</td>
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<tr>
<td></td>
<td>interrelationships</td>
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<tr>
<td></td>
<td>• exploration of scenarios and possible outcomes with justification</td>
<td></td>
<td>• description of scenarios and possible outcomes with statements</td>
<td>• identification of scenarios or possible outcomes</td>
<td>• statements about outcomes</td>
</tr>
<tr>
<td></td>
<td>of conclusions/recommendations</td>
<td></td>
<td>of conclusion/recommendation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• discriminating selection, use and presentation of scientific</td>
<td>• explanation of scenarios and possible outcomes with discussion</td>
<td>• selection, use and presentation of scientific data and ideas to</td>
<td>• selection, use and presentation of scientific data or ideas in</td>
<td>• presentation of scientific data or ideas.</td>
</tr>
<tr>
<td></td>
<td>data and ideas to make meaning accessible to intended audiences</td>
<td>of conclusions/recommendation</td>
<td>make meaning accessible to intended audiences in range of formats.</td>
<td>range of formats.</td>
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<tr>
<td></td>
<td>through innovative use of range of formats.</td>
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</table>
8. Language education

Teachers of Senior English have a special responsibility for language education. However, it is the responsibility of all teachers to develop and monitor students’ abilities to use the forms of language appropriate to their own subject areas. Their responsibility entails developing the following skills:

- ability in the selection and sequencing of information required in the various forms (such as reports, essays, interviews and seminar presentations)
- the use of technical terms and their definitions
- the use of correct grammar, spelling, punctuation and layout.

Students should understand and use appropriate scientific terms and phrases wherever the need arises. In order to achieve understanding of scientific terms, it may be necessary for students to develop their own glossaries as they progress through a course in Physics. Assessment in Physics needs to take into consideration appropriate use of language.

Students should be engaged in learning experiences which involve them in:

<table>
<thead>
<tr>
<th>Drawing upon sources of information, such as:</th>
<th>Using language for the purposes of:</th>
<th>Presenting information in forms such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>observations</td>
<td>restating information</td>
<td>laboratory and field notes and reports</td>
</tr>
<tr>
<td>demonstrations</td>
<td>reporting results</td>
<td>formal reports</td>
</tr>
<tr>
<td>experiments</td>
<td>giving instructions</td>
<td>letters</td>
</tr>
<tr>
<td>textbooks</td>
<td>formulating a hypothesis</td>
<td>abstracts</td>
</tr>
<tr>
<td>handbooks of data</td>
<td>designing an experiment</td>
<td>biographies</td>
</tr>
<tr>
<td>manuals of procedures</td>
<td>explaining a relationship</td>
<td>précis</td>
</tr>
<tr>
<td>product brochures</td>
<td>arguing a proposition</td>
<td>reviews</td>
</tr>
<tr>
<td>specification sheets</td>
<td>proposing action</td>
<td>oral presentations</td>
</tr>
<tr>
<td>computer files</td>
<td>defending a position</td>
<td>seminars</td>
</tr>
<tr>
<td>journal articles</td>
<td>justifying a stand</td>
<td>discussions</td>
</tr>
<tr>
<td>magazines</td>
<td>evaluating an argument</td>
<td>expositions</td>
</tr>
<tr>
<td>newspapers</td>
<td>developing an idea</td>
<td>demonstrations</td>
</tr>
<tr>
<td>broadcast media</td>
<td>interpreting a theory</td>
<td>charts</td>
</tr>
<tr>
<td>Internet</td>
<td>persuading</td>
<td>graphs</td>
</tr>
<tr>
<td>CD-ROMs</td>
<td>making conclusions</td>
<td>sketches</td>
</tr>
<tr>
<td>advertisements</td>
<td>following instructions</td>
<td>models</td>
</tr>
<tr>
<td>videos or films</td>
<td>predicting the results of an</td>
<td>photographs</td>
</tr>
<tr>
<td>lectures</td>
<td>experiment</td>
<td>electronic media</td>
</tr>
<tr>
<td>interviews</td>
<td>evaluating scientific arguments</td>
<td></td>
</tr>
<tr>
<td>discussions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. Quantitative concepts and skills

Success in dealing with life and work depends on the development and integration of a range of abilities, such as being able to:

- comprehend basic concepts and terms underpinning the areas of forces, energy, motion, measurement and algebra
- extract, convert or translate information given in numerical or algebraic forms, diagrams, graphs or tables
- calculate, apply algebraic procedures and implement algorithms
- use calculators and computers
- use skills or apply concepts from one problem or one subject domain to another.

Some subjects focus on the development and application of numerical and other mathematical concepts and skills. These subjects may provide a basis for the general development of such quantitative skills or have a distinct aim, such as to prepare students to cope with the quantitative demands of their personal lives or to participate in a specific workplace environment.

Nevertheless, in all subjects students are to be encouraged to develop their understanding and to learn through the incorporation — to varying degrees — of mathematical strategies and approaches. Similarly, students should be presented with experiences that stimulate their mathematical interest and hone those quantitative skills that contribute to operating successfully within each of their subject domains.

