Engineering 2019 v1.1

General Senior Syllabus

This syllabus is for implementation with Year 11 students in 2019.

Contents

1 Course overview — 1

1.1 Introduction — 1

- 1.1.1 Rationale — 1
- 1.1.2 Learning area structure — 2
- 1.1.3 Course structure — 3

1.2 Teaching and learning — 4

- 1.2.1 Syllabus objectives — 4
- 1.2.2 Underpinning factors — 5
- 1.2.3 Aboriginal perspectives and Torres Strait Islander perspectives — 9
- 1.2.4 Pedagogical and conceptual frameworks — 10
- 1.2.5 Subject matter — 13

1.3 Assessment — general information — 14

- 1.3.1 Formative assessments — Units 1 and 2 — 14
- 1.3.2 Summative assessments — Units 3 and 4 — 14

1.4 Reporting standards — 16

2 Unit 1: Engineering fundamentals and society — 18

2.1 Unit description — 18

2.2 Unit objectives — 19

2.3 Topic 1: Engineering history — 19

2.4 Topic 2: The problem-solving process in Engineering — 20

2.5 Topic 3: Engineering communication — 20

2.6 Topic 4: Introduction to engineering mechanics — 21

2.7 Topic 5: Introduction to engineering materials — 23

2.8 Assessment guidance — 24

3 Unit 2: Emerging technologies — 25

3.1 Unit description — 25

3.2 Unit objectives — 26

3.3 Topic 1: Emerging needs — 26

3.4 Topic 2: Emerging processes and machinery — 27

3.5 Topic 3: Emerging materials — 29

3.6 Topic 4: Exploring autonomy — 30

3.7 Assessment guidance — 31

4 Unit 3: Statics of structures and environmental considerations ____ 32
4.1 Unit description 32
4.2 Unit objectives 33
4.3 Topic 1: Application of the problem-solving process in Engineering 34
4.4 Topic 2: Civil structures and the environment 35
4.5 Topic 3: Civil structures, materials and forces 36
4.6 Assessment 37
4.6.1 Summative internal assessment 1 (IA1): 37
Project — folio (25%) 37
4.6.2 Summative internal assessment 2 (IA2): Examination (25%) 44

5 Unit 4: Machines and mechanisms ____ 49
5.1 Unit description 49
5.2 Unit objectives 50
5.3 Topic 1: Machines in society 50
5.4 Topic 2: Materials 52
5.5 Topic 3: Machine control 53
5.6 Assessment 54
5.6.1 Summative internal assessment 3 (IA3): 54
Project — folio (25%) 54
5.6.2 Summative external assessment (EA): 61
Examination (25%) 61

6 Glossary ____ 64

7 References ____ 92

8 Version history ____ 92

1 Course overview

1.1 Introduction

1.1.1 Rationale

Technologies have been an integral part of society for as long as humans have had the desire to create solutions to improve their own and others' quality of life. Technologies have an impact on people and societies by transforming, restoring and sustaining the world in which we live.

Australia needs enterprising and innovative individuals with the ability to make discerning decisions concerning the development, use and impact of technologies. When developing technologies, these individuals need to be able to work independently and collaboratively to solve complex, open-ended problems. Subjects in the Technologies learning area prepare students to be effective problem-solvers as they learn about and work with contemporary and emerging technologies.

The problem-solving process in Engineering involves the practical application of science, technology, engineering and mathematics (STEM) knowledge to develop sustainable products, processes and services. Engineers use their technical and social knowledge to solve problems in ways that meet the needs of today's individuals, communities, businesses and environments, without compromising the potential needs of future generations. Students who study Engineering develop technical knowledge and problem-solving skills that enable them to respond to and manage ongoing technological and societal change.

Engineering includes the study of mechanics, materials science and control technologies through real-world engineering contexts where students engage in problem-based learning. Students learn to explore complex, open-ended problems and develop engineered solutions. They recognise and describe engineering problems, determine solution success criteria, develop and communicate ideas and predict, generate, evaluate and refine prototype solutions. Students justify their decision-making and acknowledge the societal, economic and environmental sustainability of their engineered solutions. The problem-based learning framework in Engineering encourages students to become self-directed learners and develop beneficial collaboration and management skills.

Engineering provides students with an opportunity to experience, first-hand and in a practical way, the exciting and dynamic work of real-world engineers. Students learn transferrable 21st century skills that support their life aspirations, including critical thinking, creative thinking, communication, collaboration and teamwork, personal and social skills, and information & communication technologies (ICT) skills. The study of Engineering inspires students to become adaptable and resilient. They appreciate the engineer's ability to confidently and purposefully generate solutions that improve the quality of people's lives in an increasingly complex and dynamic technological world.

Assumed knowledge, prior learning or experience

Students will have prior knowledge of the Australian Curriculum: Technologies in Years 7 and 8. Similarly, students will have studied the Australian Curriculum: Mathematics and the Australian Curriculum: Science in Years 9 and 10. The areas of study and subject matter draw on engineering, technology, science and mathematics knowledge.

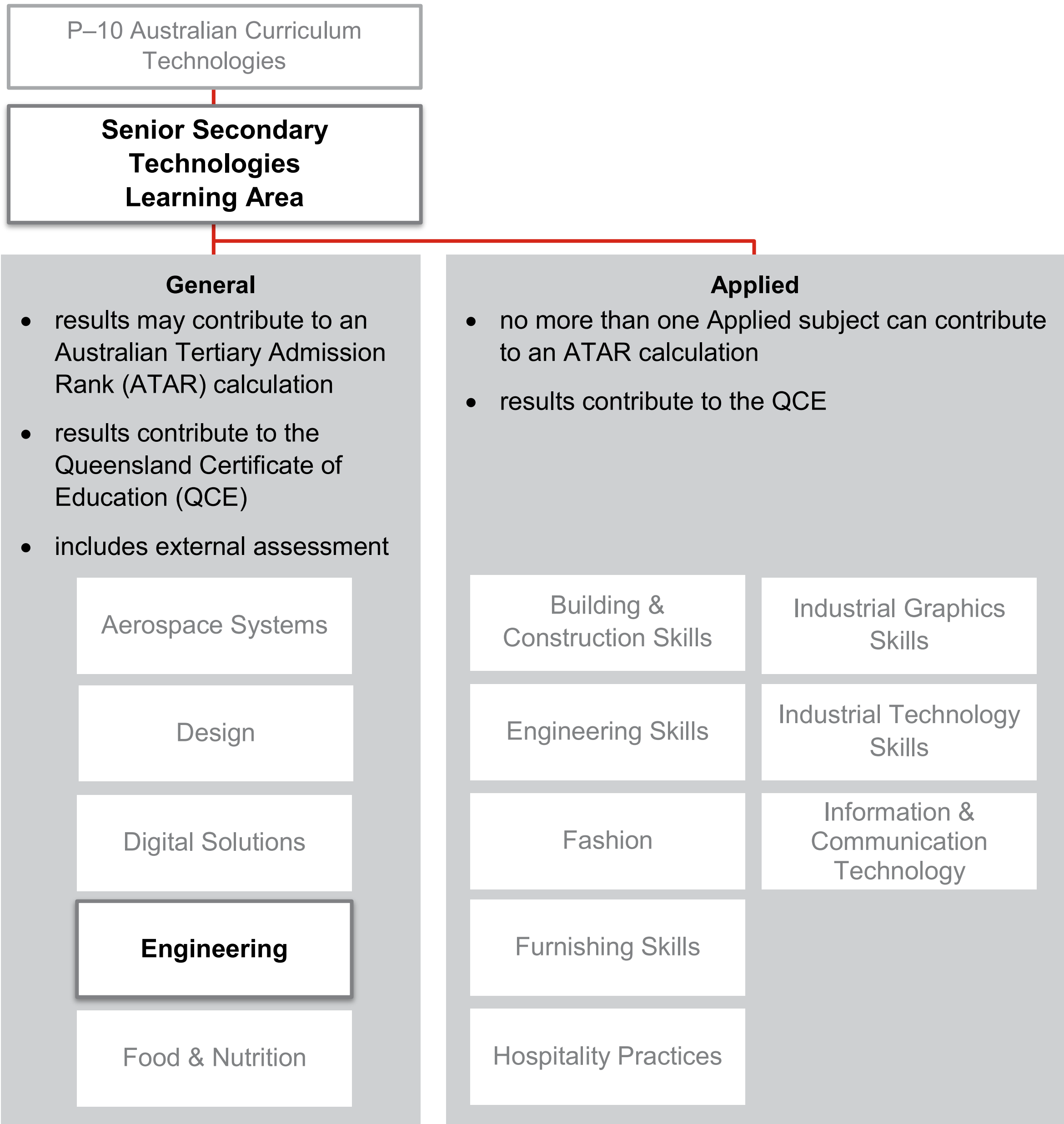
Pathways

Engineering is a General subject suited to students who are interested in pathways beyond school that lead to tertiary studies, vocational education or work. A course of study in Engineering can establish a basis for further education and employment in the field of engineering, including, but not limited to, civil, mechanical, mechatronic, electrical, aerospace, mining, process, chemical, marine, biomedical, telecommunications, environmental, micro-nano and systems. The study of engineering will also benefit students wishing to pursue post-school tertiary pathways that lead to careers in architecture, project management, aviation, surveying and spatial sciences.

1.1.2 Learning area structure

All learning areas build on the P–10 Australian Curriculum.

Figure 1: Learning area structure



1.1.3 Course structure

Engineering is a course of study consisting of four units. Subject matter, learning experiences and assessment increase in complexity from Units 1 and 2 to Units 3 and 4 as students develop greater independence as learners.

Units 1 and 2 provide foundational learning, which allows students to experience all syllabus objectives and begin engaging with the course subject matter. Students should complete Units 1 and 2 before beginning Unit 3. It is recommended that Unit 3 be completed before Unit 4.

Units 3 and 4 consolidate student learning. Only the results from Units 3 and 4 will contribute to ATAR calculations.

Figure 2 outlines the structure of this course of study.

Each unit has been developed with a notional time of 55 hours of teaching and learning, including assessment.

Figure 2: Course structure

Engineering

Unit 1
Engineering fundamentals and society

- Topic 1: Engineering history
- Topic 2: The problem-solving process in Engineering
- Topic 3: Engineering communication
- Topic 4: Introduction to engineering mechanics
- Topic 5: Introduction to engineering materials

Assessment

Formative internal assessment/s

Unit 2
Emerging technologies

- Topic 1: Emerging needs
- Topic 2: Emerging processes and machinery
- Topic 3: Emerging materials
- Topic 4: Exploring autonomy

Assessment

Formative internal assessment/s

Students should have opportunities in Units 1 and 2 to experience and respond to the types of assessment they will encounter in Units 3 and 4.

For reporting purposes, schools should develop at least *one* assessment per unit, with a maximum of *four* assessments across Units 1 and 2.

Unit 3
Statics of structures and environmental considerations

- Topic 1: Application of the problem-solving process in Engineering
- Topic 2: Civil structures and the environment
- Topic 3: Civil structures, materials and forces

Assessment

Summative internal assessment 1:

Project — folio (25%)

Summative internal assessment 2:

Examination (25%)

Unit 4
Machines and mechanisms

- Topic 1: Machines in society
- Topic 2: Materials
- Topic 3: Machine control

Assessment

Summative internal assessment 3:

Project — folio (25%)

Summative external assessment:

Examination (25%)

1.2 Teaching and learning

1.2.1 Syllabus objectives

The syllabus objectives outline what students have the opportunity to learn. Assessment provides evidence of how well students have achieved the objectives.

Syllabus objectives inform unit objectives, which are contextualised for the subject matter and requirements of the unit. Unit objectives, in turn, inform the assessment objectives, which are further contextualised for the requirements of the assessment instruments. The number of each objective remains constant at all levels, i.e. Syllabus objective 1 relates to Unit objective 1 and to Assessment objective 1 in each assessment instrument.

Syllabus objectives are described in terms of actions that operate on the subject matter. Students are required to use a range of cognitive processes in order to demonstrate and meet the syllabus objectives. These cognitive processes are described in the explanatory paragraph following each objective in terms of four levels: retrieval, comprehension, analytical processes (analysis), and knowledge utilisation, with each process building on the previous processes (see Marzano & Kendall 2007, 2008). That is, comprehension requires retrieval, and knowledge utilisation requires retrieval, comprehension and analytical processes (analysis).

By the conclusion of the course of study, students will:

Syllabus objective	Unit 1	Unit 2	Unit 3	Unit 4
1. recognise and describe engineering problems, knowledge, concepts and principles	●	●	●	●
2. symbolise and explain ideas and solutions	●	●	●	●
3. analyse problems and information	●	●	●	●
4. determine solution success criteria for engineering problems	●	●	●	●
5. synthesise information and ideas to predict possible solutions	●	●	●	●
6. generate prototype solutions to provide data to assess the accuracy of predictions	●	●	●	●
7. evaluate and refine ideas and solutions to make justified recommendations	●	●	●	●
8. make decisions about and use mode-appropriate features, language and conventions for particular purposes and contexts.	●	●	●	●

1. recognise and describe engineering problems, knowledge, concepts and principles

When students recognise engineering problems, knowledge, concepts and principles, they identify or recall related engineering technology knowledge, including mathematical calculations, and science and control technologies concepts and principles. When students describe they give an account of the characteristics or features of problems, knowledge, concepts and principles.

2. symbolise and explain ideas and solutions

When students symbolise, they represent idea and solution development in sketches, drawings, diagrams, models, tables and/or schemas. When students explain, they use knowledge, understanding and reasoning to make ideas, solutions and interrelationships plain or clear by describing them in more detail or revealing relevant facts.

3. **analyse problems and information**

   When students analyse problems and information, they research and investigate to explain and interpret, for the purpose of finding meaning or relationships. They determine the reasonableness of information and ascertain patterns, similarities and differences in order to identify elements, components and features, and their relationship to the structure of problems.

4. **determine solution success criteria for engineering problems**

   When students determine solution success criteria for engineering problems, they establish, conclude or ascertain solution needs and constraints, or requirements after consideration of elements, components and features, and their relationship to the structure of problems.

5. **synthesise information and ideas to predict possible solutions**

   When students synthesise information and ideas to predict possible solutions, they combine and integrate information and ideas, and resolve uncertainties using knowledge of materials science, mechanics and control technologies, and knowledge gained through investigation, collaboration and testing to create new understanding.

6. **generate prototype solutions to provide data to assess the accuracy of predictions**

   When students generate prototype solutions, they produce a trial solution, that when tested, provides data to assess the precision of predictions made.

7. **evaluate and refine ideas and solutions to make justified recommendations**

   When students evaluate, they appraise ideas and solutions by weighing up or assessing strengths, implications and limitations against success criteria. When students refine ideas and solutions, they modify to make improvements relative to success criteria. They use data, provided by testing, to evaluate and refine ideas and solutions. When students make justified recommendations, they put forward a point of view or suggestion with supporting evidence to make enhancements.

8. **make decisions about and use mode-appropriate features, language and conventions for particular purposes and contexts**

   When students make decisions about mode-appropriate features and conventions, they use written, visual, and spoken features to express meaning for particular purposes in a range of contexts. Written communication includes language conventions, specific vocabulary and language features such as annotations, paragraphs, and sentences. Visual communication includes photographs, sketches, drawings, diagrams and motion graphics. Spoken communication includes verbal and nonverbal features and may be for live or virtual audiences. Students use referencing conventions to practise ethical scholarship for particular purposes.

1.2.2 Underpinning factors

There are three skill sets that underpin senior syllabuses and are essential for defining the distinctive nature of subjects:

- literacy — the set of knowledge and skills about language and texts essential for understanding and conveying Engineering content
- numeracy — the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations, to recognise and understand the role of mathematics in the world, and to develop the dispositions and capacities to use mathematical knowledge and skills purposefully

- 21st century skills — the attributes and skills students need to prepare them for higher education, work and engagement in a complex and rapidly changing world.

These skill sets, which overlap and interact, are derived from current education, industry and community expectations and encompass the knowledge, skills, capabilities, behaviours and dispositions that will help students live and work successfully in the 21st century.

Together these three skill sets shape the development of senior subject syllabuses. Although coverage of each skill set may vary from syllabus to syllabus, students should be provided with opportunities to learn through and about these skills over the course of study. Each skill set contains identifiable knowledge and skills that can be directly assessed.

Literacy in Engineering

Engineering requires students to develop literacy skills that facilitate the effective communication of graphical and technical information, ideas and solutions to complex problems. Effective communication in Engineering requires students to learn how to organise and manipulate information in logical sequences to convey meaning to particular audiences for specific purposes. Students develop and enhance this capacity through their learning experiences and by documenting the problem-solving process in Engineering using a folio. They improve their ability to use knowledge of language conventions, textual features and mode-appropriate communication skills as they progress through the course of study.

These aspects of literacy knowledge and skills are embedded in the syllabus objectives, unit objectives and subject matter, and instrument-specific marking guides (ISMGs) for Engineering.

Numeracy in Engineering

The study of Engineering requires students to use and enhance their knowledge of mathematic and scientific formulas, concepts and principles. Students develop their ability to apply science, mathematics and engineering understandings in order to predict prototype solutions. They use calculations that determine failure, non-failure limits and solution performance data. Students interpret graphical information and use their spatial knowledge to represent problems, ideas and solutions. They demonstrate their mathematical ability to calculate; interpret and draw conclusions from statistics; and measure, record and use data to make decisions throughout the units of study.

These aspects of numeracy knowledge and skills are embedded in the syllabus objectives, unit objectives and subject matter, and ISMGs for Engineering.

21st century skills

The 21st century skills identified in this syllabus reflect a common agreement, both in Australia and internationally, on the skills and attributes students need to prepare them for higher education, work and engagement in a complex and rapidly changing world.

