

Engineering 2025 v1.0

General senior syllabus

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Queensland syllabuses for senior subjects

In Queensland, a syllabus for a senior subject is an official 'map' of a senior school subject. A syllabus's function is to support schools in delivering the Queensland Certificate of Education (QCE) system through high-quality and high-equity curriculum and assessment.

Syllabuses are based on design principles developed from independent international research about how excellence and equity are promoted in the documents teachers use to develop and enliven the curriculum.

Syllabuses for senior subjects build on student learning in the Prep to Year 10 Australian Curriculum and include General, General (Extension), Senior External Examination (SEE), Applied, Applied (Essential) and Short Course syllabuses.

More information about syllabuses for senior subjects is available at www.qcaa.qld.edu.au/senior/senior-subjects and in the 'Queensland curriculum' section of the *QCE and QCIA policy and procedures handbook*.

Teaching, learning and assessment resources will support the implementation of a syllabus for a senior subject. More information about professional resources for senior syllabuses is available on the QCAA website and via the QCAA Portal.

Course overview

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 real-world-related 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.

Syllabus objectives

The syllabus objectives outline what students have the opportunity to learn.

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, mechanics, materials 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 technology, mechanics, materials science and control technologies, and knowledge gained through research, investigation 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 determine the feasibility of the real-world solution.

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 solution success criteria. When students refine ideas and solutions, they modify to make improvements relative to solution 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 modifications.

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 and visual 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 and diagrams. Students use referencing conventions to practise ethical scholarship for particular purposes.

Designing a course of study in Engineering

Syllabuses are designed for teachers to make professional decisions to tailor curriculum and assessment design and delivery to suit their school context and the goals, aspirations and abilities of their students within the parameters of Queensland's senior phase of learning.

The syllabus is used by teachers to develop curriculum for their school context. The term *course of study* describes the unique curriculum and assessment that students engage with in each school context. A course of study is the product of a series of decisions made by a school to select, organise and contextualise subject matter, integrate complementary and important learning, and create assessment tasks in accordance with syllabus specifications.

It is encouraged that, where possible, a course of study is designed such that teaching, learning and assessment activities are integrated and enlivened in an authentic setting.

Course structure

Engineering is a General senior syllabus. It contains four QCAA-developed units from which schools develop their course of study.

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

Students should complete Unit 1 and Unit 2 before beginning Units 3 and 4. Units 3 and 4 are studied as a pair.

More information about the requirements for administering senior syllabuses is available in the 'Queensland curriculum' section of the [QCE and QCIA policy and procedures handbook](#).

Curriculum

Senior syllabuses set out only what is essential while being flexible so teachers can make curriculum decisions to suit their students, school context, resources and expertise.

Within the requirements set out in this syllabus and the [QCE and QCIA policy and procedures handbook](#), schools have autonomy to decide:

- how and when subject matter is delivered
- how, when and why learning experiences are developed, and the context in which learning occurs
- how opportunities are provided in the course of study for explicit and integrated teaching and learning of complementary skills.

These decisions allow teachers to develop a course of study that is rich, engaging and relevant for their students.

Assessment

Senior syllabuses set out only what is essential while being flexible so teachers can make assessment decisions to suit their students, school context, resources and expertise.

General senior syllabuses contain assessment specifications and conditions for the assessment instruments that must be implemented with Units 3 and 4. These specifications and conditions ensure comparability, equity and validity in assessment.

Within the requirements set out in this syllabus and the [QCE and QCIA policy and procedures handbook](#), schools have autonomy to decide:

- specific assessment task details
- assessment contexts to suit available resources
- how the assessment task will be integrated with teaching and learning activities
- how authentic the task will be.

In Unit 1 and Unit 2, schools:

- develop at least two but no more than four assessments
- complete at least one assessment for each unit
- ensure that each unit objective is assessed at least once.

In Units 3 and 4, schools develop three assessments using the assessment specifications and conditions provided in the syllabus.

More information about assessment in senior syllabuses is available in 'The assessment system' section of the [QCE and QCIA policy and procedures handbook](#).

Subject matter

Each unit contains a unit description, unit objectives and 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 the subject.

Subject matter itself is not the specification of learning experiences but provides the basis for the design of student learning experiences.