The distinctive nature of a subject may require that new mathematical concepts be introduced and new skills be developed. In many cases, however, it will be a matter of teachers, in the context of their own subjects, having to encourage the use of quantitative skills and understandings that were developed previously by their students. Within appropriate learning contexts and experiences in the subject, opportunities are to be provided for the revision, maintenance and extension of such skills and understandings.

Because of the mathematical underpinnings of this subject it will require the development and use of a wide range of mathematical concepts. For example:

**Algebra.** At the very heart of Physics practice is algebra — the manipulation of symbols representing physical quantities in order to analyse data and predict outcomes.

**Quantitative relationships.** The laws of Physics are mostly expressed by way of an equation relating quantities by simple and not-so-simple expressions.

**Graphical analysis.** The relationship between quantities is often best explored by plotting observed data, which can make linear, trigonometric, logarithmic, hyperbolic or parabolic relationships apparent.

**Measurement.** Precise and accurate measurement of physical quantities is essential in uncovering relationships between quantities or predicting one from the other. But for the accuracy of measurements in nuclear physics, the modern view of atomic structure may not yet have been invented.
Geometry. Physics models of concepts such as electric and magnetic fields, geometrical optics and manipulation of vectors require the use of geometric skills. Combined with scale drawing, this confers on geometry the special relationship with Physics.

Number. The manipulation of numbers is one of the most fundamental skills of Physics. Physics explores the universe from the extremely small to the extremely large: the shortest time known ($10^{-43}$ seconds) to the mass of the universe ($10^{53}$ kg). The extent of this range relies on the use of exponential or logarithmic approaches in considering and comparing these events.
10. Educational equity

Equity means fair treatment of all. In developing work programs from this syllabus, schools are urged to consider the most appropriate means of incorporating the following notions of equity.

Schools need to provide opportunities for all students to demonstrate what they know and what they can do. All students, therefore, should have equitable access to educational programs and human and material resources. Teachers should ensure that the particular needs of the following groups of students are met: female students; male students; Aboriginal students; Torres Strait Islander students; students from non–English-speaking backgrounds; students with disabilities; students with gifts and talents; geographically isolated students; and students from low socioeconomic backgrounds.

The subject matter chosen should include, whenever possible, the contributions and experiences of all groups of people. Learning contexts and community needs and aspirations should also be considered when selecting subject matter. In choosing appropriate learning experiences, teachers can introduce and reinforce non-racist, non-sexist, culturally sensitive and unprejudiced attitudes and behaviour. Learning experiences should encourage the participation of students with disabilities and accommodate different learning styles.

It is desirable that the resource materials chosen recognise and value the contributions of both females and males to society and include the social experiences of both sexes. Resource materials should also reflect the cultural diversity within the community and draw from the experiences of the range of cultural groups in the community.

Efforts should be made to identify, investigate and remove barriers to equal opportunity to demonstrate achievement. This may involve being proactive in finding out about the best ways to meet the special needs, in terms of learning and assessment, of particular students. The variety of assessment techniques in the work program should allow students of all backgrounds to demonstrate their knowledge and skills in a subject in relation to the criteria and standards stated in this syllabus. The syllabus criteria and standards should be applied in the same way to all students.

Teachers may find the following resources useful for devising an inclusive work program:

Australian Curriculum, Assessment and Certification Authorities 1996, Guidelines for Assessment Quality and Equity, Australian Curriculum, Assessment and Certification Authorities, available through QSA, Brisbane.

Department of Education, Queensland 1991, A Fair Deal: Equity guidelines for developing and reviewing educational resources, Department of Education [Education Queensland], Brisbane.

Department of Training and Industrial Relations 1998, Access and Equity Policy for the Vocational Education and Training System, DET, Brisbane.


11. Resources

The selection of resource material to support a course in Physics will be governed to some extent by local factors. It is unlikely that there is a single student or teacher resource which can be universally applied to all schools’ programs. Schools should draw upon their own resources as well as those described below.

Text and reference books
A wide variety of textbooks and resource materials that could be used as sources of information about Physics are available. Book suppliers provide information on current publications.

World Wide Web
Many interactive and static websites can be used to enhance a course in Physics and often include useful resources. Some particularly useful sites include:
- Mechanics for Physicists and Engineers
  <http://online.physics.uiuc.edu/courses/phys211/summer05/lectures/lectures.html>
- Material from UniServe (University of Sydney)
- Physics in Context — An Integrated Approach
  <www.learningincontext.com/PiC-Web/index.html>
- Sport Physics Website
- TeachNET
  <www.cew.wisc.edu/teachnet/>
- The Physics of Sport
  <http://home.nc.rr.com/enloephysics/sports.htm>
- The International Baccalaureate Physics Homepage
  <www.saburchill.com/physics/physics.html>
- The Physics of Everyday Stuff
  <www.bsharp.org/physics/stuff/index.html>
- Workshop Tutorials for Physics

Newspaper reports
Local and national newspapers include regular pages, columns and features about physics. The compilation of news files on particular topics can broaden students’ knowledge and provide a valuable source of material for developing assessment instruments.