21st century skills	Associated skills	21st century skills	Associated skills
critical thinking	• analytical thinking • problem-solving • decision-making • reasoning • reflecting and evaluating • intellectual flexibility	creative thinking	• innovation • initiative and enterprise • curiosity and imagination • creativity • generating and applying new ideas • identifying alternatives • seeing or making new links
communication	• effective oral and written communication • using language, symbols and texts • communicating ideas effectively with diverse audiences	collaboration and teamwork	• relating to others (interacting with others) • recognising and using diverse perspectives • participating and contributing • community connections
personal and social skills	• adaptability/flexibility • management (self, career, time, planning and organising) • character (resilience, mindfulness, open- and fair-mindedness, self-awareness) • leadership • citizenship • cultural awareness • ethical (and moral) understanding	information & communication technologies (ICT) skills	• operations and concepts • accessing and analysing information • being productive users of technology • digital citizenship (being safe, positive and responsible online)

Engineering helps develop the following 21st century skills:

- critical thinking
  - problem-solving using the problem-solving process in Engineering
  - analytical thinking in identifying the elements, components and features, and their relationship to the structure of problems to determine success criteria
  - decision-making by predicting solutions and making justified recommendations
  - intellectual flexibility by being open to alternative ideas and new learning
  - evaluating ideas and solutions using success criteria

- communication
  - using effective oral, written and visual communication, and using language, symbols and texts to communicate ideas, solutions and information to specified audiences
  - manipulating and using specialised language, terminology, symbols and diagrams to communicate in engineering contexts
- personal and social skills
  - developing personal, social, ethical, economic and environmental understandings in engineering contexts
  - demonstrating adaptability and flexibility to create engineered solutions in a range of engineering contexts
  - developing the ability to self-manage (time, planning and organising) during problem-solving
  - developing and enhancing the personal characteristics of resilience, mindfulness, open- and fair-mindedness, and self-awareness during problem-solving
- creative thinking
  - generating and applying new ideas to create and identify strategies that enhance opportunities for developing innovative solutions
  - demonstrating initiative and enterprise to be self-directed in learning and problem-solving
  - demonstrating curiosity and imagination to motivate learning in engineering contexts
  - synthesising information and ideas to create new understanding
  - evaluating and refining ideas and solutions to identify alternative possibilities and make new links to knowledge
- collaboration and teamwork
  - relating and interacting with others to solve problems in engineering contexts
  - recognising and using diverse perspectives to determine the social, ethical, economic, legal and environmental impacts of engineered solutions
  - participating and contributing to create personal, team and community connections
- information & communication technologies (ICT) skills
  - accessing, collating, evaluating, analysing and presenting information including performance data in spreadsheets, tables and graphs
  - being productive users of information & communication technologies (ICT) to manipulate digital information to effectively communicate development of solutions to a specified audience.

These elements of 21st century skills are embedded in the syllabus objectives, unit objectives and subject matter, and ISMGs for Engineering.

1.2.3 Aboriginal perspectives and Torres Strait Islander perspectives

The QCAA is committed to reconciliation in Australia. As part of its commitment, the QCAA affirms that:

- Aboriginal peoples and Torres Strait Islander peoples are the first Australians, and have the oldest living cultures in human history
- Aboriginal peoples and Torres Strait Islander peoples have strong cultural traditions and speak diverse languages and dialects, other than Standard Australian English
- teaching and learning in Queensland schools should provide opportunities for students to deepen their knowledge of Australia by engaging with the perspectives of Aboriginal peoples and Torres Strait Islander peoples
- positive outcomes for Aboriginal students and Torres Strait Islander students are supported by successfully embedding Aboriginal perspectives and Torres Strait Islander perspectives across planning, teaching and assessing student achievement.

Guidelines about Aboriginal perspectives and Torres Strait Islander perspectives and resources for teaching are available at www.qcaa.qld.edu.au/k-12-policies/aboriginal-torres-strait-islander-perspectives.

Where appropriate, Aboriginal perspectives and Torres Strait Islander perspectives have been embedded in the subject matter.

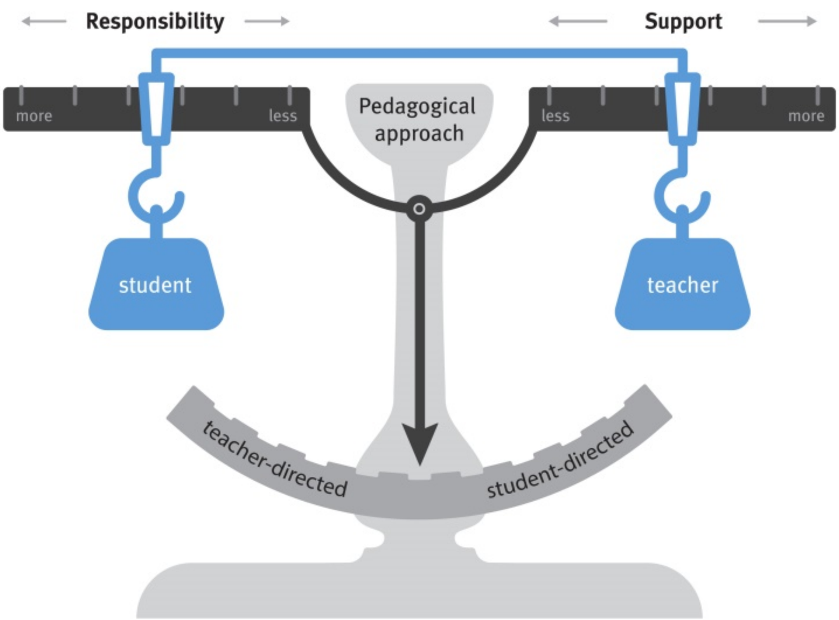
In Engineering, opportunities exist across all four units for student exploration of Aboriginal perspectives and Torres Strait Islander perspectives during problem-solving. Students gain an appreciation for and an understanding of Aboriginal peoples' and Torres Strait Islander peoples' communities and cultures as they develop, generate, evaluate and refine sustainable engineered solutions. These solutions should be developed respectfully in recognition of the inherent connectedness of Aboriginal peoples' and Torres Strait Islander peoples' culture, history, society and place, including plants and animals, and lead to improvements in the quality of people's lives in an increasingly complex and dynamic technological world.

1.2.4 Pedagogical and conceptual frameworks

Problem-based learning framework

In the Technologies learning area, the problem-based learning framework (as represented in Figure 3) provides the overarching pedagogical basis for the implementation of subject-specific problem-solving processes. Problem-based learning places students in real-world situations where they use skills associated with critical thinking, creative thinking, communication, collaboration and teamwork, personal and social interactions and information & communication technologies (ICT) in order to develop solutions that acknowledge personal, social, ethical, economic, environmental, legal and sustainability impacts.

Figure 3: Problem-based learning framework in the Technologies learning area



In Engineering:

- problem-based learning is an active process of knowledge construction that uses open-ended problems as a stimulus for student learning
- problems that support problem-based learning should
  - challenge and motivate students to engage their interest
  - provide opportunities for students to examine the problem from multiple perspectives or disciplines
  - provide multiple possible solutions and solution paths
  - require students to comprehend and use a breadth and depth of knowledge during problem-solving
  - recognise students' prior knowledge
  - recognise students' stage of cognitive development
  - provide opportunities to allow all students to explore innovative open-ended solutions
  - relate to the real world

- the learning environment is organised to represent the complex nature of the problems students are required to solve, e.g. the learning area values collaboration using teamwork and brainstorming, as these are strategies used during real-world problem-solving
- the teacher is responsible for scaffolding student learning and cognition during problem-solving as a coach, guide or facilitator to maintain the independence and self-directedness of student learning
- self-directed learning does not mean students are self-taught; instead, teachers balance their participation so that students maintain responsibility for learning, e.g. students make decisions about the knowledge and skills they require to effectively solve a problem, supported by the teacher's questioning and cueing strategies
- the perception of student self-direction in the learning process is fundamental to problem-based learning.

Engineering problems

Central to problem-based learning is the provision or identification of suitably challenging, subject-specific, context-relevant, real-world problems. Student engagement with these problems facilitates student learning of engineering subject matter. Problems suitable for Engineering:

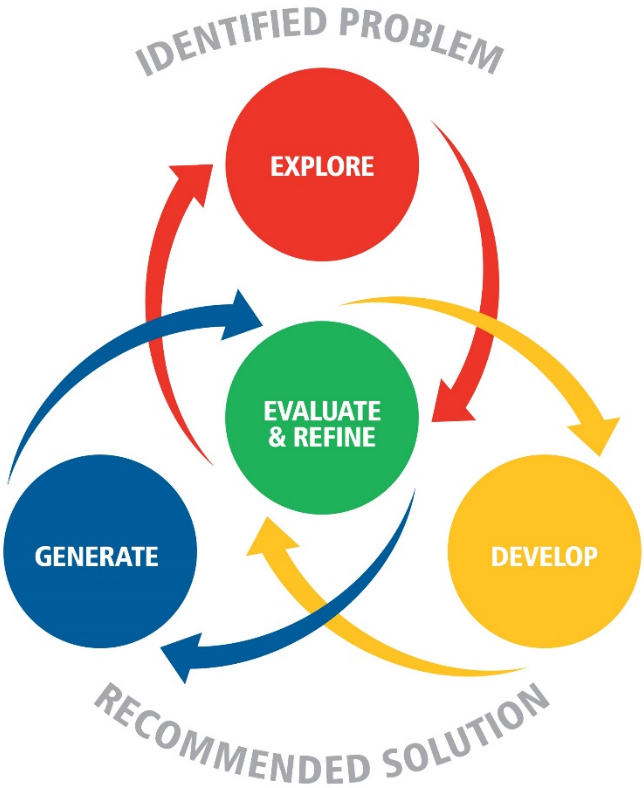
- are identified by students and/or by others in situations related to unit-specific and subject-relevant core engineering concepts and principles
- promote purposeful analytical activities undertaken in response to an identified real-world related problem that requires an engineered solution
- require the use of STEM knowledge to develop, generate and test solutions
- are resolved using the problem-solving process.

The problem-solving process in Engineering

The problem-solving process in Engineering is analytical and technical in nature. The process is iterative and proceeds through a number of phases, requiring students to recognise and describe problems. They analyse problems and information to determine solution success criteria, which provide a benchmark for possible engineered solutions. Students use knowledge of science, technology, engineering and mathematics (STEM) to develop and test a range of ideas. Students make decisions to select a prototype solution for analysis, testing and refinement prior to generation. They use data, provided by testing the generated prototype solution, to evaluate performance and make justified recommendations for future improvements.

The problem-solving process in Engineering involves student engagement with the four phases of explore, develop, generate, and evaluate and refine.

Figure 4: The problem-solving process in Engineering



To explore the problem, students:

- recognise and describe characteristics of the problem and determine their importance
- analyse the problem and associated engineering technology information to identify the elements, components and features, and their relationship to the structure of the problem
- research and investigate similar problem situations or solutions to understand the nature of the problem (i.e. best engineering practice)
- recognise the STEM knowledge known and unknown in relation to the problem
- test and/or calculate to understand the engineering fundamentals of the problem
- determine solution success criteria (i.e. needs and constraints, or requirements) considering the identified elements, components and features, and their relationship to the structure of the problem.

To develop ideas, students:

- evaluate idea development using solution success criteria
- brainstorm and discuss ideas with colleagues through teamwork and collaboration
- sketch ideas
- calculate to determine the limits for prototype solution development
- test materials and processes to support idea development
- synthesise ideas
- prototype ideas for testing and refinement

- review solution success criteria
- predict a solution.

To generate solutions, students:

- project manage the generation of the prototype solution
- create drawings that demonstrate an understanding of the Australian standards for engineering drawings — either manual or using computer-aided drafting (CAD) — to facilitate generation of a prototype solution
- communicate the processes proposed to generate the prototype solution
- calculate to predict prototype solution performance and communicate data for an audience using diagrams, tables and spreadsheets
- resolve uncertainties to refine the prototype solution
- generate the prototype solution using processes including 3D printing, laser cutting, hand and/or machine manufacture and virtual production.

To evaluate and refine, students:

- perform testing of the prototype solution, including destructive and non-destructive testing, substitution and simulation to provide performance data
- evaluate the prototype solution using solution success criteria and performance data
- reanalyse test results
- consider sustainability and reliability issues
- make and justify recommendations to improve prototype solution performance.

1.2.5 Subject matter

Subject matter is the body of information, mental procedures and psychomotor procedures (see Marzano & Kendall 2007, 2008) that are necessary for students' learning and engagement with Engineering. It is particular to each unit in the course of study and provides the basis for student learning experiences.

Subject matter has a direct relationship to the unit objectives, but is of a finer granularity and is more specific. These statements of learning are constructed in a similar way to objectives. Each statement:

- describes an action (or combination of actions) — what the student is expected to do
- describes the element — expressed as information, mental procedures and/or psychomotor procedures
- is contextualised to the topic or circumstance particular to the unit.

The study of mechanics, materials science, control technologies and problem-solving forms the basis for subject matter in Engineering. Students explore complex, open-ended problems to develop, generate, evaluate and refine engineered solutions. Each unit introduces students to the knowledge and skills pertinent to the course of study, which are experienced in a range of engineering contexts.

1.3 Assessment — general information

Assessments are formative for Units 1 and 2, and summative for Units 3 and 4.

Assessment	Unit 1	Unit 2	Unit 3	Unit 4
Formative assessments	●	●		
Summative internal assessment 1			●	
Summative internal assessment 2			●	
Summative internal assessment 3				●
Summative external assessment				●

1.3.1 Formative assessments — Units 1 and 2

Formative assessments provide feedback to both students and teachers about each student's progress in the course of study.

Schools develop internal assessments for each senior subject based on the learning described in Units 1 and 2 of the subject syllabus. Each unit objective must be assessed at least once.

For reporting purposes, schools should devise at least *two* but no more than *four* assessments for Units 1 and 2 of this subject. At least *one* assessment must be completed for *each* unit.

The sequencing, scope and scale of assessments for Units 1 and 2 are matters for each school to decide and should reflect the local context.

Teachers are encouraged to use the A–E descriptors in the reporting standards (Section 1.4) to provide formative feedback to students and to report on progress.

1.3.2 Summative assessments — Units 3 and 4

Students will complete a total of *four* summative assessments — three internal and one external — that count towards their final mark in each subject.

Schools develop *three* internal assessments for each senior subject, based on the learning described in Units 3 and 4 of the syllabus.

The three summative internal assessments will be endorsed and the results confirmed by the QCAA. These results will be combined with a single external assessment developed and marked by the QCAA. The external assessment results for Engineering will contribute 25% towards a student's result.

Summative internal assessment — instrument-specific marking guides

This syllabus provides ISMGs for the three summative internal assessments in Units 3 and 4.

The ISMGs describe the characteristics evident in student responses and align with the identified assessment objectives. Assessment objectives are drawn from the unit objectives and are contextualised for the requirements of the assessment instrument.

Criteria

Each ISMG groups assessment objectives into criteria. An assessment objective may appear in multiple criteria, or in a single criterion of an assessment.

Making judgments

Assessment evidence of student performance in each criterion is matched to a performance level descriptor, which describes the typical characteristics of student work.

Where a student response has characteristics from more than one performance level, a best-fit approach is used. Where a performance level has a two-mark range, it must be decided if the best fit is the higher or lower mark of the range.

Authentication

Schools and teachers must have strategies in place for ensuring that work submitted for internal summative assessment is the student's own. Authentication strategies outlined in QCAA guidelines, which include guidance for drafting, scaffolding and teacher feedback, must be adhered to.

Summative external assessment

The summative external assessment adds valuable evidence of achievement to a student's profile. External assessment is:

- common to all schools
- administered under the same conditions at the same time and on the same day
- developed and marked by the QCAA according to a commonly applied marking scheme.

The external assessment contributes 25% to the student's result in Engineering. It is not privileged over the school-based assessment.

1.4 Reporting standards

Reporting standards are summary statements that succinctly describe typical performance at each of the five levels (A–E). They reflect the cognitive taxonomy and objectives of the course of study.

The primary purpose of reporting standards is for twice-yearly reporting on student progress. These descriptors can also be used to help teachers provide formative feedback to students and to align ISMGs.

Reporting standards

A
The student, for a range of engineering situations, demonstrates: accurate and discriminating recognition and discerning description of engineering problems, knowledge, concepts and principles; adept symbolisation and discerning explanation of ideas and solutions. The student demonstrates insightful analysis of problems and relevant information, and astute determination of essential solution success criteria. The student demonstrates: coherent and logical synthesis of relevant information and ideas to predict possible solutions; critical evaluation and discerning refinement of ideas and solutions using success criteria to make astute recommendations justified by evidence; purposeful generation of solutions to provide valid data to critically assess the accuracy of predictions; discerning decision-making about, and fluent use of, mode-appropriate features, language and conventions to communicate development of solutions for purpose.
B
The student, for a range of engineering situations, demonstrates: accurate recognition and effective description of engineering problems, knowledge, concepts and principles; methodical symbolisation and effective explanation of ideas and solutions. The student demonstrates considered analysis of problems and relevant information, and logical determination of effective solution success criteria. The student demonstrates: logical synthesis of relevant information and ideas to predict possible solutions; reasoned evaluation and effective refinement of ideas and solutions using success criteria to make considered recommendations justified by evidence; effective generation of solutions to provide valid data to effectively assess the accuracy of predictions; effective decision-making about, and proficient use of, mode-appropriate features, language and conventions to communicate development of solutions for purpose.
C
The student, for a range of engineering situations, demonstrates: appropriate recognition and description of engineering problems, knowledge, concepts and principles; competent symbolisation and appropriate explanation of ideas and solutions. The student demonstrates appropriate analysis of problems and information, and reasonable determination of some solution success criteria. The student demonstrates: simple synthesis of information and ideas to predict possible solutions; feasible evaluation and adequate refinement of ideas and solutions using some success criteria to make fundamental recommendations justified by evidence; adequate generation of solutions to provide relevant data to assess the accuracy of predictions; appropriate decision-making about, and use of, mode-appropriate features, language and conventions to communicate development of solutions for purpose.

D
The student, for a range of engineering situations, demonstrates: variable recognition and superficial description of aspects of problems, concepts or principles; variable symbolisation or superficial explanation of aspects of ideas or solutions. The student demonstrates superficial analysis of problems and partial information, and vague determination of some solution success criteria. The student demonstrates: rudimentary synthesis of partial information or ideas to predict solutions; superficial evaluation of ideas or solutions using some success criteria to make elementary recommendations; partial generation of solutions to provide elements of data to partially assess the accuracy of predictions; variable decision-making about, and inconsistent use of, mode-appropriate features, language and conventions to communicate.

E
The student, for a range of engineering situations, demonstrates recognition of aspects of problems, concepts or principles, and disjointed symbolisation or explanation of aspects of ideas or solutions. The student demonstrates the making of statements about problems, concepts or principles. The student demonstrates: unclear combinations of information or ideas; identification of a change to an idea or a solution; generation of elements of solutions; unclear or fragmented use of mode-appropriate features, language and conventions.

2 Unit 1: Engineering fundamentals and society

2.1 Unit description

In Unit 1, students learn about engineering's role in solving global and local societal problems in order to improve the human condition. Students are introduced to the problem-solving process in Engineering. They learn how to use their knowledge of fundamental mechanics and materials science concepts and principles to solve problems in ways that meet human needs while considering the economic, social, ethical, legal and environmental impacts of their solutions. Students explore the history of engineering, including ancient Egyptian, Grecian and Roman structures, to gain an appreciation for the role played by engineering in the shaping of contemporary and future societies. Students engage in practical engineering activities to learn that engineering is an applied practical discipline that uses science and mathematics concepts and principles to solve real-world problems. Students are introduced to engineering drawings that communicate ideas to a technical and non-technical audience. Students participate in a range of individual and collaborative group activities, including those associated with material and process testing, analysis of the forces acting on basic structures, and problem-solving.

Unit requirements

In this unit, teachers combine and balance direct instruction with instruction developed using the various phases of the problem-solving process in Engineering. Teachers should provide students with appropriately structured real-world problems or situations that enable them to experience the associated engineering concepts and principles. Students should be provided with opportunities to collaboratively make decisions in groups as they learn about and through problem-solving.