Subject matter has a direct relationship with the unit objectives and provides statements of learning that have been constructed in a similar way to objectives.

Aboriginal perspectives and Torres Strait Islander perspectives

The QCAA is committed to reconciliation. 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.

Complementary skills

Opportunities for the development of complementary skills have been embedded throughout subject matter. These skills, which overlap and interact with syllabus subject matter, 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.

These complementary skills are:

- literacy — the knowledge, skills, behaviours and dispositions about language and texts essential for understanding and conveying English language 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 skills include critical thinking, creative thinking, communication, collaboration and teamwork, personal and social skills, and digital literacy. The explanations of associated skills are available at www.qcaa.qld.edu.au/senior/senior-subjects/general-subjects/21st-century-skills.

It is expected that aspects of literacy, numeracy and 21st century skills will be developed by engaging in the learning outlined in this syllabus. Teachers may choose to create additional explicit and intentional opportunities for the development of these skills as they design the course of study.

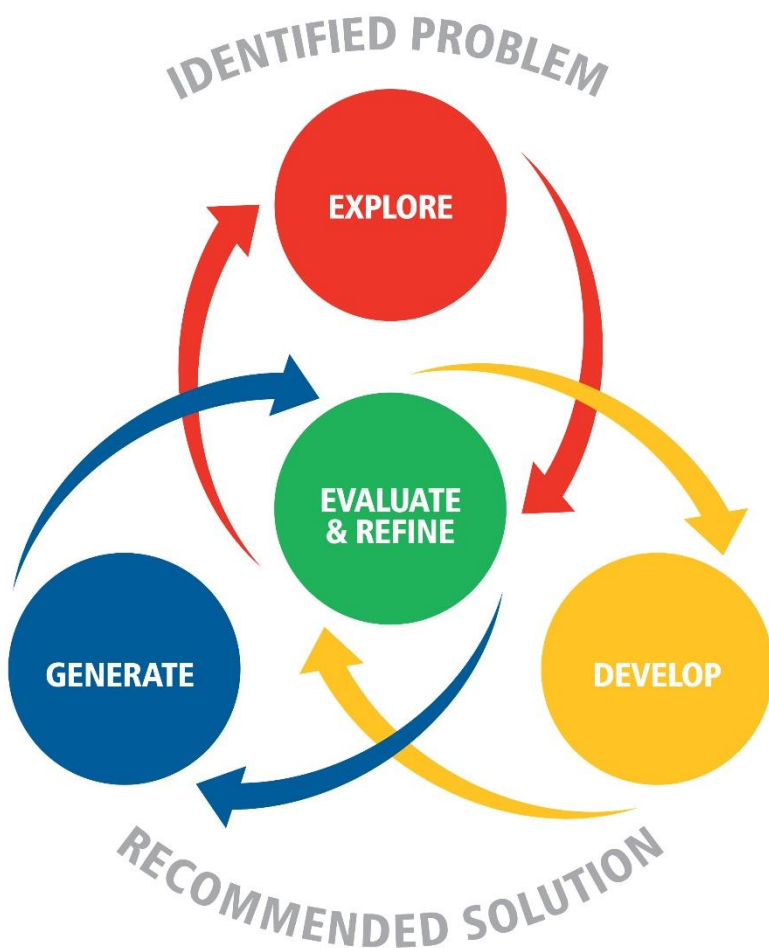
Additional subject-specific information

Additional subject-specific information has been included to support and inform the development of a course of study.

Procedural knowledge

This procedural knowledge must be integrated into the subject matter and assessment of all units. Each of the units in Engineering has a particular context with associated knowledge and skills. The units are structured to provide students with the opportunity to apply the engineering problem-solving process (see Figure 1) and associated knowledge and skills through each of the four units.

Figure 1: 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.

To explore the problem, students:

- recognise and describe the characteristics of the real-world problem in relation to engineering technology knowledge, mechanics, materials science and control technologies concepts and principles
- analyse the real-world problem and associated engineering information to identify the elements, components and features, and their relationship to the structure of the problem to evaluate their importance
- research and investigate similar problem situations or solutions to understand the nature of the real-world problem, i.e. what is best engineering practice?
- test and/or calculate to understand the engineering fundamentals of the real-world 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 real-world problem.