Periodicals
Many useful teaching strategies are reported in the *Australian Science Teachers’ Journal* as well as state science teachers’ journals such as *The Queensland Science Teacher*. These journals often contain details and information about free materials, teaching kits and some worthwhile commercial packages.
Useful topics may also be found in science research journals and discipline-specific journals. Lists of these are contained in listings of periodicals held in most libraries.

Commonwealth Science and Industrial Research Organisation (CSIRO) publications contain articles of direct relevance to the topics of this syllabus. Other publications from various sources such as the Australian Academy of Science, conservation and environmental groups and scientific organisations may contain recent and useful information.

Popular science periodicals such as *Scientific American* and *New Scientist* provide information on areas of latest research. *Australasian Science* and the CSIRO periodical *Helix* contain relevant articles. School librarians should be able to provide assistance with identifying and locating other useful periodicals.

**Electronic media and learning technology**

A wide range of videos, DVDs and television recordings are available on topics related to Physics. A variety of computer software programs and CD-ROMs may be useful for a course in Physics, as learning tools, to gain access to information presented in a variety of forms and to assist students in gaining ICT skills. Educational program distributors are able to supply updated resource lists.

The ABC television series “Catalyst” usually contains items of value. Documentaries produced by the National Geographic Society and similar bodies are telecast frequently and copies of these programs are available, for educational use, at a reasonable cost.

“The Science Show” and “Ockham’s Razor” are regular radio series (on ABC Radio National) pitched at an appropriate level.

**Organisations and community resources**

A variety of government and community organisations provide personnel, advice, resources and information to assist in constructing and implementing a course in Physics. The Queensland Museum, for example, provides a valuable storehouse of materials and expert knowledge. Links with community groups and organisations not only provide relevant and up-to-date resources for students but also help to improve the credibility of the course in the eyes of the community.

There may be protocols that must be observed when working with Aboriginal and Torres Strait Islander organisations and community groups, for example meeting with the elders before an activity is conducted. One such set of protocols may be found in the Aboriginal and Torres Strait Islander Studies Senior Syllabus.

A number of centres have been set up in capital cities and in mobile format. For example, Questacon (the National Science and Technology Centre in Canberra) and the Queensland Museum Sciencentre in Brisbane offer information and programs for schools.

**Professional associations**

The Australian Science Teachers Association (ASTA) is the professional association for science teachers in Australia. Membership of the Science Teachers Association of Queensland (STAQ) gives automatic membership in ASTA. <www.staq.qld.edu.au>

The Australian Institute of Physics is the professional association for physicists in Australia. Various grades of membership are open to Physics teachers and these also provide a subscription to the Institute’s journal, *Australian Physics*. Details may be found at <www.aip.org.au>.
Appendix A: Glossary

Algorithm
Process or set of rules to be used; systematic procedure to solve a problem in a finite number of steps; step-by-step approach.

Analyse
Break up a whole into its parts; examine in detail to determine the nature of; look more deeply into and detect the relationships between parts.

Assessment instrument
Particular methods developed and used by a school to gather information about student achievement.

Assessment techniques
The methods (categories) identified in the syllabus to gather evidence about student achievement. Senior syllabuses describe suitable techniques and prescribe the mix of assessment techniques for verification folios.

Communicate
Convey information about; make known; impart; reveal clearly; manifest.

Compare
Display recognition of similarities and differences and recognise the significance of these similarities and differences.

Concept
An abstract idea or a mental symbol, typically associated with a corresponding representation in language or symbology, that denotes all of the objects in a given category or class of entities, interactions, phenomena, or relationships between them. Concepts are abstract in that they omit the differences of the things in their extension, treating them as if they were identical. They are universal in that they apply equally to everything in their extension. Concepts are also the basic elements of propositions. Concepts are discursive and result from reason. Concepts help to integrate apparently unrelated observations and phenomena into viable hypotheses and theories.

Conclusion
Final result or summing up; inference deduced from previous information; reasoned judgment.

Contextualised
A context is a framework for linking concepts and learning experiences that enables students to identify and understand the application of Physics to their world. A context is a group of related situations, phenomena, technical applications and social issues likely to be encountered by students. A context provides a meaningful application of concepts in real-world situations.

Contrast
Display recognition of differences by deliberate juxtaposition of contrary elements.

Criteria (singular: “criterion”)
A criterion is a property, dimension or characteristic by which something is judged or appraised. In senior syllabuses, the criteria are the significant dimensions of the subject, described in the rationale and used to categorise the general objectives and exit criteria.
Criteria sheets
Developed from the standards associated with exit criteria to describe the attributes of student work anticipated at each level of achievement for the particular assessment instrument.

Data
In the context of the Physics syllabus, data is thought of as documented information or evidence of any kind that lends itself to scientific interpretation. Data may be quantitative or qualitative.