Notional time allocation by topic and assessment

	Unit topic	Notional hours
Topic 1	Engineering history	3
Topic 2	The problem-solving process in Engineering	6
Topic 3	Engineering communication	8
Topic 4	Introduction to engineering mechanics	10
Topic 5	Introduction to engineering materials	8
Assessment integrated within the unit		20

2.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

1. recognise and describe mechanical and structural problems, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to engineering fundamentals and society
2. symbolise and explain ideas and solutions in relation to engineering fundamentals and society
3. analyse mechanical and structural problems, and information in relation to engineering fundamentals and society
4. determine solution success criteria for mechanical and structural problems
5. synthesise information and ideas to predict possible mechanical and structural solutions
6. generate mechanical and structural prototype solutions to provide data to assess the accuracy of predictions
7. evaluate and refine ideas and solutions to make justified recommendations
8. make decisions about and use mode-appropriate features, language and conventions to communicate development of solutions.

2.3 Topic 1: Engineering history

Guiding question: How has engineering in the past informed contemporary engineering practice?

Subject matter
In this topic, students will: • explore the implications of an engineered solution developed by an ancient civilisation, e.g. Egyptians, Greeks or Romans, including – materials, including timber, stone, bronze and iron – structures, e.g. bridges, dams, buildings and roads – technologies, e.g. military engineering and power technologies • investigate the historic development of an engineering field, e.g. civil, mechanical, electrical, telecommunication or transport • recognise engineering career pathways in civil, mechanical and electrical engineering • identify current and future opportunities in three engineering professions selected from micro-nano, chemical, aerospace, environmental, biomedical, space, processing, software and mechatronics engineering • recognise the role played by engineering in supporting communities and improving peoples' lives • recognise and describe ethical engineering practice as defined by the Engineers Australia *Code of Ethics* (2017) for engineering practice • explore the social, economic and environmental contributions of an engineered solution to a global or local problem, e.g. air and road transportation safety or environmental pollution.

2.4 Topic 2: The problem-solving process in Engineering

Guiding question: What processes are used to develop and create engineered solutions?

Subject matter
In this topic, students will: • recognise the problem-solving process in Engineering • solve basic problems using the problem-solving process in Engineering, e.g. create a paper crane to support a given load, create a paper bridge to self-support across a given span • explore the phases of the problem-solving process in Engineering • use collaboration and brainstorming strategies to develop ideas to solve a problem, e.g. an identified school community problem • use sketching techniques to represent ideas.

2.5 Topic 3: Engineering communication

Guiding question: Engineers communicate to achieve purpose. What knowledge and skills are needed to communicate to various audiences in engineering?

Subject matter

In this topic, students will:
• identify and describe different types of engineering communication, including annotations and callouts in sketches and engineering drawings, folio structure and format, and summary report for a specified client
• explore fundamental concepts of engineering communication, including scale, units, layout, title, orientation, parts list and the level of drawing detail required to support production
• recognise Australian Standards for engineering drawings, including a basic understanding of the purpose of *Technical Drawing: Part 101 — General principles* (AS1100.101–1992), *Technical Drawing: Part 201 — Mechanical engineering drawing* (AS1100.201-1992) and *Technical Drawing: Part 501 — Structural engineering drawing* (AS/NZS1100.501:2002), which is to
  – provide technical conventions for all Australian engineers, architects, designers, surveyors and patternmakers to follow
  – provide a common technical and graphical language that simplifies communication and reduces the need for extensive annotations in drawings
• investigate sketching and basic drawing standards using simple exercises and engineering problems, e.g. community seating, wheel chair locking device for use in public transport, including
  – line quality, including straights and curves
  – plane and solid shapes
  – orthographic
  – isometric and oblique views
  – joint detail, e.g. truss joints
  – assembly
• recognise and interpret drawings, including orthographic, pictorial, electrical and control circuits
• investigate the use of force diagrams (also referred to as free-body diagrams) used in the calculation of force vectors for bodies in equilibrium
• recognise CAD and identify a number of software programs used to communicate various engineering information in 2D and 3D platforms

Subject matter
• contrast CAD with other methods of engineering communication, including sketching and drawing • generate rudimentary engineering objects/products using basic drawing standards, including – dimensioning – orthographic – pictorial (isometric) • create a basic spreadsheet using provided data, e.g. results of materials analysis • classify datasets and use basic spreadsheet formulas, including performance index weight of project ($\frac{\text{weight held}}{\text{weight of project}}$), weight and strength of materials • represent data in tabular form • generate a graph from multiple datasets • explore the documentation required in a folio, including how to explore problems and generate ideas using brainstorming and sketching communication strategies.

2.6 Topic 4: Introduction to engineering mechanics

Guiding question: How can knowledge of engineering mechanics inform engineered solutions to problems?

Subject matter

In this topic, students will:

- define engineering mechanics, engineering statics, engineering dynamics, mass, force and matter
- examine Newton's three laws
- recognise common engineering quantities, SI units and symbols as outlined in the table below

Quantity (symbol)	SI unit (symbol)	Quantity (symbol)	SI unit (symbol)
acceleration (*a*)	metre per second squared (m/s^2)	modulus of elasticity or Young's modulus (*E*)	pascal (Pa)
area (*A*)	square metre (m^2)	moment of force or torque (τ)	newton metre (N m)
density or mass density (ρ)	kilogram per cubic metre (kg/m^3)	power (*P*)	watt (W)
electric charge (Q)	coulomb (C)	pressure (*P*)	pascal (Pa)
electric current (I)	ampere (A)	speed (υ)	metres per second (m/s)
electric potential (φ)	volt (V)	stress (σ)	pascal (Pa)
electric resistance (*R*)	ohm (Ω)	volume (V)	cubic metre (m^3)
force (*F*)	newton (N)	work (*W*), energy (*E*), amount of heat (Q)	joule (J)

- define the characteristics of a force, including
  - $force = mass \times acceleration$
  - push or pull exerted by one body on another
  - characterised by magnitude, direction and point of application
- comprehend components of a force, including
  - differentiate and relate force, gravity, mass, density and weight

Subject matter

$density = \frac{mass}{volume}$

- calculate unknown forces using Pythagoras' theorem

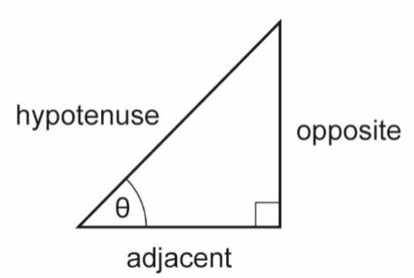
  $a^2 + b^2 = c^2$

- calculate horizontal and vertical components using trigonometry and graphical methods

  $horizontal\ component\ F_H = F\cos\theta$

  $vertical\ component\ F_V = F\ \sin\theta$

  $F_T = \sqrt{{F_H}^2 + {F_V}^2}\ and\ \tan\theta = \frac{F_V}{F_H}$



  $\sin\theta = \frac{opposite\ side}{hypotenuse}$

  $\cos\theta = \frac{adjacent\ side}{hypotenuse}$

  $\tan\theta = \frac{opposite\ side}{adjacent\ side}$

- define concurrent forces, non-concurrent forces, coplanar forces and collinear forces
- define transmissibility of a force
- represent simple problems graphically using free-body diagrams and force diagrams

- comprehend scalar and vector quantities, including
  - define a scalar quantity
  - define a vector quantity
  - communicate scalar and vector quantities in graphical form
  - determine the resultant/equilibrant using graphical and mathematical methods
  - calculate addition of vectors
  - identify the conditions of equilibrium
- comprehend moments, including
  - define a moment
  - explore the uses of moments to calculate unknowns
  - calculate a moment using the formula
    - $M = Fd$
  - calculate addition of moments using the formula
    - $M_T = M_1 + M_2 + M_3 + \cdots$
  - determine a moment of a couple
  - determine reactions at supports with only vertical loading considered
- comprehend the resultant of non-concurrent forces, including
  - determine the resultant of simple forces on beams
  - determine the resultant of multiple forces on beams (point of application and angle of force to the beam)
- conduct experiments on simple truss frame forms to identify tensile and compressive forces
- determine how structures transfer forces.

2.7 Topic 5: Introduction to engineering materials

Guiding question: What impacts do material properties have on decisions made about ideas and solutions?

Subject matter

In this topic, students will:

- classify materials, including
  - recognise and describe how engineers classify materials into metals and alloys, composite materials, ceramics and natural materials
- comprehend structure of the solid state of materials, including
  - recognise, describe and compare solids, liquids and gases
- investigate primary bonding, i.e. ionic, covalent, metallic
- recognise the properties of engineering materials, including those outlined below

Class	Property	Class	Property
physical	dimensions, shape	mechanical	strength: tension, compression, shear and flexure (under static, impact or fatigue conditions)
	density or specific gravity		stiffness, toughness
	porosity		elasticity, plasticity
	moisture content		ductility, brittleness
	macrostructure		hardness, wear resistance
	microstructure		
chemical	oxide or compound	thermal	specific heat
	composition		expansion
	acidity or alkalinity		conductivity
	resistance to corrosion or weathering		
physio-chemical	water-absorptive or water repellent action	electrical and magnetic	conductivity
	shrinkage and swell due to moisture changes		magnetic permeability
			galvanic action
acoustical	sound transmission	optical	colour
	sound reflection		light transmission
			light reflection

- comprehend the effects of materials processing and manufacturing techniques on grain structure in the context of two of the following (cold and hot working, annealing, casting and forging, welding, rolling and extrusion)
- identify features of a stress vs. strain graph, including stress, strain, stiffness, ultimate tensile strength, toughness, proportional limit, yield stress, Young's modulus, elastic and plastic limit
- recognise types of tests, including routine tests, exploratory tests, destructive tests, non-destructive or

Subject matter
proving tests, virtual tests, tests on specially prepared samples or scaled models, full-scale tests or tests on the completed article or structure, and inspection techniques • conduct mechanical testing and inspections of materials using two of the previous test examples • comprehend types of loading, including tensile, compressive, bending, shear and torsion.

2.8 Assessment guidance

In constructing assessment instruments for Unit 1, schools should ensure that the objectives cover, or are chosen from, the unit objectives. If one assessment instrument is developed for a unit, it must assess all the unit objectives; if more than one assessment instrument is developed, the unit objectives must be covered across those instruments.

The suggested techniques for Unit 1 are a project — folio and an examination.

3 Unit 2: Emerging technologies

3.1 Unit description

In Unit 2, students explore the needs of contemporary and future societies. Students investigate the emergence of new materials, processes and machines developed to solve problems in relation to rapidly evolving needs. This unit builds on the knowledge gained in the previous unit and reinforces engineering's role in solving global and local societal problems in order to improve the human condition. Students use their knowledge of mechanics, materials science and control technologies to solve problems in ways that meet contemporary and future human needs while considering the social, economic, ethical, legal and environmental impacts of their solutions. Students investigate new and emerging technologies in relation to engineering fields including biomedical, aerospace, energy and electrical. They engage in practical engineering activities using the knowledge gained in this unit to solve real-world problems. Students participate in a range of individual and collaborative group activities including those associated with advanced materials, health, renewable energy, autonomous vehicles and robotics.

Unit requirements

In this unit, teachers combine and balance direct instruction with instruction developed using the various phases of the problem-solving process in Engineering. Teachers should provide students with appropriately structured real-world problems or situations that enable them to experience the associated engineering concepts and principles. Students should be provided with opportunities to collaboratively make decisions in groups as they learn about and through problem-solving.

Topic 2 includes subject matter in relation to the problem-solving process in Engineering and students should experience this learning separately from assessment. Teachers may provide learning experiences that incorporate subject matter from the other topics in Unit 2 during this problem-solving activity.

Notional time allocation by topic and assessment

	Unit topic	Notional hours
Topic 1	Emerging needs	8
Topic 2	Emerging processes and machinery	9
Topic 3	Emerging materials	10
Topic 4	Exploring autonomy	8
Assessment integrated within the unit		20

3.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

1. recognise and describe emerging societal problems, engineering technology knowledge, and mechanics, materials science and control technologies concepts and principles, in relation to emerging technologies
2. symbolise and explain ideas and solutions in relation to emerging technologies
3. analyse emerging societal problems, and information in relation to emerging technologies
4. determine solution success criteria for emerging societal problems
5. synthesise information and ideas to predict possible emerging societal solutions
6. generate emerging societal prototype solutions to provide data to assess the accuracy of predictions
7. evaluate and refine ideas and solutions to make justified recommendations
8. make decisions about and use mode-appropriate features, language and conventions to communicate development of solutions.

3.3 Topic 1: Emerging needs

Guiding question: What skills and knowledge will today's engineers need to solve tomorrow's problems?

Subject matter
In this topic, students will: • identify and investigate a problem in an area of growing demand, e.g. health, sustainability, energy, food security or international aid • recognise how the problem-solving process in Engineering can be applied to future problems, e.g. – reduction in biodiversity – environmental degradation caused by human and industrial waste – climate change, i.e. increasing global temperatures • explore a future problem by identifying the scope, known and unknown variables, constraints and objectives, considering the social, economic and environmental issues. Examples of future problems include – lack of affordable space-saving housing – overpopulation and centralised rather than decentralised living conditions – reducing air travel costs and the environmental impacts of the increasing use of air travel – environmental health deterioration, e.g. water quality and availability • investigate the ethical, legal, social and economic impacts associated with current and future engineering contexts, including biomedical advances, space colonisation, nanotechnology, robotics and biomimicry • critically examine the role of technology and its impact on society and the environment • brainstorm possible future problem situations in an emerging need area, determine the success criteria required and consider the implications for idea and prototype solution development.

3.4 Topic 2: Emerging processes and machinery

Guiding question: In what ways do solution success criteria inform problem-solving?

Subject matter
In this topic, students will:

- demonstrate sketching and drawing techniques to communicate the development of ideas and prototype solutions, including
  - pictorials
  - orthographic views
  - detail of components and joints, e.g. prosthetic limb
- perform calculations to validate ideas using solution success criteria, constraints and relevant mathematical and engineering concepts and principles
- define additive and subtractive manufacturing processes
- explain how additive manufacturing facilitates the creation of new designs with internal structures or porosities in medical and industrial applications, e.g. light-weighting and lean manufacturing
- investigate the use of the rapid prototyping techniques of 3D printing and laser cutting to generate a prototype solution to a real-world problem, e.g. a component for a hand prosthesis that holds a kitchen utensil
- calculate problems involving linear motion, displacement, velocity and acceleration, acceleration due to gravity using formulas

$$v_{av} = \frac{s}{t}$$

$$a = \frac{v-u}{t}$$

- describe the importance of unmanned vehicles, drones, supersonic flight and hypersonic flight in future applications, including
  - dangerous occupations
  - repetitive processes
  - global enterprises
- comprehend and describe the benefits and the ethical, legal, social, economic and/or environmental risks of controversial technologies (such as drones and self-driven vehicles), including
  - employment
  - transportation costs
  - vehicular and road safety
- comprehend the ethical and social implications of emerging technologies, including
  - intelligent robotics
  - intelligent computers and sensors
- comprehend the concept of built-in or planned obsolescence and identify the issues for sustainability, reliability and the environment
- communicate the problem-solving process in Engineering to solve an identified problem (e.g. a vehicle that can safely and effectively traverse the Moon or Mars surface, a mechanical arm that positions heavy equipment during space mission asset deployment, a lifting or movement device that assists a person with a specific functional or movement disability), including
  - exploration of the problem
    - research previous similar problem situations or solutions to understand the nature of the problem
    - test and/or calculate to understand the engineering fundamentals of the problem
    - analyse the problem and information to identify the elements, components and features, and their relationship to the structure of the problem, including project management milestones (i.e. resource and time constraints)
    - determine and prioritise solution success criteria, considering the identified elements, components and features, and their relationship to the structure of the problem

Subject matter
– development of ideas ▪ brainstorm and discuss ideas with colleagues ▪ sketch ideas ▪ evaluate idea development using solution success criteria ▪ determine solution parameters, e.g. weight, materials, manufacturing issues ▪ test materials ▪ integrate ideas ▪ prototype ideas for testing and refinement ▪ predict a solution – generation of the prototype solution ▪ demonstrate basic project management skills ▪ create engineering drawings to support production of the prototype solution ▪ decide, communicate, explain and justify the processes proposed to generate the prototype solution ▪ consider safety issues concerning the production of the prototype solution ▪ perform calculations to predict prototype solution performance and document results in relation to solution success criteria, for an audience ▪ resolve uncertainties to optimise prototype solution generation ▪ use processes to generate the prototype solution, e.g. 3D printing, laser cutting, hand and/or machine manufacture and virtual production – evaluation and refinement ▪ perform destructive, non-destructive and/or virtual testing of the prototype solution to provide performance data ▪ evaluate prototype solution performance data using solution success criteria ▪ reanalyse test results and failure parameters ▪ consider sustainability issues ▪ make and justify recommendations to improve prototype solution performance.

3.5 Topic 3: Emerging materials

Guiding question: How might materials be used to effectively address emerging needs?

Subject matter
In this topic, students will:

- conduct materials testing (physically or virtually) — include a minimum of three of tensile testing and the elastic limit, the proportional limit, stiffness, yield stress, proof stress, ultimate strength, ductility, rupture, hardness, transverse, shear, impact, fatigue, torsion and non-destructive testing
- generate a stress–strain diagram and identify yield stress, ultimate tensile strength (UTS), Young's modulus, elastic limit, plastic deformation and fracture failure
- comprehend factor of safety
- explore hardness, impact and ultrasonic tests
- calculate using formulas for

$$stress\ (\sigma) = \frac{P}{A}$$

$$strain\ (\varepsilon) = \frac{change\ in\ length}{original\ length} = \frac{\Delta L}{L}$$

Note: Strain is a ratio and is therefore without units

$$Young's\ modulus\ or\ Modulus\ of elasticity\ (E) = \frac{PL}{A\Delta L} = \frac{stress}{strain} = \frac{\sigma}{\varepsilon}$$

E = Young's modulus in pascals (Pa)
P = applied load (force) in newtons (N)
L = gauge length (original length) in metres (m)
A = cross sectional area in square metres (m^2)
ΔL = change in length in metres (m)

$$factor\ of\ safety = \frac{yield\ stress}{allowable\ working\ stress}$$

$$ultimate\ tensile\ strength\ (UTS) = \frac{maximum\ load}{oringinal\ cross{-}sectional\ area}$$

- recognise Young's modulus, stress–strain diagrams for steel, aluminium and aluminium alloys, copper and copper alloys, polymers, ceramics and composite materials
- investigate general uses of biodegradable polymers in medical applications in two of the following examples
  - tissue engineering, e.g. future developments in heart vascular repair and organ replacement
  - drug delivery
  - orthopaedics, e.g. bone and joint replacement
- investigate the mechanical properties (tensile strength, weight, wear resistance) and the biomedical properties (biocompatibility and bio-inertness) of materials, in the context of one of the following examples
  - prosthesis, e.g. hip implant and dental implant
  - bio-ceramics, e.g. bone cements and bone grafting
  - bio-scaffolding, e.g. tissue engineering
- investigate and contrast emerging natural and synthetic polymers, including
  - natural polymers, including protein, cellulose (wood), resins, starch, shellac, silk, wood, DNA and lignin
  - synthetic polymers, including low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), nylon and Teflon (polytetrafluoroethylene).