Decision
The process of coming to a conclusion or determination about something, resolving or forming conclusions, providing a judgment or an answer; a choice formed after considering various alternatives.

Deduce
Infer; reach a conclusion which is necessarily true provided a set of assumptions is true.

Demonstrate
Explain process; prove or show to be true; provide evidence.

Depth
The development of knowledge and understandings from simple through to complex.

Describe
Give an account of in speech or writing; convey an idea or impression of; characterise; represent pictorially; depict; trace the form or outline of.

Determine
Come to a resolution or decide.

Discuss
Consider a particular topic in speaking or writing; talk or write about a topic to reach a decision.

Estimate
Calculate an approximate amount or quantity.

Evaluate
Establish the value, quality, importance, merit, relevance or appropriateness of information, data or arguments based on logic as opposed to subjective preference.

Exemplify
Show or illustrate, using examples.

Exit level of achievement
The standard reached by students at exit, judged by matching standards in student work with the exit criteria and standards stated in a syllabus.

Explain
Make clear or understandable; show knowledge in detail.

Formative assessment
Used to provide feedback to students, parents and teachers about achievement over the course of study. This enables students and teachers to identify the students’ strengths and weaknesses so students may improve their achievement and better manage their own learning.

General objectives
General objectives are those which the school is intended to pursue directly and student achievement of these is assessed by the school.

Hypothesis (plural: “hypotheses”)
A tentative explanation for a phenomenon, used as a basis for further investigation.
Identify
Recognise, name or select.

Illustrate
Make clear or intelligible; exemplify.

Interpret
Give meaning to information presented in various forms — words, symbols, pictures, graphs, etc.

Investigative process
The process of examining or inquiring into something with organisation, care and precision; the questions chosen should be of interest to students, should encourage additional questioning, and should challenge students to explore a range of solutions.

Justify
Provide sound reasons based on logic or theory to support response; prove or show statements are just or reasonable; convince.

Key competencies
Defined skills essential for effective participation in adult life, including further education and employment.

Key concepts
Accepted broad scientific (physical) understandings.

Key ideas
Statements that illustrate the depth and scope of the key concepts.

Moderation
Name given to the quality assurance process for senior secondary studies used by the QSA to ensure that:
- Authority subjects taught in schools are of the highest possible standard
- student results in the same subject match the requirements of the syllabus and are comparable across the state
- the process used is transparent and publicly accountable.

Phenomenon (plural: “phenomena”)
An observable or detectable event.

Primary data
Information that does not already exist, collected under research guidelines.

Processes
Events where there are (chemical) changes determined by the atomic and molecular composition and structure of the substances involved.

Qualitative
Concerned with quality; based on verbal analysis.

Quantitative
Concerned with measurement; based on mathematical analysis.

Reliability
Ability to be trusted to be accurate or correct or to provide a correct result.

Scaffolding
The scaffolding analogy comes from the building industry, and refers to the process of supporting a student’s learning to solve a problem or perform a task that could not be accomplished by that student alone. The aim is to support the student as much as necessary while they build their understanding and ability to use the new learning, and then gradually reduce the support until the student can use the new learning independently.
Secondary data
The result of research that involves the summary, collation and/or synthesis of existing research rather than primary research (where data is collected from, for example, research subjects or experiments).

Solutions
Answers to problems, investigations, research or questions.

Standard
A fixed reference point for use in assessing or describing the quality of something. In senior syllabuses, standards are usually described at five points within each exit criterion.

Student profile of achievement
This records information about student performance on instruments undertaken periodically throughout the course of study. Techniques are chosen to sample the significant aspects of a course across relevant exit criteria to ensure balance in assessment. In particular, it is important that the profile of achievement illustrates how assessment of significant aspects is selectively updated and eventually leads to summative assessment within each exit criterion.

Summative assessment
Provides cumulative information on which levels of achievement are determined at exit from the course of study. It follows, therefore, that it is necessary to plan the range of assessment instruments to be used, when they will be administered, and how they will contribute to the determination of exit levels of achievement.

Synthesise
Assemble constituent parts into a coherent, unique and/or complex entity. The term entity includes a system, theory, communication, plan, set of operations.

Theory
A set of facts, propositions or principles analysed in their relation to one another and used, especially in science, to explain phenomena.

Validity
Sound, reasonable, relevant, defensible, well grounded, able to be supported with logic or theory.

Verification
Towards the end of Year 12, school submissions, one for each Authority subject, are sent to the relevant (usually district) review panels, who review the material to confirm that the standards assigned to students’ work are in line with the descriptors in the syllabus. These submissions comprise folios of the work of sample students about to exit from the course of study, together with the school’s judgment of the value of the work of each of those students.

Verification folio
This is the collection of documents (tests, reports, assignments, checklists and other assessment instruments) used to make the decision about a student’s level of achievement. At October verification, it will contain 4–6 pieces of work that conform to the underlying principles of assessment as outlined in Section 7.8. Usually these pieces of work will be common to all submitted folios.