3.6 Topic 4: Exploring autonomy

Guiding question: Power and control — how can today's technology unlock tomorrow's autonomy?

Subject matter

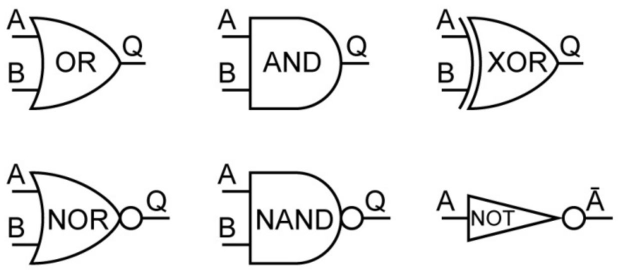
In this topic, students will:

- compare and contrast alternative energy sources, including solar, geothermal, hydro, wind, tidal and biomass
- describe emerging automation, including intelligent robotics, intelligent sensors, computer vision and industrial control systems
- explore unmanned vehicles, including drones, cars, trucks and space
- recognise thermal and electrical conductors and insulators, including
  - valence electrons
  - ionic and covalent compounds
  - materials that conduct (most metals) or resist (most non-metals) electron flow
- distinguish between alternating and direct current
- describe the characteristics of electricity in a domestic housing context, including power, energy, charge, current, resistance and voltage
- comprehend the relationships between power, energy, charge, current, resistance and voltage, and solve problems using formulas

$$V = IR$$
$$P = VI$$
$$E = Pt$$

- identify and comprehend the function of the symbols that represent components of electric circuits, including resistors (variable and fixed), voltage source, wires, alternating current and direct current, fuse, earth, switch and light bulb

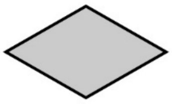
- create circuit diagrams using physical circuits
- create physical circuits using circuit diagrams
- problem-solve circuits that are non-functional
- recognise between icon-, text- and symbol-based control language
- recognise logic control, including
  - logic gates
    - AND/OR/NOT/NAND/NOR/XOR
    - standard symbols



  - truth tables — logical true, logical false, logical identity and logical negation
- create flow charts for a variety of situations using the symbols outlined in the table below; examples include

Subject matter

- decision-making, e.g. to finish a school assignment or go with a friend to the cinema
- support structure for school learning, e.g. school administration, teachers, support staff, students, parents, buildings and resources
- simple machines, e.g. push bike or skate board.

Flow chart symbol	Name	Function
	**Start/end**	An oval represents a start or end point
	**Arrows**	A line is a connector that shows relationships between the representative shapes
	**Input/output**	A parallelogram represents input or output
	**Process**	A rectangle represents a process
	**Decision**	A diamond indicates a decision

3.7 Assessment guidance

In constructing assessment instruments for Unit 2, schools should ensure that the objectives cover, or are chosen from, the unit objectives. If one assessment instrument is developed for a unit, it must assess all the unit objectives; if more than one assessment instrument is developed, the unit objectives must be covered across those instruments.

The suggested techniques for Unit 2 are a project — folio and an examination.

4 Unit 3: Statics of structures and environmental considerations

4.1 Unit description

In Unit 3, students learn about engineering's role in solving global and local societal problems to improve the human condition. Students investigate civil structures to examine the benefits and the social and environmental consequences of their construction and use. Students engage in practical engineering activities to learn that engineering is an applied practical discipline that uses science and mathematics concepts and principles to solve real-world problems. Students participate in a range of individual and collaborative group activities, including those associated with material and process testing, and analysis of the forces acting on structures. Students investigate the difficulties involved in engineering solutions for communities where environmental extremes must be considered, including those associated with intense cold and heat, storms, drought or flood.

Unit requirements

In this unit, teachers combine and balance direct instruction with instruction developed using the various phases of the problem-solving process in Engineering. Teachers should provide students with appropriately structured real-world problems or situations that enable them to experience the associated engineering concepts and principles. Students should be provided with opportunities to collaboratively make decisions in groups as they learn about and through problem-solving.

Topic 1 includes subject matter in relation to the problem-solving process in Engineering and students should experience this learning separately from assessment. Teachers may provide learning experiences that incorporate subject matter from the other topics in Unit 3 during this problem-solving activity.

Notional time allocation by topic and assessment

	Unit topic	Notional hours
Topic 1	Application of the problem-solving process in Engineering	10
Topic 2	Civil structures and the environment	10
Topic 3	Civil structures, materials and forces	15
Assessment integrated within the unit		20

4.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

Unit objective	IA1	IA2
1. recognise and describe structural problems, engineering technology knowledge, and mechanics and materials science concepts and principles, in relation to structures	●	●
2. symbolise and explain ideas and solutions in relation to structures	●	●
3. analyse structural problems, and information in relation to structures	●	●
4. determine solution success criteria for structural problems	●	
5. synthesise information and ideas to predict possible structural solutions	●	●
6. generate structural prototype solutions to provide data to assess the accuracy of predictions	●	
7. evaluate and refine ideas and solutions to make justified recommendations	●	
8. make decisions about and use mode-appropriate features, language and conventions to communicate development of solutions.	●	

4.3 Topic 1: Application of the problem-solving process in Engineering

Guiding question: How do you solve complex open-ended structural problems in engineering?

Subject matter

In this topic, students will:
• use and document the problem-solving process in Engineering to solve a complex open-ended problem, examples include
  – a crane/bridge structure required to support a given load
  – a tower subjected to a variety of loads
• explore the selected problem
  – identify project management milestones (resource and time constraints)
  – research previous similar problem situations or solutions to understand the nature of the problem
  – identify significant issues related to the problem and classify their relative importance, including ethical, social, economic and environmental impacts
  – analyse the problem and information to identify the elements, components and features, and their relationship to the structure of the problem
  – determine and prioritise solution success criteria considering the identified elements, components and features, and their relationship to the structure of the problem
• develop ideas
  – brainstorm and discuss ideas with colleagues
  – sketch ideas
  – calculate to determine solution parameters
  – test materials
  – synthesise ideas and solutions
  – evaluate idea development using solution success criteria
  – prototype ideas for testing and refinement
  – predict a solution
• generate the prototype solution
  – demonstrate basic project management skills using a Gantt chart or spreadsheet
  – create structural engineering drawings to facilitate production of the prototype solution
  – decide, communicate, explain and justify the processes proposed to generate the prototype solution
  – consider safety issues concerning the production of the solution
  – perform calculations to predict prototype solution performance and document results in relation to solution success criteria, for an audience
  – resolve uncertainties to optimise prototype solution generation
  – use processes to generate the prototype solution, e.g. 3D printing, laser cutting, hand and/or machine manufacture and virtual production
• evaluate and refine
  – perform destructive, non-destructive and/or virtual testing of the prototype solution to provide performance data
  – evaluate the prototype solution performance data using solution success criteria
  – reanalyse test results and failure parameters
  – consider sustainability issues
  – make and justify recommendations to improve prototype solution performance.

4.4 Topic 2: Civil structures and the environment

Guiding question: In what ways has the design of contemporary structures contributed to environmental sustainability?

Subject matter
In this topic, students will: • investigate the scope of civil engineering in two of the following sub-disciplines − coastal engineering − construction engineering − earthquake engineering − environmental engineering − water resource engineering − structural engineering • recognise engineering innovation in civil structures and their impact on people's lives in one of the following − smart structures that cool, warm and reduce power consumption − composite building materials that reduce weight while maintaining strength − simplified and safer building techniques that save time, expense and social and environmental impacts of lengthy construction periods • identify the construction and processing materials used in civil structures (including timber, rock, earth, brick, concrete and steel) • examine the environmental implications from the use of materials in civil structures, including − loss of habitat − erosion − extractive industries/mining, e.g. rock, sand, loams − demolition, including recycling and disposal • comprehend the concept of built-in or planned obsolescence as applied to structures and identify the ethical issues for sustainability, reliability and the environment • investigate the historical development of a bridge, road, aqueduct, bridge, dam, skyscraper, church or sports stadium • investigate a technological development that has had, or may have, an impact on the sustainability of structures in communities that experience environmental extremes, such as cold and heat, tropical storms, drought or flood, examples include − 3D-printed buildings − micro-modular housing − prefabrication and assembly on site − smart structures − intelligent structural systems − automation.

4.5 Topic 3: Civil structures, materials and forces

Guiding question: How do engineers use materials and construction techniques to withstand environmental extremes?

Subject matter
In this topic, students will: • solve beam reactions at different types of supports (pin and roller) for vertical, horizontal and angled forces • investigate and perform calculations on simple truss frame forms, including – actions (loads) – reactions at supports with horizontal, vertical and angled loading considered – method of joints and method of sections (graphical and analytical methods) • examine bending stress induced by point loads, including – concept of shear force and bending moment – shear force and bending moment diagrams for vertical point loads only (at the end or the middle) • contrast the material properties, including, toughness, hardness, brittleness, ductility, tensile and compressive strength of – glass – bricks – wood vs. timber – laminates, including laminated veneer lumber (LVL), plywood, fibreglass – polymers – concrete – steel • compare and contrast stress–strain diagrams for timber (soft and hardwood) and mild steel, including – shear, compressive and tensile stress – yield stress, proof stress, toughness, stiffness and elasticity (Young's modulus), proportional limit (Hooke's law), engineering applications • investigate engineering materials as used to construct various civil structures, including – concrete composition – concrete reinforcement – pre- and post-tensioning • examine corrosion, including – corrosive environments – dry corrosion, wet corrosion, stress corrosion – corrosion protection methods (galvanising, sacrificial anode, coatings) • conduct a material life cycle assessment, including sustainability, of one of timber, concrete, composite materials, glass, bricks or plastics.

4.6 Assessment

4.6.1 Summative internal assessment 1 (IA1): Project — folio (25%)

Description

This assessment focuses on a problem-solving process that requires the application of a range of cognitive, technical and creative skills and theoretical understandings. The response is a coherent work that documents the iterative process undertaken to develop a solution to a problem. It may include written paragraphs and annotations, diagrams, sketches, drawings, photographs, tables, spreadsheets and prototypes.

This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

1. recognise and describe the structural problem, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures
2. symbolise and explain ideas and a solution in relation to structures
3. analyse the structural problem and information in relation to structures
4. determine solution success criteria for the structural problem
5. synthesise information and ideas to predict a possible structural solution
6. generate a structural prototype solution to provide data to assess the accuracy of predictions
7. evaluate and refine ideas and a solution to make justified recommendations
8. make decisions about and use mode-appropriate features, language and conventions to communicate development of the prototype solution.

Specifications

Description

In Engineering, a folio involves individual students documenting the application of the problem-solving process in response to an identified real-world problem that requires an engineered solution. The response will include the following folio and referencing conventions:

- headings that organise and communicate the student's thinking through the iterative phases of the problem-solving process in Engineering
- a table of contents page
- a reference list and a recognised system of in-text referencing.

For this assessment, teachers will provide an appropriate structural problem context. For example:

- a failure problem within a truss structure that requires a sustainable solution, e.g. bridge, tower, crane, roof truss, extendable solar panel arm, space station, boat mast, residential high-rise, playground equipment, early wing design, jetty, stadium, scaffolding, concert stage, exoskeleton braces, bicycle, launch platforms, vehicle chassis
- a temporary or permanent structure that could be used to house displaced or homeless individuals during disasters such as a flood or cyclone event, e.g. tent, shelter, bunker, sports hall, swag, yurt
- an addition to an existing house or structure that is required to support a given load and withstand extreme environmental forces, e.g. deck, suspended slab, dam wall, tunnel, retaining wall, shipping container housing.

The folio will be in two parts and include the following assessable evidence.

Part A documents the development of an engineered solution, including:

- recognition and description of
  - the characteristics of the structural problem, including knowns, unknowns, assumptions and boundaries
  - the engineering mechanics and materials science fundamentals of the structural problem
  - mitigation of environmental and sustainability impacts, including corrosion, habitat loss, erosion, and life cycle assessment associated with the structural problem
- symbolisation and explanation of ideas and the solution to the structural problem using annotated sketching, drawings including basic drawing standards (hand or CAD), force vectors, free-body diagrams, graphs, tables and/or schemas
- analysis of the structural problem and engineering mechanics, materials science, technology and research information in relation to structures, to identify the elements, components and features, and their relationship to the structure of the problem, including project management milestones (i.e. resource and time constraints)
- determination of solution success criteria, considering the identified elements, components and features, and their relationship to the structure of the structural problem, including for example, beam performance index
- synthesis of engineering mechanics, materials science, technology and research information and ideas to predict a possible solution to the structural problem
- evaluation and refinement of idea and solution development in relation to solution success criteria including
  - testing of materials and processes e.g. cross-beam experiment to determine beam performance index, compression testing
  - calculations using mechanics concepts and principles to predict prototype solution performance
  - evaluation of prototype solution performance data and the reliability of the prototype solution, including use of the beam performance index
- generation of the prototype solution for testing including
  - virtual and/or physical manipulation of materials, scaled modelling, 3D printing, laser cutting

- annotations on photographs or screen captures of the prototype solution prior to and after testing
- performance of destructive, non-destructive and/or virtual testing of the prototype solution to provide performance data

- recommendation and justification of future modifications or enhancements to ideas and the solution to the structural problem
- communication of the development of ideas and the solution for the structural problem using written and visual features, e.g. PMI (plus, minus, interesting) charts, sketches, drawings, diagrams, graphs, tables and/or schemas
- communication of data using diagrams, tables and/or spreadsheets

Part B communicates a summary report for the specified client drawn from Part A documentation and includes key pictures, tables, graphs, sketches and drawings that provide a concise account of the preferred solution to the structural problem, including key features and any recommendations made to inform future solution development.

Conditions

- Duration: 5–7 weeks
- Length:
  - Part A: 7–9 single-sided A3 pages or equivalent digital media
  - Part B: 2–3 single-sided A4 pages or equivalent digital media
- Other:
  - the table of contents and reference list are not included in the page count
  - schools should implement authentication strategies that reflect QCAA guidelines.

Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the objectives assessed in the folio.

Criterion	Objectives	Marks
Retrieving and comprehending	1 and 2	5
Analysing	3 and 4	7
Synthesising and evaluating	5, 6 and 7	9
Communicating	8	4
Total		**25**

Instrument-specific marking guide

Criterion: Retrieving and comprehending

Assessment objectives

1. recognise and describe the structural problem, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures
2. symbolise and explain ideas and a solution in relation to structures

The student work has the following characteristics:	Marks
• accurate and discriminating recognition and discerning description of the structural problem, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures • adept symbolisation and discerning explanation of ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas.	4–5
• accurate recognition and appropriate description of the structural problem, engineering technology knowledge, and some mechanics and materials science concepts and principles in relation to structures • competent symbolisation and appropriate explanation of some ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas.	2–3
• variable recognition and superficial description of aspects of the structural problem, concepts or principles in relation to structures • variable symbolisation or superficial explanation of aspects of ideas or a solution in relation to structures.	1
• does not satisfy any of the descriptors above.	0

Criterion: Analysing

Assessment objectives

3. analyse the structural problem, and information in relation to structures
4. determine solution success criteria for the structural problem

The student work has the following characteristics:	Marks
• insightful analysis of the structural problem, and relevant engineering mechanics, materials science, technology and research information in relation to structures, to identify the relevant elements, components and features, and their relationship to the structure of the problem • astute determination of essential solution success criteria for the structural problem.	6–7
• considered analysis of the structural problem, and relevant engineering mechanics, materials science, technology and research information in relation to structures, to identify the relevant elements, components and features, and their relationship to the structure of the problem • logical determination of effective solution success criteria for the structural problem.	4–5
• appropriate analysis of the structural problem, and engineering mechanics, materials science, technology and research information in relation to structures, to identify some of the elements, components or features of the problem • reasonable determination of some solution success criteria for the structural problem.	2–3
• statements about the structural problem, or information in relation to structures • vague determination of some solution success criteria for the structural problem.	1
• does not satisfy any of the descriptors above.	0

Criterion: Synthesising and evaluating

Assessment objectives

5. synthesise information and ideas to predict a possible structural solution
6. generate a structural prototype solution to provide data to assess the accuracy of predictions
7. evaluate and refine ideas and a solution to make justified recommendations

The student work has the following characteristics:	Marks
• coherent and logical synthesis of relevant engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • purposeful generation of a structural prototype solution to provide valid performance data to critically assess the accuracy of predictions • critical evaluation and discerning refinement of ideas and a solution using success criteria to make astute recommendations justified by data and research evidence.	8–9
• logical synthesis of relevant engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • effective generation of a structural prototype solution to provide valid performance data to effectively assess the accuracy of predictions • reasoned evaluation and effective refinement of ideas and a solution using success criteria to make considered recommendations justified by data and research evidence.	6–7
• simple synthesis of engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • adequate generation of a structural prototype solution to provide relevant performance data to assess the accuracy of predictions • feasible evaluation and adequate refinement of ideas and a solution using some success criteria to make fundamental recommendations justified by data and research evidence.	4–5
• rudimentary synthesis of partial engineering mechanics, materials science, technology or research information, or ideas to predict a structural solution • partial generation of a structural prototype solution to provide elements of performance data to partially assess the accuracy of predictions • superficial evaluation of ideas or a solution using some success criteria to make elementary recommendations.	2–3
• unclear combinations of information or ideas • generation of elements of a structural prototype solution • identification of a change about an idea or the solution.	1
• does not satisfy any of the descriptors above.	0

Criterion: Communicating

Assessment objective

8. make decisions about and use mode-appropriate features, language and conventions to communicate development of the prototype solution

The student work has the following characteristics:	Marks
• discerning decision-making about, and fluent use of, – written and visual features to communicate about a solution – language for a technical audience – grammatically accurate language structures – folio and referencing conventions.	3–4
• variable decision-making about, and inconsistent use of, – written and visual features – suitable language – grammar and language structures – folio or referencing conventions.	1–2
• does not satisfy any of the descriptors above.	0

4.6.2 Summative internal assessment 2 (IA2): Examination (25%)

Description

The examination assesses the application of a range of cognitions to multiple provided items — questions, scenarios and problems.

Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

1. recognise and describe structural problems, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures
2. symbolise and explain ideas and solutions in relation to structures
3. analyse structural problems and information in relation to structures
5. synthesise information and ideas to predict possible structural solutions.

Note: Objectives 4, 6, 7 and 8 are not assessed in this instrument.

Specifications

Description

Short response

- consists of a number of items that may ask students to respond to the following activities
  - sketching, drawing, graphs, tables and diagrams
  - writing multiple-choice, single-word, sentence or short-paragraph responses drawn from Unit 3 subject matter in each topic
  - calculating using formulas drawn from Unit 3, Topic 3 subject matter
  - responding to seen or unseen stimulus materials
- where applicable, students are required to write in full sentences, constructing a response so that ideas are maintained, developed and justified
- the examination must assess a balance across the assessment objectives
- the total number of marks used in an examination marking scheme is a school decision. However, in order to correctly apply the ISMG, the percentage allocation of marks must match the following specifications.

Mark allocations

Percentage of marks	Degree of difficulty
~20%	**Complex unfamiliar** This item type requires students to choose and apply appropriate procedures in a situation where: • relationships and interactions have a number of elements and connections are made with knowledge, concepts and principles in relation to structures, and • all the information to solve the problem is not immediately identifiable, that is – the required procedure is not clear from the way the question is posed, and – in a context in which students have had limited prior experience. Typically, these items focus on objectives 3 and 5, and can provide evidence of objectives 1 and 2. They require sustained analysis and synthesis of relevant information to develop responses.
~20%	**Complex familiar** This item type requires students to show competence with the use and comprehension of definitions, procedures, concepts and techniques in a situation where: • relationships and interactions have a number of elements and connections are made with knowledge, concepts and principles in relation to structures, and • all of the information to solve the problem is identifiable, that is – the required procedure is clear from the way the question is posed, or – in a context that has been a focus of prior learning. Typically, these items focus on objectives 3 and 5, and can provide evidence of objectives 1 and 2. They require analysis and synthesis of relevant information to develop responses.
~60%	**Simple familiar** This item type requires students to show competence with the use and comprehension of definitions, procedures, concepts and techniques in a situation where: • relationships and interactions are obvious and have few elements, and • all of the information to solve the problem is identifiable, that is – the required procedure is clear from the way the question is posed, or – in a context that has been a focus of prior learning. Typically, these items focus on objectives 1, 3 and 5, and can provide evidence of objective 2. They require recognition and description, and some analysis and synthesis of information to develop responses.

Conditions

- Time: 2 hours plus perusal (10 minutes)
- Length: 800–1000 words in total or equivalent, including
  - a number of multiple choice, single-word or sentence response items
  - a number of short-paragraph response items of 100–150 words per item
  - a number of items requiring calculations

- the number of short-response items should allow students to complete the response in the set time

- Other
  - seen stimulus — teachers must ensure the purpose of the technique is not compromised
  - unseen stimulus — materials or questions must not be copied from information or texts that students have previously been exposed to or have used directly in class
  - when stimulus materials are used, they will be succinct enough to allow students sufficient time to engage with them; for stimulus materials that are lengthy, complex or large in number, they will be shared with students prior to the administration of the assessment instrument
  - only the QCAA formula sheet must be provided
  - notes are not permitted
  - use of technology is required: non-programmable scientific calculator only permitted
  - protractor and ruler required.

Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the objectives assessed in the examination.

Criterion	Objectives	Marks
Engineering knowledge and problem-solving	1, 2, 3 and 5	25
Total		**25**

Note: Unit objectives 4, 6, 7 and 8 are not assessed in this instrument.

Instrument-specific marking guide

Criterion: Engineering knowledge and problem-solving

Assessment objectives

1. recognise and describe structural problems, engineering technology knowledge, and mechanics and materials science concepts and principles in relation to structures
2. symbolise and explain ideas and solutions in relation to structures
3. analyse structural problems and information in relation to structures
5. synthesise information and ideas to predict possible structural solutions

<table>
<tr><th>The student work has the following characteristics:</th><th>Cut-off</th><th>Marks</th></tr>
<tr><td rowspan="2">• across the full range of simple familiar, complex familiar and complex unfamiliar situations
– accurate and discriminating recognition and discerning description of structural problems, knowledge, concepts and principles; adept symbolisation and discerning explanation of ideas and solutions; insightful and accurate analysis of problems and information; coherent and logical synthesis of information and ideas to predict possible solutions.</td><td>> 96%</td><td>25</td></tr>
<tr><td>> 93%</td><td>24</td></tr>
</table>

The student work has the following characteristics:	Cut-off	Marks
• in a comprehensive range of simple familiar, complex familiar and complex unfamiliar situations – accurate and discriminating recognition and discerning description of structural problems, knowledge, concepts and principles; adept symbolisation and discerning explanation of ideas and solutions; insightful and accurate analysis of problems and information; coherent and logical synthesis of information and ideas to predict possible solutions.	> 89%	23
	> 86%	22
• in a comprehensive range of simple familiar situations, and in complex familiar and complex unfamiliar situations – accurate recognition and effective description of structural problems, knowledge, concepts and principles; methodical symbolisation and effective explanation of ideas and solutions; considered analysis of problems and information; logical synthesis of information and ideas to predict possible solutions.	> 82%	21
	> 78%	20
• in a range of simple familiar situations, and in complex familiar and complex unfamiliar situations – accurate recognition and effective description of structural problems, knowledge, concepts and principles; methodical symbolisation and effective explanation of ideas and solutions; considered analysis of problems and information; logical synthesis of information and ideas to predict possible solutions.	> 75%	19
	> 71%	18
• in a range of simple familiar situations and in complex familiar situations – appropriate recognition and description of structural problems, knowledge, concepts and principles; competent symbolisation and appropriate explanation of ideas and solutions; appropriate analysis of problems and information; simple synthesis of information and ideas to predict possible solutions.	> 68%	17
	> 64%	16
• in a range of simple familiar situations and in some complex familiar situations – appropriate recognition and description of structural problems, knowledge, concepts and principles; competent symbolisation and appropriate explanation of ideas and solutions; appropriate analysis of problems and information; simple synthesis of information and ideas to predict possible solutions.	> 60%	15
	> 57%	14
• in simple familiar situations – appropriate recognition and description of structural problems, knowledge, concepts and principles; variable symbolisation and appropriate explanation of ideas and solutions; appropriate analysis of problems and information; simple synthesis of information and ideas to predict possible solutions.	> 53%	13
	> 50%	12
• in simple familiar situations – variable recognition and superficial description of structural problems, knowledge, concepts and principles; variable symbolisation and superficial explanation of ideas and solutions; superficial analysis of problems and information; rudimentary synthesis of information and ideas to predict possible solutions.	> 46%	11
	> 42%	10
• in some simple familiar situations – variable recognition and superficial description of aspects of structural problems, knowledge, concepts and principles; superficial explanation of ideas and solutions; superficial analysis of problems and information; rudimentary synthesis of information and ideas to predict partial possible solutions.	> 37%	9
	> 33%	8
• in a limited range of simple familiar situations – variable recognition and superficial description of aspects of structural problems, knowledge, concepts and principles; superficial explanation of ideas and solutions; superficial analysis of aspects of problems and information;	> 28%	7
	> 24%	6

The student work has the following characteristics:	Cut-off	Marks
unclear combination of information and ideas.		
• disjointed recognition and statements about aspects of structural problems, knowledge, concepts and principles; identification of a change about ideas, solutions and information; unclear combination of information and ideas.	> 19%	5
	> 14%	4
• statements about aspects of structural problems, knowledge, concepts and principles; statements about ideas, solutions and information; isolated and unclear combination of information and ideas.	> 10%	3
	> 5%	2
• isolated and unclear statements about aspects of structural problems, knowledge, concepts and principles.	> 0%	1
• does not satisfy any of the descriptors above.		0

5 Unit 4: Machines and mechanisms

5.1 Unit description

In Unit 4, students extend their knowledge of Units 1, 2 and 3 to develop an understanding of dynamics through machines and mechanisms, including the uniform accelerated motion of objects in one dimension, apparent weight, and motion on an inclined plane. They examine the effect of frictional forces on the motion of objects. Students investigate the functional requirements of machines and mechanisms and establish a working knowledge of their operation in real-world contexts. They differentiate between the properties of materials used in the manufacture of machines and mechanisms in engineering fields such as mechanical, electrical, biomedical and mechatronics.

In this culminating unit, students apply the knowledge gained in previous units to solve problems in ways that meet human needs while considering the social, ethical, economic and environmental impacts of their solutions. Students engage in practical engineering activities to learn that engineering is an applied practical discipline that uses science and mathematics concepts and principles to solve real-world problems. Students participate in a range of individual and collaborative group activities, including those associated with material and process testing and analysis of the forces acting on machines and mechanisms.

Unit requirements

In this unit, teachers combine and balance direct instruction with instruction developed using the various phases of the problem-solving process in Engineering. Teachers should provide students with appropriately structured real-world problems or situations that enable them to experience the associated engineering concepts and principles. Students should be provided with opportunities to collaboratively make decisions in groups as they learn about and through problem-solving.

Notional time allocation by topic and assessment

	Unit topic	Notional hours
Topic 1	Machines in society	15
Topic 2	Materials	14
Topic 3	Machine control	6
Assessment integrated within the unit		20

5.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

Unit objective	IA3	EA
1. recognise and describe machine and mechanism problems, engineering technology knowledge, and mechanics, materials science and control technologies concepts and principles in relation to machines and mechanisms	•	•
2. symbolise and explain ideas and solutions in relation to machines and mechanisms	•	•
3. analyse machine and mechanism problems, and information in relation to machines and mechanisms	•	•
4. determine solution success criteria for machine and mechanism problems	•	
5. synthesise information and ideas to predict possible machine and mechanism solutions	•	•
6. generate machine and mechanism prototype solutions to provide data to assess the accuracy of predictions	•	
7. evaluate and refine ideas and solutions to make justified recommendations	•	
8. make decisions about and use mode-appropriate features, language and conventions to communicate development of solutions.	•	

5.3 Topic 1: Machines in society

Guiding question: What would the world be like without machines?

Subject matter
In this topic, students will:

- explore engineering careers that involve machines and/or mechanisms, including mechanical, mechatronic and biomechanical engineering
- comprehend how engineers use their expertise to benefit communities
- analyse community problems involving machines as solutions, i.e. engineers without borders, human interface, disaster response and safety
- recognise and describe basic machines and their purpose, including
  - bicycle
  - car jack
  - crow bar
- identify four types of motion, including linear, rotary, oscillatory and reciprocal
- define mechanical advantage (MA) and velocity ratio (VR)
- calculate MA and VR using the formulas

$$MA = \frac{load}{effort} = \frac{F_L}{F_E}$$

$$VR = \frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load} = \frac{d_E}{d_L}$$

- explore and calculate the function and operation of mechanical components, using mechanical

Subject matter
advantage and velocity ratio, including – inclined planes and screws – levers (first, second and third order) – gears and gear ratio, including spur, worm, and rack and pinion – first order pulleys and belts • investigate and solve problems involving mechanical engineering concepts and principles, including – work (done) ▪ $W = force \times distance = F\ d$ – power (rate of doing work) ▪ $P = \frac{work\ done}{time\ taken} = \frac{W}{t}$ • calculate for energy sources and conversions (i.e. total mechanical energy is the sum of kinetic energy and potential energy), using formulas $KE = \frac{1}{2}mv^2$ $PE = mgh$ • calculate energy efficiency, using formula $\eta = \frac{MA}{VR} = \frac{useful\ output}{input}$ • solve problems involving the equations of uniformly accelerated motion in one dimension (including vertical and horizontal movement), using formulas $v = u + at$ $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$ • recognise that friction is a force opposing motion • define coefficient of friction (μ), normal force (F_N) and angle of repose (θ) • solve problems using coefficient of friction, normal force and angle of repose, using formulas $\mu_s = \tan\theta$ $F_f = \mu F_N$ • distinguish between and solve integrated linear motion problems involving static and kinetic friction, using formulas $F_f = \mu_s F_N$ $F_f = \mu_k F_N$ • solve problems involving one-body systems in motion on an inclined plane, including uniform velocity and uniform acceleration.

5.4 Topic 2: Materials

Guiding question: What material to use when?

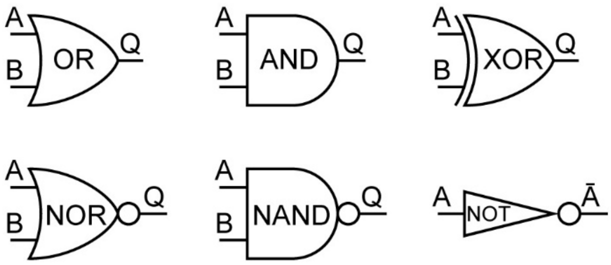
Subject matter

In this topic, students will:
• identify key features on a basic stress–strain diagram
• recognise and interpret stress–strain diagrams for mild steel, ceramics and polymers and identify, where applicable, stress, strain, stiffness, ultimate tensile strength, toughness, proportional limit, yield stress, Young's modulus, elastic and plastic limit
• interpret a lead–tin thermal-equilibrium phase diagram; identify key features, components and phases
• calculate percentages solid and liquid, along with composition solid and liquid, using the inverse lever rule
• identify microstructures of the steel and cast iron portions of an iron–carbon phase diagram, including austenite, cementite, ferrite, pearlite and sketch the mild-, medium- and high-carbon steel areas at room temperature
• recognise the industrial/mechanical applications for
  – low carbon steel (0.07% to 0.15% carbon)
    ▪ automobile body parts and wire products
  – mild carbon steel (0.15% to 0.30% carbon)
    ▪ structural plates and sections, stampings, forgings, seamless tubes and boiler plate
  – medium carbon steel (0.30% to 0.60% carbon)
    ▪ forgings and automotive components, including shafts, axles, gears and crankshafts
    ▪ medium carbon steels in the 0.40% to 0.60% carbon range are used for train rails, wheels and axles
  – high carbon steel (0.60% to 1.25% carbon)
    ▪ high-strength spring materials and wires, cutting tools, punches, dies and industrial knives
  – ultra-high carbon steel (1.25% to 2.00% carbon)
    ▪ highly tempered non-industrial-purpose knives, punches and axles
• comprehend that the chemical composition of materials contributes to physical properties and therefore to usability for mild-, medium- and high-carbon steel at room temperature
• investigate the current uses of plastics in a contemporary engineering context, including
  – polyethylene: plastic containers, water pipes and cable insulation
  – polypropylene: laboratory equipment, electronics and automobile products
  – acrylonitrile butadiene styrene (ABS), e.g. automotive body parts, household electronics and electrical appliances and business equipment
  – polylactic acid (PLA), e.g. automobile interiors and medical implants, e.g. screws, plates, pins, rods, mesh
  – polyvinyl chloride (PVC), e.g. automobile parts, electronic and electrical equipment, water/waste drainage pipe and furniture
  – nylon, e.g. gears, rollers, guides, bearings and wear pads.

5.5 Topic 3: Machine control

Guiding question: In what ways can control technologies be used to create engineered solutions?

Subject matter

In this topic, students will:
• apply logic control, including
  − logic gates
    ▪ AND/OR/NOT/NAND/NOR/XOR
    ▪ standard symbols, including

 	
  − truth tables — logical true, logical false, logical identity and logical negation
• create logic gate circuits and corresponding truth tables based on specified conditions, including
  − traffic light function
  − boom gates at a railway crossing
  − thermostatically controlled incubator or cooking system or barbecue
  − sun-tracking systems for solar panels
  − solar-powered devices, e.g. battery chargers, model vehicles, lighting systems.

5.6 Assessment

5.6.1 Summative internal assessment 3 (IA3): Project — folio (25%)

Description

This assessment focuses on a problem-solving process that requires the application of a range of cognitive, technical and creative skills and theoretical understandings. The response is a coherent work that documents the iterative process undertaken to develop a prototype solution to a problem, situation or need. It includes written paragraphs and annotations, diagrams, sketches, drawings, photographs, tables, spreadsheets and prototypes.

This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

1. recognise and describe the machine and/or mechanism problem, engineering technology knowledge, and mechanics, materials science and control technologies concepts and principles in relation to machines and/or mechanisms
2. symbolise and explain ideas and a solution in relation to machines and/or mechanisms
3. analyse the machine and/or mechanism problem and information in relation to machines and/or mechanisms
4. determine solution success criteria for the machine and/or mechanism problem
5. synthesise information and ideas to predict a possible machine and/or mechanism solution
6. generate a machine and/or mechanism prototype solution to provide data to assess the accuracy of predictions
7. evaluate and refine ideas and a solution to make justified recommendations
8. make decisions about and use mode-appropriate features, language and conventions to communicate development of the prototype solution.

Specifications

Description

In Engineering, a folio involves individual students documenting the application of the problem-solving process in response to an identified real-world problem that requires an engineered solution. The response will include the following folio and referencing conventions:

- headings that organise and communicate the student’s thinking through the iterative phases of the problem-solving process in Engineering
- a table of contents page
- a reference list and a recognised system of in-text referencing.

For this assessment, teachers will provide an appropriate mechanical and/or mechanisms problem context. For example:

- a vehicle that solves a unique automated/transport/manufacturing problem, e.g. alternate powered car, unmanned drone, cleaning robot, Mars rover, use of a programmable logic controller (PLC) or microcontroller to develop an automated sewage pipe inspection robot
- mechanism to assist people, e.g. allow an arthritic hand to pick up, hold and use a kitchen utensil, 3D-printed biomedical joints, solar pump, an everyday device to support mobility-restricted persons.

The folio will be in two parts and include the following assessable evidence.

Part A documents the development of an engineered solution, including:

- recognition and description of
  - the characteristics of the mechanical and/or mechanisms problem, including knowns, unknowns, assumptions and boundaries
  - the engineering mechanics, materials science and control technologies fundamentals of the mechanical and/or mechanisms problem
  - mitigation of environmental and sustainability impacts associated with the mechanical and/or mechanisms problem, including corrosion, life cycle assessment, safety, pollution, maintenance and energy efficiency
- symbolisation and explanation of ideas and the solution to the mechanical and/or mechanisms problem using annotated sketching, drawings including basic drawing standards (hand or CAD), logic and electrical circuit diagrams, flow charts and free-body diagrams, graphs, tables and/or schemas
- analysis of the mechanical and/or mechanisms problem and engineering mechanics, materials science, and control technologies, technology and research information in relation to machines and mechanisms, to identify the elements, components and features, and their relationship to the structure of the problem, including project management milestones (i.e. resource and time constraints)
- determination of solution success criteria, considering the identified elements, components and features, and their relationship to the structure of the mechanical and/or mechanisms problem, including for example, performance index, speed, weight, aerodynamics, power
- synthesis of engineering mechanics, materials science, control technologies, technology and research information and ideas to predict a possible solution to the mechanical and/or mechanisms problem
- evaluation and refinement of idea and solution development in relation to solution success criteria including
  - testing of materials and processes e.g. pulleys and gear testing, friction, solar panel efficiency, motor efficiency
  - calculations using mechanics concepts and principles to predict prototype solution performance, including predicted mass, velocity, acceleration and efficiency
  - evaluation of prototype solution performance data and the reliability of the prototype solution, including use of the performance index, speed, weight, aerodynamics and power
- generation of the prototype solution for testing including
  - virtual and/or physical manipulation of materials, scaled modelling, 3D printing, laser cutting

- annotations on photographs or screen captures of the prototype solution prior to and after testing
  - performance of destructive, non-destructive and/or virtual testing of the prototype solution to provide performance data
- recommendation and justification of future modifications or enhancements to ideas and the solution to the mechanical and/or mechanisms problem
- communication of the development of ideas and the solution for the mechanical and/or mechanisms problem using written and visual features, e.g. PMI (plus, minus, interesting) charts, sketches, drawings, diagrams, graphs, tables and/or schemas
- communication of data using diagrams, tables and/or spreadsheets

Part B communicates a summary report for the specified client drawn from Part A documentation and includes key pictures, tables, graphs, sketches and drawings that provide a concise account of the preferred solution to the structural problem, including key features and any recommendations made to inform future solution development.