Work program
The school’s program of study in Authority and Authority-registered subjects for which the students’ results may be recorded on QSA certificates (requirements are listed on the QSA website).
Appendix 1: Scientific literacy

In *The National Review of the Status and Quality of Teaching and Learning of Science in Australian Schools*, Goodrum, Hackling and Rennie (2001) argued that the broad purpose of teaching science in the compulsory years of schooling is to develop scientific literacy for all students. Likewise, the report *Re-imagining Science Education: Engaging students in science for Australia’s future* (Tytler 2007) suggests that scientific literacy should be used as a focus for driving change in school science, citing the pace of technological advancement and global issues as reasons for a focus on developing scientifically informed citizens.

The explanations provided in this appendix are neither exhaustive nor totally definitive. However, to assist in the implementation of this syllabus a shared understanding amongst science teachers needs to be established. It is with this intent that these explanations are provided.

**Scientific literacy**

The overarching aim of any study of any science, including this course of study in Physics, is to develop students’ scientific literacy. The defining and re-defining of the meaning of scientific literacy is ongoing, but on page 15 of their report Goodrum, Hackling and Rennie provide a useful definition that considers and builds on both the National Science Council’s 1996 definition and that provided by the OECD in 1999. They define it as

> the capacity for persons to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions and draw evidence based conclusions, and to make informed decisions about the environment and their own health and well being.

The National Science Council (1996, p. 22) explains further that

Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed.

Scientific literacy is not a static quality. It is a way of thinking and a way of viewing and interacting with the world. Scientific literacy is encouraged and developed through working scientifically.

**Working scientifically**

Working scientifically encompasses the analytical approaches of scientific inquiry and investigation with conceptual and behavioural understandings and dispositions. In the context of this syllabus it stems from the global aims and includes the assessable general objectives as well as attitudes and values.
Working scientifically is a challenging interaction between existing beliefs, the goal of better understanding, and the processes and methods of exploring, generating, testing and relating ideas. It involves a number of attitudes: valuing ideas and seeking explanations; respecting evidence and logical reasoning; open-mindedness, critical-mindedness and persistence; scepticism about evidence and arguments; honesty and openness to new ideas; creativity and lateral thinking; ethical behaviour; regard for the consequences of decisions and the well-being of the living and non-living components of the environment; accepting the provisional nature of knowledge. (Curriculum Corporation 1994, p. 15)

Further, in the Years 1 to 10 Science Key Learning Area Syllabus working scientifically is described thus:

the practices and dispositions of science. These include a complex assortment of activities, mental processes, routines and protocols that are the essence of the scientific enterprise. Because it is a hallmark of the activities of scientists, “working scientifically” features prominently in effective science education.

When “working scientifically”, students make sense of the phenomena they experience as they investigate, understand and communicate. They develop an appreciation of “working scientifically” when they learn the concepts of science through engaging in the widest range of active learning experiences. Engaging in science in this way contributes to students’ sense of awe and wonder about the beauty and power of the universe. (Queensland Schools Curriculum Council 1996, p. 1)

Inquiry

Research has demonstrated that learning occurs best in science when “learners build upon their existing knowledge or restructure what they know as a result of their understanding being extended or challenged in some way” (Goodrum, Hackling & Rennie 2001, p. 18). Using an inquiry or investigative approach is an effective way to attain this goal. Inquiry is an overarching term used to describe a teaching and learning process that incorporates skills necessary for students to have in science classrooms. An inquiry can be defined as “a systematic investigation into an idea (problem) or issue. Inquiry-based learning encompasses the processes of posing problems, gathering information, thinking creatively about possibilities, making decisions and justifying conclusions” (Department of Education Tasmania 2006).

Inquiry is used in exploring science issues, solving science problems, conducting science experiments and conducting science generally. The skills of scientific inquiry include:

questioning, predicting, hypothesising, investigating and gathering evidence, organising data to elicit patterns, testing and refining ideas, developing explanations for natural phenomena and communicating these to others. (Curriculum Corporation 2006, p. 2)

Scientific inquiries are often considered synonymous with scientific investigations.

Scientific investigations

Investigation of scientific questions and problems allows students to embark on a meaningful and intellectually stimulating interpretation of their surroundings, involving use of scientific techniques and procedures and leading to the development of knowledge, concepts, ideas, theories and principles in Physics. The construction of knowledge and understanding therefore allows more questions to be investigated. The two areas are linked essentially in the teaching and learning of Physics, resulting in students who can respond critically and creatively to changes in material use, society and technology.
The syllabus emphasises the linkage and integration between investigative and knowledge-based physics and promotes individual, group and societal understanding of the role it plays in the state of the environment, the quality of human life, social and economic practices and the direction of technological change. Students who complete the course should be able to understand and act responsibly on Physics issues. They should communicate effectively in a variety of media and modes and be empowered with the ability to investigate problems and apply physical concepts in order to make sound decisions in the future.