Conditions

- Duration: 5–7 weeks
- Length:
  - Part A: 7–9 single-sided A3 pages or equivalent digital media
  - Part B: 2–3 single-sided A4 pages or equivalent digital media
- Other:
  - the table of contents and reference list are not included in the page count
  - schools should implement authentication strategies that reflect QCAA guidelines.

Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the objectives assessed in the folio.

Criterion	Objectives	Marks
Retrieving and comprehending	1 and 2	5
Analysing	3 and 4	7
Synthesising and evaluating	5, 6 and 7	9
Communicating	8	4
Total		**25**

Instrument-specific marking guide

Criterion: Retrieving and comprehending

Assessment objectives

1. recognise and describe the machine and/or mechanism problem, engineering technology knowledge, and mechanics, materials science and control technologies concepts and principles in relation to machines and/or mechanisms
2. symbolise and explain ideas and a solution in relation to machines and/or mechanisms

The student work has the following characteristics:	Marks
• accurate and discriminating recognition and discerning description of the machine and/or mechanism problem, engineering technology knowledge, and mechanics, materials science and control technologies concepts and principles in relation to machines and/or mechanisms • adept symbolisation and discerning explanation of ideas and a solution in relation to machines and/or mechanisms with sketches, drawings, diagrams, graphs, tables and/or schemas.	4–5
• accurate recognition and appropriate description of the machine and/or mechanism problem, engineering technology knowledge, and some mechanics, materials science and control technologies concepts and principles in relation to machines and/or mechanisms • competent symbolisation and appropriate explanation of some ideas and a solution in relation to machines and/or mechanisms with sketches, drawings, diagrams, graphs, tables and/or schemas.	2–3
• variable recognition and superficial description of aspects of the machine and/or mechanism problem, concepts or principles in relation to machines and mechanisms • variable symbolisation or superficial explanation of aspects of ideas or a solution in relation to machines and/or mechanisms.	1
• does not satisfy any of the descriptors above.	0

Criterion: Analysing

Assessment objectives

3. analyse the machine and/or mechanism problem and information in relation to machines and/or mechanisms
4. determine solution success criteria for the machine and/or mechanism problem

The student work has the following characteristics:	Marks
• insightful analysis of the machine and/or mechanism problem, and relevant engineering mechanics, materials science, control technologies, technology, and research information in relation to machines and/or mechanisms, to identify the relevant elements, components and features, and their relationship to the structure of the problem • astute determination of essential solution success criteria for the machine and/or mechanism problem.	6–7
• considered analysis of the machine and/or mechanism problem, and relevant engineering mechanics, materials science, control technologies, technology, and research information in relation to machines and/or mechanisms, to identify the relevant elements, components and features, and their relationship to the structure of the problem • logical determination of effective solution success criteria for the machine and/or mechanism problem.	4–5
• appropriate analysis of the machine and/or mechanism problem, and engineering mechanics, materials science, control technologies, technology, and research information in relation to machines and/or mechanisms, to identify some of the elements, components or features of the problem • reasonable determination of some solution success criteria for the machine and/or mechanism problem.	2–3
• statements about the machine and/or mechanism problem, or information in relation to machines and/or mechanisms • vague determination of some solution success criteria for the machine and/or mechanism problem.	1
• does not satisfy any of the descriptors above.	0

Criterion: Synthesising and evaluating

Assessment objectives

5. synthesise information and ideas to predict a possible machine and/or mechanism solution
6. generate a machine and/or mechanism prototype solution to provide data to assess the accuracy of predictions
7. evaluate and refine ideas and a solution to make justified recommendations

The student work has the following characteristics:	Marks
• coherent and logical synthesis of relevant engineering mechanics, materials science, control technologies, technology and research information, and ideas to predict a possible machine and/or mechanism solution • purposeful generation of a machine and/or mechanism prototype solution to provide valid performance data to critically assess the accuracy of predictions • critical evaluation and discerning refinement of ideas and a solution using success criteria to make astute recommendations justified by data and research evidence.	8–9
• logical synthesis of relevant engineering mechanics, materials science, control technologies, technology and research information, and ideas to predict a possible machine and/or mechanism solution • effective generation of a machine and/or mechanism prototype solution to provide valid performance data to effectively assess the accuracy of predictions • reasoned evaluation and effective refinement of ideas and a solution using success criteria to make considered recommendations justified by data and research evidence.	6–7
• simple synthesis of engineering mechanics, materials science, control technologies, technology and research information, and ideas to predict a possible machine and/or mechanism solution • adequate generation of a machine and/or mechanism prototype solution to provide relevant performance data to assess the accuracy of predictions • feasible evaluation and adequate refinement of ideas and a solution using some success criteria to make fundamental recommendations justified by data and research evidence.	4–5
• rudimentary synthesis of partial engineering mechanics, materials science, control technologies, technology or research information, or ideas to predict a machine and/or mechanism solution • partial generation of a machine and/or mechanism prototype solution to provide elements of performance data to partially assess the accuracy of predictions • superficial evaluation of ideas or a solution using some success criteria to make elementary recommendations.	2–3
• unclear combinations of information or ideas • generation of elements of a machine and/or mechanism prototype solution • identification of a change about an idea or the solution.	1
• does not satisfy any of the descriptors above.	0

Criterion: Communicating

Assessment objective

8. make decisions about and use mode-appropriate features, language and conventions to communicate development of the prototype solution

The student work has the following characteristics:	Marks
• discerning decision-making about, and fluent use of, – written and visual features to communicate about a solution – language for a technical audience – grammatically accurate language structures – folio and referencing conventions.	3–4
• variable decision-making about, and inconsistent use of, – written and visual features – suitable language – grammar and language structures – folio or referencing conventions.	1–2
• does not satisfy any of the descriptors above.	0

5.6.2 Summative external assessment (EA): Examination (25%)

General information

Summative external assessment is developed and marked by the QCAA. In Engineering it contributes 25% to a student's overall subject result.

The external assessment in Engineering is common to all schools and administered under the same conditions, at the same time, on the same day.

Description

The examination assesses the application of a range of cognitions to multiple provided items — questions, scenarios and problems.

Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

1. recognise and describe machine and mechanism problems, and mechanics, materials science and control technologies concepts and principles, in relation to machines and mechanisms
2. symbolise and explain ideas and solutions in relation to machines and mechanisms
3. analyse machine and mechanism problems, and information in relation to machines and mechanisms
5. synthesise information and ideas to predict possible machine and mechanism solutions.

Note: Objectives 4, 6, 7 and 8 are not assessed in this instrument.

Specifications

Description

Short response

- consists of a number of items that may ask students to respond to the following activities
  - sketching, drawing, graphs, tables and diagrams
  - writing multiple-choice, single-word, sentence or short-paragraph responses drawn from Unit 4 subject matter in each topic
  - calculating using formulas drawn from across Unit 4 subject matter
  - responding to seen or unseen stimulus materials
- where applicable, students are required to write in full sentences, constructing a response so that ideas are maintained, developed and justified
- the examination must assess a balance across the assessment objectives
- the percentage allocation of marks must match the following specifications.

Mark allocations

Percentage of marks	Degree of difficulty
~20%	**Complex unfamiliar** This item type requires students to choose and apply appropriate procedures in a situation where: • relationships and interactions have a number of elements and connections are made with knowledge, concepts and principles in relation to machines and mechanisms, and • all the information to solve the problem is not immediately identifiable, that is – the required procedure is not clear from the way the question is posed, and – in a context in which students have had limited prior experience. Typically, these items focus on objectives 3 and 5, and can provide evidence of objectives 1 and 2. They require sustained analysis and synthesis of relevant information to develop responses.
~20%	**Complex familiar** This item type requires students to show competence with the use and comprehension of definitions, procedures, concepts and techniques in a situation where: • relationships and interactions have a number of elements and connections are made with knowledge, concepts and principles in relation to machines and mechanisms, and • all of the information to solve the problem is identifiable, that is – the required procedure is clear from the way the question is posed, or – in a context that has been a focus of prior learning. Typically, these items focus on objectives 3 and 5, and can provide evidence of objectives 1 and 2. They require analysis and synthesis of relevant information to develop responses.
~60%	**Simple familiar** This item type requires students to show competence with the use and comprehension of definitions, procedures, concepts and techniques in a situation where: • relationships and interactions are obvious and have few elements, and • all of the information to solve the problem is identifiable, that is – the required procedure is clear from the way the question is posed, or – in a context that has been a focus of prior learning. Typically, these items focus on objectives 1, 3 and 5, and can provide evidence of objective 2. They require recognition and description, and some analysis and synthesis of information to develop responses.

Conditions

- Time: 2 hours plus perusal (10 minutes)
- Length: 800–1000 words in total or equivalent, including
  - a number of multiple-choice, single-word or sentence response items
  - a number of short-paragraph response items of 100–150 words per item
  - a number of items requiring calculations.

- Other:
  - only the QCAA formula sheet must be provided
  - notes are not permitted
  - use of technology is required: non-programmable scientific calculator only permitted
  - protractor and ruler required.

Instrument-specific marking guide

No ISMG is provided for the summative external assessment.

6 Glossary

Term	Explanation
A	
acceleration	the rate at which an object's velocity changes
accomplished	highly trained or skilled in a particular activity; perfected in knowledge or training; expert
accuracy	the condition or quality of being true, correct or exact; freedom from error or defect; precision or exactness; correctness; in science, the extent to which a measurement result represents the quantity it purports to measure; an accurate measurement result includes an estimate of the true value and an estimate of the uncertainty
accurate	precise and exact; to the point; consistent with or exactly conforming to a truth, standard, rule, model, convention or known facts; free from error or defect; meticulous; correct in all details
adept	very/highly skilled or proficient at something; expert
adequate	satisfactory or acceptable in quality or quantity equal to the requirement or occasion
analyse	dissect to ascertain and examine constituent parts and/or their relationships; break down or examine in order to identify the essential elements, features, components or structure; determine the logic and reasonableness of information; examine or consider something in order to explain and interpret it, for the purpose of finding meaning or relationships and identifying patterns, similarities and differences
annotate	make or furnish critical or explanatory notes, or comment; add notes or comments to (a picture, drawing, sketch or diagram)
applied learning	the acquisition and application of knowledge, understanding and skills in real-world or lifelike contexts that may encompass workplace, industry and community situations; it emphasises learning through doing and includes both theory and the application of theory, connecting subject knowledge and understanding with the development of practical skills
Applied subject	a subject whose primary pathway is work and vocational education; it emphasises applied learning and community connections; a subject for which a syllabus has been developed by the QCAA with the following characteristics: results from courses developed from Applied syllabuses contribute to the QCE; results may contribute to ATAR calculations
apply	use knowledge and understanding in response to a given situation or circumstance; carry out or use a procedure in a given or particular situation
appraise	evaluate the worth, significance or status of something; judge or consider a text or piece of work

Term	Explanation
appreciate	recognise or make a judgment about the value or worth of something; understand fully; grasp the full implications of
appropriate	acceptable; suitable or fitting for a particular purpose, circumstance, context etc.
apt	suitable to the purpose or occasion; fitting, appropriate
area of study	a division of, or a section within a unit
argue	give reasons for or against something; challenge or debate an issue or idea; persuade, prove or try to prove by giving reasons
aspect	a particular part of a feature of something; a facet, phase or part of a whole
assess	measure, determine, evaluate, estimate or make a judgment about the value, quality, outcomes, results, size, significance, nature or extent of something
assessment	purposeful and systematic collection of information about students' achievements
assessment instrument	a tool or device used to gather information about student achievement
assessment objectives	drawn from the unit objectives and contextualised for the requirements of the assessment instrument (see also 'syllabus objectives', 'unit objectives')
assessment technique	the method used to gather evidence about student achievement, (e.g. examination, project, investigation)
astute	showing an ability to accurately assess situations or people; of keen discernment
ATAR	Australian Tertiary Admission Rank
Australian standards for engineering drawings	guidelines for technical drawings in engineering disciplines; some examples are provided below: AS 1100.101–1992 defines the general principles for technical drawing and shows tables of symbols and abbreviations and their meanings AS 1100.201–1992 is for mechanical engineering drawing and includes information for surface texture, welding, centre holes, pipelines, springs, gears, splines, seals and knurling AS/NZS 1100.501: 2002 is for structural engineering drawing; it looks at general applications like dimensioning, lines, symbols, abbreviations, structural elements, scales, cross referencing and arrangement of elements as well as specific applications for structural steel
authoritative	able to be trusted as being accurate or true; reliable; commanding and self-confident; likely to be respected and obeyed
automation	the use of various control systems for operating equipment such as machinery, processes in factories, steering and stabilisation of ships, aircraft and other applications with minimal or reduced human intervention

Term	Explanation
B	
balanced	keeping or showing a balance; not biased; fairly judged or presented; taking everything into account in a fair, well-judged way
basic	fundamental
basic drawing standards	are the fundamental requirements (i.e. scale, units, layout, titles, subtitles, orientation, parts list, dimensions, line types and quality) included in engineering drawings that are used to fully and clearly define requirements for the production of engineered items
biomimicry	an approach to innovation that seeks sustainable solutions to human challenges by emulating the patterns and strategies found in natural environments
built-in or planned obsolescence	a method of stimulating consumer demand by designing products that wear out or become outmoded after limited use
C	
CAD	computer-aided drafting; software used by drafters, architects and engineers to help them create lines, shapes and planes that can be combined, moved, rotated, adjusted and rendered; measurements and calculations can be included; computer-aided drafting can be used to create 2D and 3D models and drawings such as floor plans and rendered pictorial views of objects and structures; also known as computer-assisted design and computer-assisted design and drafting (CADD)
calculate	determine or find (e.g. a number, answer) by using mathematical processes; obtain a numerical answer showing the relevant stages in the working; ascertain/determine from given facts, figures or information
callout	a short string of text connected by a line, arrow, or similar graphic to a feature of an illustration or technical drawing, and giving information about that feature
categorise	place in or assign to a particular class or group; arrange or order by classes or categories; classify, sort out, sort, separate
challenging	difficult but interesting; testing one's abilities; demanding and thought-provoking; usually involving unfamiliar or less familiar elements
characteristics	a set of distinguishing aspects (including attributes and behaviours) of an object, material, living thing, system or event
clarify	make clear or intelligible; explain; make a statement or situation less confused and more comprehensible
clarity	clearness of thought or expression; the quality of being coherent and intelligible; free from obscurity of sense; without ambiguity; explicit; easy to perceive, understand or interpret
classify	arrange, distribute or order in classes or categories according to shared qualities or characteristics

Term	Explanation
class time	includes the time made available for students to independently respond to extended assessment tasks and any associated and required teaching and learning time
clear	free from confusion, uncertainty, or doubt; easily seen, heard or understood
clearly	in a clear manner; plainly and openly, without ambiguity
Code of Ethics	defines the values and principles that shape the decisions made in engineering practice (Engineers Australia 2017)
coherent	having a natural or due agreement of parts; connected; consistent; logical, orderly; well-structured and makes sense; rational, with parts that are harmonious; having an internally consistent relation of parts
cohesive	characterised by being united, bound together or having integrated meaning; forming a united whole
collinear forces	lie in the same plane and have the same line of action
comment	express an opinion, observation or reaction in speech or writing; give a judgment based on a given statement or result of a calculation
communicate	convey knowledge and/or understandings to others; make known; transmit
compare	display recognition of similarities and differences and recognise the significance of these similarities and differences
competent	having suitable or sufficient skills, knowledge, experience, etc. for some purpose; adequate but not exceptional; capable; suitable or sufficient for the purpose; having the necessary ability, knowledge or skill to do something successfully; efficient and capable (of a person); acceptable and satisfactory, though not outstanding
competently	in an efficient and capable way; in an acceptable and satisfactory, though not outstanding, way
complex	composed or consisting of many different and interconnected parts or factors; compound; composite; characterised by an involved combination of parts; complicated; intricate; a complex whole or system; a complicated assembly of particulars
components	parts (made of two or more elements) that make up a whole object or system and perform specific functions

Term	Explanation
composite materials	materials made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components; the individual components remain separate and distinct within the finished structure; the new material may be preferred for many reasons: common examples include materials that are stronger, lighter or less expensive when compared to traditional materials; typical engineered composite materials include: • composite building materials such as cements and concrete • reinforced plastics such as fibre-reinforced polymer • metal composites • ceramic composites (composite ceramic and metal matrices) (also called ‘composition materials’ or shortened to ‘composites’)
compounds	formed when two or more elements are combined chemically in fixed proportions by weight; all compounds can be broken down by one means or another into their component elements
comprehend	understand the meaning or nature of; grasp mentally
comprehensive	inclusive; of large content or scope; including or dealing with all or nearly all elements or aspects of something; wide-ranging; detailed and thorough, including all that is relevant
computer vision	an interdisciplinary field that deals with how computers can be made to gain high-level understanding from digital images or videos; engineering uses computer vision to automate tasks that the human visual system could perform, e.g. fault recognition in mass manufacturing processes
computer-aided drafting	CAD; software used by drafters, architects and engineers to help them create lines, shapes and planes that can be combined, moved, rotated, adjusted and rendered; measurements and calculations can be included; computer-aided drafting can be used to create 2D and 3D models and drawings such as floor plans and rendered pictorial views of objects and structures; also known as computer-assisted design and computer-assisted design and drafting (CADD)
concepts	abstract ideas, formed by mentally combining all its characteristics or particulars; a theoretical construct; a generalised mental operation
concise	expressing much in few words; giving a lot of information clearly and in a few words; brief, comprehensive and to the point; succinct, clear, without repetition of information
concurrent forces	two or more forces whose lines of action intersect at the same point to cause rotation; the forces do not necessarily have to be applied;
conduct	direct in action or course; manage; organise; carry out

Term	Explanation
consider	think deliberately or carefully about something, typically before making a decision; take something into account when making a judgment; view attentively or scrutinise; reflect on
considerable	fairly large or great; thought about deliberately and with a purpose
considered	formed after careful and deliberate thought
consistent	agreeing or accordant; compatible; not self-opposed or self-contradictory, constantly adhering to the same principles; acting in the same way over time, especially so as to be fair or accurate; unchanging in nature, standard, or effect over time; not containing any logical contradictions (of an argument); constant in achievement or effect over a period of time
constraints	limitations or restrictions that must be considered and accommodated when providing a solution to a problem, e.g. teacher-specified limitations, available time, physical realities, legalities
construct	create or put together (e.g. an argument) by arranging ideas or items; display information in a diagrammatic or logical form; make; build
contrast	display recognition of differences by deliberate juxtaposition of contrary elements; show how things are different or opposite; give an account of the differences between two or more items or situations, referring to both or all of them throughout
control technologies	a device or set of devices that manage, command, direct or regulate the behaviour of other devices or systems; a mechanical, optical or electronic system that is used to maintain a desired output
controlled	shows the exercise of restraint or direction over; held in check; restrained, managed or kept within certain bounds
convincing	persuaded by argument or proof; leaving no margin of doubt; clear; capable of causing someone to believe that something is true or real; persuading or assuring by argument or evidence; appearing worthy of belief; credible or plausible
coplanar forces	lie in the same plane
couple	in physics, two parallel forces that have the same magnitude, opposite directions and are separated by a perpendicular distance; the resultant force of a couple tends to cause rotation in a specified direction
course	a defined amount of learning developed from a subject syllabus
create	bring something into being or existence; produce or evolve from one's own thought or imagination; reorganise or put elements together into a new pattern or structure or to form a coherent or functional whole
creative	resulting from originality of thought or expression; relating to or involving the use of the imagination or original ideas to create something; having good imagination or original ideas