Experimental investigations involve specialised sets of knowledge and skills particular to the area of science under study, and are often seen as a subset of scientific investigations. Experiments produce primary data.

**The common aspects of scientific inquiry and scientific investigation**

It has been demonstrated that effective learning in the sciences can be conducted through scientific investigations.

All investigations have three similar phases, which can be loosely grouped as follows:*

- establishment of an interest, issue, question or problem to be examined, explored, investigated or solved
- processes and methodologies associated with the above
- discussion of and critical reflection on the outcomes.

Investigations use particular ways of thinking and problem solving, and are an effective strategy for:

- development of higher-order thinking skills
- increasing student involvement in and ownership of the curriculum
- encompassing effective teaching and learning principles
- recognising and catering for individual difference.

Investigations help shape learning. They may occur as a classroom activity over a lesson, or as activities that occur over a few lessons or longer. They may be the focus of a unit or an assessment or part of an assessment.

An investigation may range from being very teacher directed, to one that has some elements that are student managed, to those that are totally open ended, requiring a high degree of student independence.

**Using scientific investigations**

Learning that leads to a deep understanding is acquired through the active construction of meaning by students. An important method of constructing meaning is through processes of investigation. These processes take account of students’ construction of new knowledge on the basis of their previous understandings about a topic, and allow time for these to be clarified.

Investigations will commonly be initiated by a general exploration of the area of interest until an issue, question or problem can be defined. The teacher may start this off, but students’ involvement in specifying the topic, purpose and audience is to be encouraged.

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* As an example, the inquiry process outlined in the Years 1–10 Science Key Learning Area Syllabus is:
  - investigating
  - understanding
  - communicating.
As a result of further collection of information and identification of the scientific skills, processes, concepts or strategies integral to the scientific investigation, tentative research questions should be posed, or a hypothesis formulated, and appropriate research techniques selected. Research questions and hypotheses are tentative because they could be changed as a result of issues that emerge during the investigation. With the research question or hypothesis in mind, the student conducts detailed research, which will often include experiments in Physics.

Scientific investigations require students to be involved in selecting an appropriate way of gathering information from a diverse range of primary sources (experimental data, statistics, surveys and questionnaires) and secondary sources (print and electronic material). Scientific investigation requires careful analysis of the information acquired. Emphasis should be placed on making the student aware of ways in which application of a scientific inquiry and investigation process may serve to determine outcomes. In analysing data collected by others, the student should be aware of variables that can affect the collection and validity of this data and avoid making unwarranted generalisations. The student also needs to be critical of the source of that data. Decision making must be supported by the processing of data and evidence. The student may wish to make further recommendations, take action on the conclusions reached, or suggest follow-up research or modifications to the research and experimentation undertaken.

The process of scientific investigation is not a linear one. Rather, it involves a recursive and reflective return to earlier steps, either to monitor progress or to adapt and adjust the questions or hypothesis in relation to new information. Such metacognitive reflection applies not only to the conclusions of the research but also to the conduct of the scientific investigation itself.

Possible scientific inquiry and investigation models

Not all units of work need be explored through investigative approaches. Choosing to use an approach and the selection of an inquiry model will depend on the context being studied and the nature of the proposed inquiry. The models below can be used in Physics.

<table>
<thead>
<tr>
<th><strong>Experimental investigation</strong></th>
<th><strong>Hypothesis-based inquiry</strong></th>
<th><strong>Inquiry process</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Define the question.</td>
<td>• Set down the topic being investigated and the objectives for studying the topic.</td>
<td>• Deciding on the research issue:</td>
</tr>
<tr>
<td>• Gather information and resources.</td>
<td>• Establish and refine the hypothesis as a statement or question.</td>
<td>– identify the topic or issue</td>
</tr>
<tr>
<td>• Form hypothesis.</td>
<td>• Gather and analyse data relevant to the hypothesis.</td>
<td>– locate a range of sources</td>
</tr>
<tr>
<td>• Perform experiment and collect data.</td>
<td>• Synthesise and evaluate data relevant to the hypothesis.</td>
<td>– frame a research question or hypothesis and select the research techniques.</td>
</tr>
<tr>
<td>• Analyse data.</td>
<td>• Confirm or reject the hypothesis and establish generalisations or conclusions.</td>
<td>• Conducting the research:</td>
</tr>
<tr>
<td>• Interpret data and draw conclusions that serve as a starting point for new hypotheses.</td>
<td>• Determine the best way to present the outcomes of the data gathering, testing and conclusions.</td>
<td>– gather data, collect evidence</td>
</tr>
<tr>
<td>• Publish/present results.</td>
<td>• If the hypothesis is rejected, reflect on possible modifications.</td>
<td>– produce findings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Making judgments:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– make decisions or draw conclusions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– evaluate and justify.</td>
</tr>
</tbody>
</table>
Appendix 2: Developing context-based units of work

It is a requirement of the syllabus that at least two units of work, one in Year 11 and one in Year 12, need to be contextualised. These units of work each need to be of at least 20 hours duration. The following information is provided to help teachers develop context-based units of work.