Term	Explanation
credible	capable or worthy of being believed; believable; convincing
criterion	the property or characteristic by which something is judged or appraised
critical	involving skilful judgment as to truth, merit, etc.; involving the objective analysis and evaluation of an issue in order to form a judgment; expressing or involving an analysis of the merits and faults of a work of literature, music, or art; incorporating a detailed and scholarly analysis and commentary (of a text); rationally appraising for logical consistency and merit
critique	review (e.g. a theory, practice, performance) in a detailed, analytical and critical way
current	in electronics, the rate of movement of charge carriers from one part of a conductor to another
cursory	hasty, and therefore not thorough or detailed; performed with little attention to detail; going rapidly over something, without noticing details; hasty; superficial
D	
data	documented information or evidence of any kind that lends itself to scientific interpretation; data may be quantitative or qualitative
decide	reach a resolution as a result of consideration; make a choice from a number of alternatives
deduce	reach a conclusion that is necessarily true, provided a given set of assumptions is true; arrive at, reach or draw a logical conclusion from reasoning and the information given
defensible	justifiable by argument; capable of being defended in argument
define	give the meaning of a word, phrase, concept or physical quantity; state meaning and identify or describe qualities
demonstrate	prove or make clear by argument, reasoning or evidence, illustrating with practical example; show by example; give a practical exhibition
density	the density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume; the symbol most often used for density is ρ (the lower case Greek letter rho), although the Latin letter D can also be used; mathematically, density is defined as mass divided by volume
derive	arrive at by reasoning; manipulate a mathematical relationship to give a new equation or relationship; in mathematics, obtain the derivative of a function
describe	give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something

Term	Explanation
design	produce a plan, simulation, model or similar; plan, form or conceive in the mind; in English, select, organise and use particular elements in the process of text construction for particular purposes; these elements may be linguistic (words), visual (images), audio (sounds), gestural (body language), spatial (arrangement on the page or screen) and multimodal (a combination of more than one)
detailed	executed with great attention to the fine points; meticulous; including many of the parts or facts
determine	establish, conclude or ascertain after consideration, observation, investigation or calculation; decide or come to a resolution
develop	elaborate, expand or enlarge in detail; add detail and fullness to; cause to become more complex or intricate
devise	think out; plan; contrive; invent
diagrams	symbolic representations of information according to some visualisation technique; often two-dimensional and geometric; symbols, charts, graphs and maps are forms of diagrams
differentiate	identify the difference/s in or between two or more things; distinguish, discriminate; recognise or ascertain what makes something distinct from similar things in mathematics, obtain the derivative of a function
discerning	discriminating; showing intellectual perception; showing good judgment; making thoughtful and astute choices; selected for value or relevance
discriminate	note, observe or recognise a difference; make or constitute a distinction in or between; differentiate; note or distinguish as different
discriminating	differentiating; distinctive; perceiving differences or distinctions with nicety; possessing discrimination; perceptive and judicious; making judgments about quality; having or showing refined taste or good judgment
discuss	examine by argument; sift the considerations for and against; debate; talk or write about a topic, including a range of arguments, factors or hypotheses; consider, taking into account different issues and ideas, points for and/or against, and supporting opinions or conclusions with evidence
disjointed	disconnected; incoherent; lacking a coherent order/sequence or connection
displacement	a vector quantity representing the location of the destination relative to the origin of motion only, irrespective of the path actually negotiated between the two points
distance	the total length of the pathway taken between the origin and the destination point

Term	Explanation
distinguish	recognise as distinct or different; note points of difference between; discriminate; discern; make clear a difference/s between two or more concepts or items
diverse	of various kinds or forms; different from each other
document	support (e.g. an assertion, claim, statement) with evidence (e.g. decisive information, written references, citations)
draw conclusions	make a judgment based on reasoning and evidence
drone	a powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a payload
dynamics	concerned with the study of forces (linear) and torques (rotational) and their effect on motion
E	
effective	successful in producing the intended, desired or expected result; meeting the assigned purpose
efficient	working in a well-organised and competent way; maximum productivity with minimal expenditure of effort; acting or producing effectively with a minimum of waste, expense or unnecessary effort
elements	constituent parts of a more complex whole; a fundamental, essential or irreducible part of a composite entity; two or more elements make a component
elementary	simple or uncompounded; relating to or dealing with elements, rudiments or first principles (of a subject); of the most basic kind; straightforward and uncomplicated
energy	the potential to move or bring about changes; the higher the energy content, the greater the impact when it is transformed or transferred
engineering	the application of scientific, physical, mechanical and mathematical principles as a part of the process of developing and maintaining solutions, products, structures and systems that improve quality of life
engineering drawings	technical drawings used to fully and clearly define requirements for engineered items; their purpose is to capture all the geometric features of a product or a component and required for a manufacturer to produce that component
equilibrium	a particle is in mechanical equilibrium if the net force on that particle is zero; by extension, a physical system made up of many parts is in mechanical equilibrium if the net force on each of its individual parts is zero
erroneous	based on or containing error; mistaken; incorrect

Term	Explanation
essential	absolutely necessary; indispensable; of critical importance for achieving something
ethical	relating to moral principles that govern a person's or a group's behaviour
evaluate	make an appraisal by weighing up or assessing strengths, implications and limitations; make judgments about ideas, works, solutions or methods in relation to selected criteria; examine and determine the merit, value or significance of something, based on criteria
examination	a supervised test that assesses the application of a range of cognitions to one or more provided items such as questions, scenarios and/or problems; student responses are completed individually, under supervised conditions, and in a set timeframe
examine	investigate, inspect or scrutinise; inquire or search into; consider or discuss an argument or concept in a way that uncovers the assumptions and interrelationships of the issue
experiment	try out or test new ideas or methods, especially in order to discover or prove something; undertake or perform a scientific procedure to test a hypothesis, make a discovery or demonstrate a known fact
explain	make an idea or situation plain or clear by describing it in more detail or revealing relevant facts; give an account; provide additional information
explicit	clearly and distinctly expressing all that is meant; unequivocal; clearly developed or formulated; leaving nothing merely implied or suggested
explore	look into both closely and broadly; scrutinise; inquire into or discuss something in detail
express	convey, show or communicate (e.g. a thought, opinion, feeling, emotion, idea or viewpoint) in words, art, music or movement, convey or suggest a representation of; depict
extended response	an open-ended assessment technique that focuses on the interpretation, analysis, examination and/or evaluation of ideas and information in response to a particular situation or stimulus; while students may undertake some research when writing of the extended response, it is not the focus of this technique; an extended response occurs over an extended and defined period of time
Extension subject	a two-unit subject (Units 3 and 4) for which a syllabus has been developed by QCAA, that is an extension of one or more General subject/s, studied concurrently with, Units 3 and 4 of that subject or after completion of, Units 3 and 4 of that subject
extensive	of great extent; wide; broad; far-reaching; comprehensive; lengthy; detailed; large in amount or scale

Term	Explanation
external assessment	summative assessment that occurs towards the end of a course of study and is common to all schools; developed and marked by the QCAA according to a commonly applied marking scheme
external examination	a supervised test, developed and marked by the QCAA, that assesses the application of a range of cognitions to multiple provided items such as questions, scenarios and/or problems; student responses are completed individually, under supervised conditions, and in a set timeframe
extrapolate	infer or estimate by extending or projecting known information; conjecture; infer from what is known; extend the application of something (e.g. a method or conclusion) to an unknown situation by assuming that existing trends will continue or similar methods will be applicable
F	
factor of safety	the ratio of the yield stress of a member or piece of material to the actual working stress or the maximum permissible stress when in use
factual	relating to or based on facts; concerned with what is actually the case; actually occurring; having verified existence
familiar	well-acquainted; thoroughly conversant with; well known from long or close association; often encountered or experienced; common; (of materials, texts, skills or circumstances) having been the focus of learning experiences or previously encountered in prior learning activities
feasible	capable of being achieved, accomplished or put into effect; reasonable enough to be believed or accepted; probable; likely
features	prominent or conspicuous elements, components or characteristics of a structured whole
flow chart	a diagram that shows step-by-step progression through a procedure or system especially using connecting lines, arrows and a set of conventional symbols; used to illustrate a solution model to a given problem
fluent	spoken or written with ease; able to speak or write smoothly, easily or readily; articulate; eloquent; in artistic performance, characteristic of a highly developed and excellently controlled technique; flowing; polished; flowing smoothly, easily and effortlessly
fluently	in a graceful and seemingly effortless manner; in a way that progresses smoothly and readily

Term	Explanation
force	a push or pull between objects, which may cause one or both objects to change speed and/or the direction of their motion (i.e. accelerate) or change their shape; scientists identify four fundamental forces: the gravitational, the electromagnetic (involving both electrostatic and magnetic forces), the weak nuclear forces and the strong nuclear forces; all interactions between matter can be explained as the action of one, or a combination, of the four fundamental forces
force diagram	also free-body diagram; a graphical illustration used to visualise the applied forces, movements and resulting reactions on a body in a steady state condition (no acceleration of the system); depict a body or connected bodies with all of the applied forces and moments, as well as reactions, that act on a body or bodies
formative assessment	assessment whose major purpose is to improve teaching and student achievement
fragmented	disorganised; broken down; disjointed or isolated
free-body diagram	also force diagram; a graphical illustration used to visualise the applied forces, movements and resulting reactions on a body in a steady state condition (no acceleration of the system); depict a body or connected bodies with all of the applied forces and moments, as well as reactions, that act on a body or bodies
frequent	happening or occurring often at short intervals; constant, habitual, or regular
fundamental	forming a necessary base or core; of central importance; affecting or relating to the essential nature of something; part of a foundation or basis
G	
Gantt chart	a visual representation of a project schedule; a type of bar chart, a Gantt chart shows the start and finish dates of the different required elements of a project
General subject	a subject for which a syllabus has been developed by the QCAA with the following characteristics: results from courses developed from General syllabuses contribute to the QCE; General subjects have an external assessment component; results may contribute to ATAR calculations
generate	produce; create; bring into existence
H	
hypersonic flight	flight speeds that exceed Mach 5 within Earth's atmosphere
hypothesise	formulate a supposition to account for known facts or observed occurrences; conjecture, theorise, speculate; especially on uncertain or tentative grounds

Term	Explanation
I	
identify	distinguish; locate, recognise and name; establish or indicate who or what someone or something is; provide an answer from a number of possibilities; recognise and state a distinguishing factor or feature
illogical	lacking sense or sound reasoning; contrary to or disregardful of the rules of logic; unreasonable
implement	put something into effect, e.g. a plan or proposal
implicit	implied, rather than expressly stated; not plainly expressed; capable of being inferred from something else
improbable	not probable; unlikely to be true or to happen; not easy to believe
inaccurate	not accurate
inappropriate	not suitable or proper in the circumstances
inconsistent	lacking agreement, as one thing with another, or two or more things in relation to each other; at variance; not consistent; not in keeping; not in accordance; incompatible, incongruous
independent	thinking or acting for oneself, not influenced by others
in-depth	comprehensive and with thorough coverage; extensive or profound; well-balanced or fully developed
industrial control systems	a general term that encompasses several types of control systems and associated instrumentation used in industrial production, including supervisory control and data acquisition (SCADA) systems, distributed control systems (DCS), and other smaller control system configurations such as programmable logic controllers (PLC) often found in the industrial sector
infer	derive or conclude something from evidence and reasoning, rather than from explicit statements; listen or read beyond what has been literally expressed; imply or hint at
informed	knowledgeable; learned; having relevant knowledge; being conversant with the topic; based on an understanding of the facts of the situation (of a decision or judgment)
innovation	either something new or a change made to an existing product, process, idea, or field
innovative	new and original; introducing new ideas; original and creative in thinking
input	something put into a system to activate or modify a process, e.g. people, raw materials, power, energy, money, time, equipment, software or data
insightful	showing understanding of a situation or process; understanding relationships in complex situations; informed by observation and deduction

Term	Explanation
instrument-specific marking guide	ISMG; a tool for marking that describes the characteristics evident in student responses and aligns with the identified objectives for the assessment (see 'assessment objectives')
integral	*adjective* necessary for the completeness of the whole; essential or fundamental; *noun* in mathematics, the result of integration; an expression from which a given function, equation, or system of equations is derived by differentiation
intelligent robotics	concerns the melding of artificial perception, strategic reasoning and robotic action in potentially unstructured and time-varying environments to fulfil useful physical tasks, whether in industry or for security, healthcare, search and rescue or civil defence etc.
intelligent sensors	sensor device that is able to perform a number of intelligent functions as part of its task or duty; able to self-test, self-validate and self-adapt as well as self-identify; understand the environment they are put into and can manage a wide range of conditions
intended	designed, meant; done on purpose, intentional
internal assessment	assessments that are developed by schools; summative internal assessments are endorsed by the QCAA before use in schools and results externally confirmed contribute towards a student's final result
interpret	use knowledge and understanding to recognise trends and draw conclusions from given information; make clear or explicit; elucidate or understand in a particular way; bring out the meaning of, e.g. a dramatic or musical work, by performance or execution; bring out the meaning of an artwork by artistic representation or performance; give one's own interpretation of; identify or draw meaning from, or give meaning to, information presented in various forms, such as words, symbols, pictures or graphs
investigate	carry out an examination or formal inquiry in order to establish or obtain facts and reach new conclusions; search, inquire into, interpret and draw conclusions about data and information
investigation	an assessment technique that requires students to research a specific problem, question, issue, design challenge or hypothesis through the collection, analysis and synthesis of primary and/or secondary data; it uses research or investigative practices to assess a range of cognitions in a particular context; an investigation occurs over an extended and defined period of time
irrelevant	not relevant; not applicable or pertinent; not connected with or relevant to something

Term	Explanation
ISMG	instrument-specific marking guide; a tool for marking that describes the characteristics evident in student responses and aligns with the identified objectives for the assessment (see 'assessment objectives')
isolated	detached, separate, or unconnected with other things; one-off; something set apart or characterised as different in some way
iterative	recursive; revisiting earlier parts of a process to further clarify meaning or refine ideas and solutions
J	
judge	form an opinion or conclusion about; apply both procedural and deliberative operations to make a determination
justified	sound reasons or evidence are provided to support an argument, statement or conclusion
justify	give reasons or evidence to support an answer, response or conclusion; show or prove how an argument, statement or conclusion is right or reasonable
K	
kinetic energy	the energy associated with the movement of an object
L	
laminated veneer lumber	LVL; a high-strength engineered wood product used primarily for structural applications; comparable in strength to solid timber, concrete and steel; manufactured by bonding together rotary peeled or sliced thin wood veneers under heat and pressure
law	a statement describing invariable relationships between phenomena in specified conditions, frequently expressed mathematically
learning area	a grouping of subjects, with related characteristics, within a broad field of learning, e.g. the Arts, sciences, languages
levers	rigid bodies capable of rotating on a point on themselves to amplify an input force to provide a greater output force, which is said to provide leverage
life cycle assessment	assessing a product's full environmental cost/impact over the life cycle of the product (cradle-to-grave or cradle-to-cradle); includes extracting and processing materials, manufacturing, transporting and distribution, use, reuse and maintenance, recycling and final disposal; quantifies the environmental impact rather than the financial impact
linear motion	straight line motion or an idealisation of approximately straight line motion when an object moves from one place to another

Term	Explanation
logical	rational and valid; internally consistent; reasonable; reasoning in accordance with the principles/rules of logic or formal argument; characterised by or capable of clear, sound reasoning; (of an action, decision, etc.) expected or sensible under the circumstances
logically	according to the rules of logic or formal argument; in a way that shows clear, sound reasoning; in a way that is expected or sensible
LVL	laminated veneer lumber; a high-strength engineered wood product used primarily for structural applications; comparable in strength to solid timber, concrete and steel; manufactured by bonding together rotary peeled or sliced thin wood veneers under heat and pressure
M	
machines	apparatus using mechanical power and having several parts, each with a definite function and together performing a particular task
make decisions	select from available options; weigh up positives and negatives of each option and consider all the alternatives to arrive at a position
manipulate	adapt or change to suit one's purpose
mass	the measure of an object’s resistance to acceleration (a change in its state of motion) when a force is applied; the SI unit of mass is the kilogram (kg)
material	a substance from which a thing is or can be made, i.e. natural (e.g. animals, food, fibre, timber, mineral) or fabricated (e.g. metal alloys, plastics, textiles, composites); materials are used to create products or environments, and their structure can be manipulated by applying knowledge of their origins, structure, characteristics, properties and uses
materials science	study of the nature, properties and classification of materials, their use in science and the development of technologies, and of the various mechanisms used for modifying materials
matter	anything that has mass and volume (occupies space)
mechanical advantage	a measure of the force amplification achieved by using a tool, mechanical device or machine system; ideally, the device preserves the input power and simply trades off forces against movement to obtain a desired amplification in the output force; the model for this is the law of the lever
mechanics	study of the application of mechanics to solve problems involving common engineering elements; covers the effects of forces on the condition of machines, structures, and their components when at rest or in motion, particularly the mechanics of rigid structures, machines and components

Term	Explanation
mechanisms	a system of parts working together in a machine; pieces of machinery
mental procedures	a domain of knowledge in Marzano's taxonomy, and acted upon by the cognitive, metacognitive and self-systems; sometimes referred to as 'procedural knowledge' there are three distinct phases to the acquisition of mental procedures — the cognitive stage, the associative stage, and the autonomous stage; the two categories of mental procedures are skills (single rules, algorithms and tactics) and processes (macroprocedures)
metal	a solid material that is typically solid at ordinary temperatures, lustrous on a freshly cut surface, malleable, fusible and ductile to some degree, usually with good electrical and thermal conductivity, e.g. iron, gold, silver, and aluminium, and alloys such as steel
methodical	performed, disposed or acting in a systematic way; orderly; characterised by method or order; performed or carried out systematically
mind map	a purposeful diagram used to visually organise information; allows the abstract relationships between ideas to be explored and refined; visual representations may include images, words and parts of words; usually a central idea or concept is placed in the middle and associated ideas arranged around it
minimal	least possible; small, the least amount; negligible
model	a representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships in an object, system or idea; can be either a physical model, such as a scale model of a car or house that shows the form of a final production design, and is made with tools, jigs and fixtures; or virtual, such as a simulator program that demonstrates the capabilities of a vending machine through interaction with a computer user
modify	change the form or qualities of; make partial or minor changes to something
moment	the moment of a force about a point or axis provides a measure of the tendency of the force to cause an object to rotate about the point or axis
momentum	the product of an object's mass and its velocity
multimodal	uses a combination of at least two modes (e.g. spoken, written), delivered at the same time, to communicate ideas and information to a live or virtual audience, for a particular purpose; the selected modes are integrated so that each mode contributes significantly to the response
N	
nanotechnology	the study and application of extremely small elements at the scale of 1 to 100 nanometres

Term	Explanation
narrow	limited in range or scope; lacking breadth of view; limited in amount; barely sufficient or adequate; restricted
Newton's three laws	1. an object at rest stays at rest unless acted on by an external force 2. the direction of the acceleration of an object is in the direction of the net external force acting on it 3. forces always occur in equal and opposite pairs
non-concurrent forces	two or more forces whose magnitudes are equal but act in opposite directions with a common line of action
nuanced	showing a subtle difference or distinction in expression, meaning, response, etc.; finely differentiated; characterised by subtle shades of meaning or expression; a subtle distinction, variation or quality; sensibility to, awareness of, or ability to express delicate shadings, as of meaning, feeling, or value
O	
objectives	see 'syllabus objectives', 'unit objectives', 'assessment objectives'
obvious	clearly perceptible or evident; easily seen, recognised or understood
one-body systems	mechanics describes and predicts the conditions of rest or motion of a body subjected to a given force or system of forces (Schlenker & McKern 1976)
open-ended problems	loosely structured and complex, having no one correct solution or solution path, and requiring students to comprehend and apply a breadth and depth of knowledge during problem-solving
optimal	best, most favourable, under a particular set of circumstances
organise	arrange, order; form as or into a whole consisting of interdependent or coordinated parts, especially for harmonious or united action
organised	systematically ordered and arranged; having a formal organisational structure to arrange, coordinate and carry out activities
orthographic	a scaled, multi-view drawings of a 3D object to show each view separately in a series of 2D drawings, e.g. top or bottom, front, back and sides; in Australia, orthogonal drawings use third-angle projection for layout of the views; orthogonal drawings may also include the measurements on each view and are used to develop lists of material requirements; in these drawings, each edge is represented by a connected line, each segment of which is parallel to a coordinate axis
output	a result of something (physical or virtual) such as power, energy, action, material or information produced by a person, machine or a system
outstanding	exceptionally good; clearly noticeable; prominent; conspicuous; striking

Term	Explanation
P	
partial	not total or general; existing only in part; attempted, but incomplete
particular	distinguished or different from others or from the ordinary; noteworthy
perceptive	having or showing insight and the ability to perceive or understand; discerning (see also 'discriminating')
performance	an assessment technique that requires students to demonstrate a range of cognitive, technical, creative and/or expressive skills and to apply theoretical and conceptual understandings, through the psychomotor domain; it involves student application of identified skills when responding to a task that involves solving a problem, providing a solution or conveying meaning or intent; a performance is developed over an extended and defined period of time
performance index	a tabulated set of data that supports evaluation of a prototype solution's performance relative to success criteria
persuasive	capable of changing someone's ideas, opinions or beliefs; appearing worthy of approval or acceptance; (of an argument or statement) communicating reasonably or credibly (see also 'convincing')
perusal time	time allocated in an assessment to reading items and tasks and associated assessment materials; no writing is allowed; students may not make notes and may not commence responding to the assessment in the response space/book
planning time	time allocated in an assessment to planning how to respond to items and tasks and associated assessment materials; students may make notes but may not commence responding to the assessment in the response space/book; notes made during planning are not collected, nor are they graded or used as evidence of achievement
polished	flawless or excellent; performed with skilful ease
power	the rate at which work is done, or the rate at which energy is transferred or transformed; usually measured in watts
precise	definite or exact; definitely or strictly stated, defined or fixed; characterised by definite or exact expression or execution
precision	accuracy; exactness; exact observance of forms in conduct or actions
predict	give an expected result of an upcoming action or event; suggest what may happen based on available information
principles	specific types of generalisations that deal with relationships; a proposition that serves as the foundation for a system of belief or behaviour or for a chain of reasoning
problem-solving process	consists of subject specific problem-solving processes (explore, develop, generate and evaluate) used to iteratively find solutions to difficult or complex problems or situations

Term	Explanation
product	an assessment technique that focuses on the output or result of a process requiring the application of a range of cognitive, physical, technical, creative and/or expressive skills, and theoretical and conceptual understandings; a product is developed over an extended and defined period of time; in Technologies, a designed solution; a tangible end result of a human, construction, mechanical, manufacturing or digital process; created by practical application of knowledge and skills
proficient	well advanced or expert in any art, science or subject; competent, skilled or adept in doing or using something
project	an assessment technique that focuses on a problem-solving process requiring the application of a range of cognitive, technical and creative skills and theoretical understandings; the response is a coherent work that documents the iterative process undertaken to develop a solution and includes written paragraphs and annotations, diagrams, sketches, drawings, photographs, video, spoken presentations, physical prototypes and/or models; a project is developed over an extended and defined period of time
project manage	the act of planning, organising, controlling resources, monitoring timelines, and the processes used to generate a prototype solution to provide data that assesses the accuracy of predictions made concerning performance
project management	a responsibility for planning, organising, controlling resources, monitoring timelines and activities, and completing a project to achieve a goal that meets identified criteria for judging success
property	attribute of an object or material, normally used to describe attributes common to a group
propose	put forward (e.g. a point of view, idea, argument, suggestion) for consideration or action
prototype	a trial solution to test an idea to inform further development; demonstrates the interaction of the components of a product, service or environment; its purpose is to identify if and how well a solution functions and can be tested by stakeholders
prove	use a sequence of steps to obtain the required result in a formal way
psychomotor procedures	a domain of knowledge in Marzano's taxonomy, and acted upon by the cognitive, metacognitive and self-systems; these are physical procedures used to negotiate daily life and to engage in complex physical activities; the two categories of psychomotor procedures are skills (foundational procedures and simple combination procedures) and processes (complex combination procedures)
purposeful	having an intended or desired result; having a useful purpose; determined; resolute; full of meaning; significant; intentional

Term	Explanation
Q	
QCE	Queensland Certificate of Education
qualitative data	information that is not numerical in nature
quantitative data	numerical information
R	
rapid prototyping	a range of techniques used to quickly fabricate a scale model of a physical part or assembly using 3D computer-assisted design (CAD); construction of the part or assembly is usually done using 3D printing or additive layer manufacturing technology
realise	create or make (e.g. a musical, artistic or dramatic work); actualise; make real or concrete; give reality or substance to
reasonable	endowed with reason; having sound judgment; fair and sensible; based on good sense; average; appropriate, moderate
reasoned	logical and sound; based on logic or good sense; logically thought out and presented with justification; guided by reason; well-grounded; considered
recall	remember; present remembered ideas, facts or experiences; bring something back into thought, attention or into one's mind
recognise	identify or recall particular features of information from knowledge; identify that an item, characteristic or quality exists; perceive as existing or true; be aware of or acknowledge
refine	to make partial or minor changes to something in order to improve it; modify in relation to selected criteria
refined	developed or improved so as to be precise, exact or subtle
reflect on	think about deeply and carefully
rehearsed	practised; previously experienced; practised extensively
related	associated with or linked to
relevance	being related to the matter at hand
relevant	bearing upon or connected with the matter in hand; to the purpose; applicable and pertinent; having a direct bearing on
reliability	ability to be trusted to be accurate or correct or to provide a correct result
reliable	constant and dependable or consistent and repeatable
repetitive	containing or characterised by repetition, especially when unnecessary or tiresome
reporting	providing information that succinctly describes student performance at different junctures throughout a course of study

Term	Explanation
resolve	in the Arts, consolidate and communicate intent through a synthesis of ideas and application of media to express meaning
resultant	the single force and associated torque obtained by combining a system of forces and torques acting on a rigid body; the defining feature of a resultant force, or resultant force-torque, is that it has the same effect on the rigid body as the original system of forces
robotics	a branch of engineering that involves the conception, design, manufacture, and operation of robots; this field overlaps with electronics, computer science, artificial intelligence, mechatronics, nanotechnology and bioengineering
routine	often encountered, previously experienced; commonplace; customary and regular; well-practiced; performed as part of a regular procedure, rather than for a special reason
rudimentary	relating to rudiments or first principles; elementary; undeveloped; involving or specifically basic principles; relating to an immature, undeveloped or basic form
S	
safe	secure; not risky
scalar quantity	has magnitude but no direction, e.g. mass, volume and length are scalar quantities
schema	describes the cognition used during aspects of problem-solving that organises information; a representation that records and clarifies thinking, e.g. mind maps
science, technology, engineering and mathematics	STEM; typically used when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development
secure	sure; certain; able to be counted on; self-confident; poised; dependable; confident; assured; not liable to fail
select	choose in preference to another or others; pick out
sensitive	capable of perceiving with a sense or senses; aware of the attitudes, feelings or circumstances of others; having acute mental or emotional sensibility; relating to or connected with the senses or sensation
sequence	place in a continuous or connected series; arrange in a particular order
show	provide the relevant reasoning to support a response
SI units	International System of Units; a standardised system of definitions and rules for writing and presenting measurements; comprises a coherent system of units of measurement built on seven base units; it defines twenty-two named units, and includes many more unnamed coherent derived units; also establishes a set of twenty prefixes to the unit names and unit symbols that may be used when specifying multiples and fractions of the units

Term	Explanation
significant	important; of consequence; expressing a meaning; indicative; includes all that is important; sufficiently great or important to be worthy of attention; noteworthy; having a particular meaning; indicative of something
simple	easy to understand, deal with and use; not complex or complicated; plain; not elaborate or artificial; may concern a single or basic aspect; involving few elements, components or steps
simple truss frame forms	are rigid planar structures composed of slender members joined together at their end points to form a series of integrated triangles
simplistic	characterised by extreme simplification, especially if misleading; oversimplified
simulation	a representation of a process, event or system that imitates a real or idealised situation
sketches	drawings or paintings in simple form, giving essential features but not necessarily with detail or accuracy; in mathematics, represent by means of a diagram or graph; the sketch should give a general idea of the required shape or relationship and should include features; in Technologies, a two-dimensional informal visualisation method completed freehand, often instantly capturing an idea for later use and therefore lacking in presentation quality; sketches are usually produced manually, using pencil, ink and paper, but may be software-assisted
skilful	having technical facility or practical ability; possessing, showing, involving or requiring skill; expert, dexterous; demonstrating the knowledge, ability or training to perform a certain activity or task well; trained, practised or experienced
skilled	having or showing the knowledge, ability or training to perform a certain activity or task well; having skill; trained or experienced; showing, involving or requiring skill
solutions	ideas, concepts, products, systems, components or processes that have been developed through a problem-solving process
solve	find an answer to, explanation for, or means of dealing with (e.g. a problem); work out the answer or solution to (e.g. a mathematical problem); obtain the answer/s using algebraic, numerical and/or graphical methods
sophisticated	of intellectual complexity; reflecting a high degree of skill, intelligence, etc.; employing advanced or refined methods or concepts; highly developed or complicated
specific	clearly defined or identified; precise and clear in making statements or issuing instructions; having a special application or reference; explicit, or definite; peculiar or proper to something, as qualities, characteristics, effects, etc.

Term	Explanation
specifications	what the users of the product or service need in terms of features, functions, performance, constraints and quality; written in terms of what the product must do or qualities it must have
speed	the rate at which an object covers distance
sporadic	happening now and again or at intervals; irregular or occasional; appearing in scattered or isolated instances
statics	the branch of mechanics concerned with the analysis of loads (force and torque, or moment) acting on physical systems that do not experience an acceleration, but are in static equilibrium with their environment; when in static equilibrium, the acceleration of the system is zero and the system is either at rest, or its centre of mass moves at constant velocity
STEM	science, technology, engineering and mathematics; typically used when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development
straightforward	without difficulty; uncomplicated; direct; easy to do or understand
structure	give a pattern, organisation or arrangement to; construct or arrange according to a plan; an ordered assembly of elements, components and features that form an organised pattern or system
structured	organised or arranged so as to produce a desired result
subject	a branch or area of knowledge or learning defined by a syllabus; school subjects are usually based in a discipline or field of study (see also 'course')
subject matter	the subject-specific body of information, mental procedures and psychomotor procedures that are necessary for students' learning and engagement within that subject
substantial	of ample or considerable amount, quantity, size, etc.; of real worth or value; firmly or solidly established; of real significance; reliable; important, worthwhile
substantiated	established by proof or competent evidence
subtle	fine or delicate in meaning or intent; making use of indirect methods; not straightforward or obvious
success criteria	a descriptive list of essential features against which success can be measured; the compilation of criteria involves literacy skills to select and use appropriate terminology
successful	achieving or having achieved success; accomplishing a desired aim or result
succinct	expressed in few words; concise; terse; characterised by conciseness or brevity; brief and clear
sufficient	enough or adequate for the purpose

Term	Explanation
suitable	appropriate; fitting; conforming or agreeing in nature, condition, or action
summarise	give a brief statement of a general theme or major point/s; present ideas and information in fewer words and in sequence
summary report	provides a client with a concise account of the preferred solution including the key features and any recommendations made to inform future solution development; includes key pictures, tables, graphs, sketches and drawings
summative assessment	assessment whose major purpose is to indicate student achievement; summative assessments contribute towards a student's subject result
superficial	concerned with or comprehending only what is on the surface or obvious; shallow; not profound, thorough, deep or complete; existing or occurring at or on the surface; cursory; lacking depth of character or understanding; apparent and sometimes trivial
supersonic flight	flight exceeding the speed of sound
supported	corroborated; given greater credibility by providing evidence
sustainable	supporting the needs of the present without compromising the ability of future generations to support their needs
sustainable engineering	the process of designing or operating systems in ways that use energy and resources at a rate that does not compromise the natural environment, or the ability of future generations to meet their own needs
sustained	carried on continuously, without interruption, or without any diminishing of intensity or extent
syllabus	a document that prescribes the curriculum for a course of study
syllabus objectives	outline what the school is required to teach and what students have the opportunity to learn; described in terms of actions that operate on the subject matter; the overarching objectives for a course of study (see also 'unit objectives', 'assessment objectives')
symbolise	represent or identify by a symbol or symbols
synthesise	combine different parts or elements (e.g. information, ideas, components) into a whole, in order to create new understanding

Term	Explanation
system	a group of interacting objects, materials or processes that form an integrated whole; systems can be open or closed; a system has properties and or functions that can be described differently from its component parts; systems can be identified as four types: • natural systems, e.g. an ecosystem including plants and animals • designed physical systems, e.g. buildings, road networks, aircraft, airports • designed abstract systems, e.g. mathematic equations, computer algorithms • human activity systems, e.g. a team task, flight crew, human machine interface
systematic	done or acting according to a fixed plan or system; methodical; organised and logical; having, showing, or involving a system, method, or plan; characterised by system or method; methodical; arranged in, or comprising an ordered system
T	
technical	requiring special knowledge to be understood
technologies	materials, data, systems, components, tools and equipment used to create solutions for identified needs and opportunities, and the knowledge, understanding and skills used by people involved in the selection and use of these
technology	the development of products, services and environments, using various types of knowledge, including computational, design, systems, social, ethical, economic, environmental, and sustainability knowledge to meet human needs and wants; 'the know-how and creative process that may use tools, systems and resources to solve problems and enhance control over the natural and man-made environment in an endeavour to improve the human condition' (UNESCO 1985 cited in Ferguson 2009, p.7)
test	take measures to check the quality, performance or reliability of something
thorough	carried out through, or applied to the whole of something; carried out completely and carefully; including all that is required; complete with attention to every detail; not superficial or partial; performed or written with care and completeness; taking pains to do something carefully and completely
thoughtful	occupied with, or given to thought; contemplative; meditative; reflective; characterised by or manifesting thought
topic	a division of, or sub-section within a unit; all topics/sub-topics within a unit are interrelated
truth tables	a mathematical table used in logic — specifically in connection with Boolean algebra, Boolean functions and propositional calculus to show whether a propositional expression is true for all legitimate input values, i.e. logically valid

Term	Explanation
U	
unclear	not clear or distinct; not easy to understand; obscure
understand	perceive what is meant by something; grasp; be familiar with (e.g. an idea); construct meaning from messages, including oral, written and graphic communication
uneven	unequal; not properly corresponding or agreeing; irregular; varying; not uniform; not equally balanced
unfamiliar	not previously encountered; situations or materials that have not been the focus of prior learning experiences or activities
unit	a defined amount of subject matter delivered in a specific context or with a particular focus; it includes unit objectives particular to the unit, subject matter and assessment direction
unit objectives	drawn from the syllabus objectives and contextualised for the subject matter and requirements of a particular unit; they are assessed at least once in the unit (see also 'syllabus objectives', 'assessment objectives')
unrelated	having no relationship; unconnected
use	operate or put into effect; apply knowledge or rules to put theory into practice
V	
vague	not definite in statement or meaning; not explicit or precise; not definitely fixed, determined or known; of uncertain, indefinite or unclear character or meaning; not clear in thought or understanding; couched in general or indefinite terms; not definitely or precisely expressed; deficient in details or particulars; thinking or communicating in an unfocused or imprecise way
valid	sound, just or well-founded; authoritative; having a sound basis in logic or fact (of an argument or point); reasonable or cogent; able to be supported; legitimate and defensible; applicable
variable	*adjective* apt or liable to vary or change; changeable; inconsistent; (readily) susceptible or capable of variation; fluctuating, uncertain; *noun* in mathematics, a symbol, or the quantity it signifies, that may represent any one of a given set of number and other objects
variety	a number or range of things of different kinds, or the same general class, that are distinct in character or quality; (of sources) a number of different modes or references
vector quantity	a quantity that has both magnitude and direction and obeys the parallelogram law of addition, e.g. force is a vector quantity; a vector may be represented by an arrowed line segment
velocity	the rate at which an object changes its position

Term	Explanation
velocity ratio	the ratio of the distance moved by the point of application of the effort to the distance moved by the load in a simple machine
W	
weight	the weight of an object is the force on the object due to gravity measured in newtons, e.g. an object with a mass of one kilogram has a weight of approximately 9.8 newtons on the surface of the Earth
wide	of great range or scope; embracing a great number or variety of subjects, cases, etc.; of full extent
with expression	in words, art, music or movement, conveying or indicating feeling, spirit, character, etc.; a way of expressing or representing something; vivid, effective or persuasive communication
work	in physics, a concept that relates force to energy; defined as the product of a force and the displacement (distance in practical terms) of an object on which it acts

7 References

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8 Version history

Version	Date of change	Update
1.1	February 2018	Editorial edits
		Subject matter amendments
		IA1: Project — folio • Description paragraph amendment
		IA2: Examination • Specifications amendment — structure • Removal of objectives 7 and 8
		IA3: Project — folio • Description paragraph amendment
		EA: Examination • Specifications amendment — structure • Removal of objectives 7 and 8
		Reporting standards • Amendments to standard C and E to align with subjects in the Technologies Learning Area
		Amendment to ISMGs — IA1, IA2 and IA3
		Glossary updated

ISBN: 978-1-74378-031-2

Engineering General Senior Syllabus 2019

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