Contexts for learning

Students respond positively to tasks that they perceive to be purposeful and interesting to them. Therefore science activities and investigations should be conducted within a context that has relevance to the students (Goodrum, Hackling & Rennie 2001, p. 20).

Context-based learning provides students with opportunities to learn in circumstances that are relevant and interesting to them. The scientific knowledge and understanding of the students is developed, consolidated and refined in, about and through the context. It allows the teacher to use pedagogical approaches suitable to the situation, with multiple approaches often appropriate.

What is a context?

A context is a framework for linking concepts and learning experiences that enables students to identify and understand the application of Physics to their world.

The contextualised approach asks students to look at their world and identify the physics within it, to develop a deep and transferable understanding of the key concepts and ideas of physics. Contexts are central to student learning and an integral part of the learning process. Students shape and are shaped by the contexts in which these educational endeavours occur.

What is a purposeful context for learning?

A purposeful context for learning provides the stimulus for the development of a unit of work and a framework within which the key concepts and key ideas of physics can be meaningfully explored. Learning occurs best when the learner considers it to be real and relevant. Units of work developed through purposeful contexts help learners to better engage with Physics, while allowing them to understand the importance of physics in their life.

The assessment for the unit should be derived from the learning experiences developed around the context for learning. In the development of contexts for learning, schools should consider the student population, school resources, local environments, and social and technological implications and issues. Each context for learning should complement other learning through the development of key concepts and key ideas.
A purposeful context for learning:

- has relevance and consequence beyond the classroom
- is grounded in Physics
- reflects the interests and needs of students
- is topical and current or is of scientific historical importance.

It can be developed using:

- a key question or series of questions
- investigation(s)
- hypotheses to be tested
- a problem or problems to be solved
- design challenges
- topical, interesting issues.

**Selecting contexts for learning**

*Questions to consider when establishing a purposeful context for learning*

Does the purposeful context for learning:

- □ have the potential to allow students to explore significant concepts and understandings about their world?
- □ allow the key concepts and key ideas to be developed?
- □ lend itself to some form of direct experience through which students can gather first-hand information?
- □ provide relevance in some way to the lives of these students both now and in the future?
- □ provide understandings that are valuable and useful in the world beyond school?
- □ have the potential to really engage and interest students?
- □ link back in some way to an overall school plan?
- □ allow for critical reflection and action?
- □ complement other contexts being selected and not just a variation of a context?
- □ conflict with others being developed by other classes or subjects within the school?
- □ cater for the future needs of students?
- □ suitably challenge your students — will it take them beyond their existing experiences and interests?
Other considerations

☐ Is this a purposeful context for learning that the students have already explored in some depth? How can I ensure that this experience is developed, rather than repeated?

☐ Can I adequately resource this purposeful context for learning? Do we have a suitable collection of quality resources that I can use to supplement my teaching?

☐ Is there anyone I know who could help me to find out more about the purposeful context for learning — for example, community resources (factories, industries, government utilities such as power stations, museums, hospitals, government departments, CSIRO, universities, training providers, expert speakers)?

☐ Is this purposeful context for learning inclusive? Does it avoid alienation of any cultural or religious group? Does it allow for the equal participation of girls and boys?

☐ Can the purposeful context for learning be dealt with effectively in my given time frame?

☐ Do I have the expertise, familiarity or confidence to develop this purposeful context for learning?
Appendix 3: Indication of depth of treatment

The following lists provide suggestions for content. Content has been listed under the organisers to provide an indication of suggested subject matter for inclusion. Some content will be applicable under one or more of the organisers, and in those cases it has been repeated. The content listed is not exhaustive.

Forces

- Analysis of scalar and vector quantities using algebraic and graphical techniques, e.g. motion, energy, force, momentum
- Quantitative treatment of mechanical contact forces (simple to complex treatments), e.g. equilibrium problems, inclined plane problems
- Qualitative and quantitative treatment of internal and external energy transfers, e.g. heat, kinetic theory and electricity
- Quantitative treatment of non-contact forces, e.g. magnetic and electric:
  \[ F = Bqv \sin \theta \]
  \[ F = BIL \sin \theta \]
  \[ E = \frac{F}{Q} \]
- Qualitative understanding of the Inverse Square Laws
- Momentum and impulse:
  \[ p = mv \text{(vectorial)} \]
  \[ Ft = \Delta p \text{(vectorial)} \]
- Electrostatics
- Qualitative and quantitative analysis of the semiconductor applications
- Qualitative treatment of \( \alpha, \beta \) and \( \gamma \) radiation; formation, penetrating power and other properties
- Radioactivity
  - \[ A = \frac{\Delta N}{\Delta t} = -\lambda N \]
  - disintegration or decay constant, \( \lambda \)
  - interpretation of graphs of activity or number of particles with time
  - qualitative treatment of decay law
  - half life: \( t_{1/2} = 0.693/\lambda \)
- Elementary nuclear reactions in equation form, including fission and fusion.
Energy

- Analysis of scalar and vector quantities using algebraic and graphical techniques, e.g. motion, energy, force, momentum
- Qualitative and quantitative analysis of fields, e.g. gravitational, magnetic electric
- Kinetic, elastic and gravitational potential energy

\[
E_k = \frac{1}{2}mv^2 \quad E_{ep} = \frac{1}{2}kx^2 \quad E_{gp} = mgh
\]

\[
W = Fs \cos \theta \quad P = VI \quad V = Ed
\]

\[
W = VI t \quad P = \frac{W}{t} \quad V = \frac{kQ}{r}
\]

- Problems involving the conversion of energy
- Qualitative and quantitative treatment of internal and external energy transfers, e.g. heat, kinetic theory and electricity
- Quantitative treatment of ideal gases
- Characteristics of transverse and longitudinal waves
- Relationship between speed and wavelength, \( v = f\lambda \)
- Analysis of reflection, refraction, diffraction
- Analysis of interference, e.g. standing waves, air columns, strings and light, using the following formulas:

  \[
  \text{path difference} = \frac{dx}{L} \quad \text{constructive: } d \sin \theta = \frac{n\lambda}{\lambda} \quad \text{destructive: } d \sin \theta = (n - \frac{1}{2})\lambda
  \]

- Algebraic, graphical and diagrammatic analysis of light using lenses and mirrors

\[
\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad M = \frac{H_i}{H_o} \quad \text{and/or } M = \left|\frac{v}{u}\right|
\]

\[
n_1 \sin \Theta_1 = n_2 \sin \Theta_2 \quad n_1 v_1 = n_2 v_2
\]

- Ohmic conductors — Ohm’s Law and Kirchoff’s Laws in electric circuits
- Resistance combinations in series and parallel networks
- Knowledge and use of circuit symbols: DC–AC sources, earth, switch, lamp, resistor, variable resistor, voltmeter, ammeter, capacitor, diode
- DC behaviour of capacitors and the time constant of a simple RC series circuit, \( \tau = RC \)
- Nature of P- and N-type semiconductors in terms of majority charge carriers and the applications of the PN diode to rectification of AC voltages
- Qualitative and quantitative treatment of motors, generators and alternative energy technologies
- Qualitative and quantitative analysis of the semiconductor applications
- EMF proportional to rate of change of magnetic flux

\[
\phi = BA \cos \theta \quad EMF = BLv \quad EMF = -N\Delta \phi / \Delta t
\]

- Photoelectric effect
- Becquerel’s discovery of radioactivity
- Qualitative treatment of \( \alpha \), \( \beta \) and \( \gamma \) radiation; formation, penetrating power and other properties
Radioactivity

- \( A = \frac{\Delta N}{\Delta t} = -\lambda N \)
- disintegration or decay constant, \( \lambda \)
- interpretation of graphs of activity or number of particles with time
- qualitative treatment of decay law
- half life: \( t_{1/2} = \frac{0.693}{\lambda} \)

- Elementary nuclear reactions in equation form, including fission and fusion
- Calculation of mass defect in atomic mass units and conversion to energy units MeV and MeV per nucleon
- Qualitative treatment of radiation dose (gray, sievert) and effects.

Motion

- Analysis of scalar and vector quantities using algebraic and graphical techniques, e.g. motion, energy, force, momentum
- Problems involving equations for motion, e.g. linear, projectile and circular
  \[
  v = st \\
  v = u + at \\
  s = ut + \frac{1}{2}at^2 \\
  s = (v^2 + u^2) / 2a \\
  a_e = v^2 / r = 4\pi^2r / T^2
  \]

- Momentum and impulse:
  \[
  p = mv(vectorial) \\
  Ft = \Delta p(vectorial)
  \]

- Characteristics of transverse and longitudinal waves
- Relationship between speed and wavelength: \( v = f\lambda \)
- Analysis of reflection, refraction, diffraction
- Analysis of interference, e.g. standing waves, air columns, strings and light, using the following formulas:
  \[
  \text{path difference} = \frac{dx}{L} \\
  \text{constructive: } d \sin \theta = n\lambda \\
  \text{destructive: } d \sin \theta = (n - \frac{1}{2})\lambda
  \]

- Electrostatics
- Qualitative and quantitative analysis of the semiconductor applications
- Qualitative and quantitative treatment of motors, generators and alternative energy technologies
- EMF proportional to rate of change of magnetic flux
  \[
  \phi = BA \cos \theta \\
  EMF = BLv \\
  EMF = -N\Delta \phi / \Delta t
  \]

- Photoelectric effect (KE vs frequency graph and Planck’s Constant)
- Qualitative treatment of \( \alpha, \beta \) and \( \gamma \) radiation; formation, penetrating power and other properties
References


Queensland Schools Curriculum Council 1996, *Years 1 to 10 Science Key Learning Area Syllabus*, Author, Brisbane.