To develop ideas, students:

- synthesise knowledge of technology, mechanics, materials science and control technologies and knowledge gained through research, investigation and testing
- symbolise ideas using sketches, drawings, photographs, diagrams, models, tables and/or schemas
- explain using annotations, paragraphs, images and sentences to describe in detail the development of ideas using relevant factual information
- evaluate idea development using solution success criteria
- calculate to determine the limits for solution development
- test materials and processes to support idea development
- prototype ideas for testing and refinement
- review solution success criteria
- predict a real-world-related solution.

To generate solutions, students:

- create drawings that demonstrate an understanding of basic drawing standards — either manual or using computer-aided drafting (CAD) — to facilitate generation of a prototype solution
- calculate to predict prototype and real-world solution performance and communicate data for an audience using diagrams, tables and spreadsheets
- generate a prototype solution to provide valid performance data on real-world solution using processes such as virtual production, hand or machine manufacture, 3D printing or laser cutting.

To evaluate and refine, students:

- perform testing of the prototype solution, using methods such as destructive, non-destructive testing, substitution or simulation to provide performance data
- resolve uncertainties to refine the prototype solution
- reanalyse test results
- evaluate the real-world-related solution using solution success criteria and prototype performance data
- make and justify recommendations to modify real-world-related solution performance.

Reporting

General information about determining and reporting results for senior syllabuses is provided in the 'Determining and reporting results' section of the [QCE and QCIA policy and procedures handbook](#).

Reporting standards

Reporting standards are summary statements that describe typical performance at each of the five levels (A–E).

A
<p>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.</p> <p>The student demonstrates insightful analysis of problems and relevant information, and astute determination of essential solution success criteria.</p> <p>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 determine the feasibility of the real-world solution; discerning decision-making about, and proficient use of, mode-appropriate features, language and conventions to communicate development of solutions for purpose.</p>
B
<p>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.</p> <p>The student demonstrates considered analysis of problems and relevant information, and reasoned determination of effective solution success criteria.</p> <p>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 determine the feasibility of the real-world solution; effective decision-making about, and fluent use of, mode-appropriate features, language and conventions to communicate development of solutions for purpose.</p>
C
<p>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.</p> <p>The student demonstrates appropriate analysis of problems and information, and logical determination of appropriate solution success criteria.</p> <p>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 determine the feasibility of the real-world solution; appropriate decision-making about, and use of, mode-appropriate features, language and conventions to communicate development of solutions for purpose.</p>

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 reasonable 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 determine the feasibility of the real-world solution; inconsistent 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.

Determining and reporting results

Unit 1 and Unit 2

Schools make judgments on individual assessment instruments using a method determined by the school. They may use the reporting standards or develop an instrument-specific marking guide (ISMG). Marks are not required for determining a unit result for reporting to the QCAA.

The unit assessment program comprises the assessment instrument/s designed by the school to allow the students to demonstrate the unit objectives. The unit judgment of A–E is made using reporting standards.

Schools report student results for Unit 1 and Unit 2 to the QCAA as satisfactory (S) or unsatisfactory (U). Where appropriate, schools may also report a not rated (NR).

Units 3 and 4

Schools mark each of the three internal assessment instruments implemented in Units 3 and 4 using ISMGs.

Schools report a provisional mark by criterion to the QCAA for each internal assessment.

Once confirmed by the QCAA, these results will be combined with the result of the external assessment developed and marked by the QCAA.

The QCAA uses these results to determine each student's subject result as a mark out of 100 and as an A–E.

Units

Unit 1: Engineering fundamentals

In Unit 1, students learn about engineering's role in solving global and local societal problems in order to improve the human condition. They learn how to use their knowledge of fundamental mechanics and materials science concepts and principles to solve problems using the problem-solving process in Engineering 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 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 objectives

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 determine the feasibility of real-world solutions.
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.

Subject matter

Topic 1: Engineering in society

- Comprehend how the problem-solving process in Engineering can be applied to solve a structural problem in relation to engineering fundamentals.
- Recognise engineering career pathways in civil, mechanical and electrical engineering.
- Explore the implications of an engineered solution developed by an ancient civilisation, e.g. Egyptians, Greeks or Romans, including
 - materials, e.g. timber, stone, bronze and iron
 - structures, e.g. bridges, dams, buildings and roads.
- Examine the historical engineering accomplishments of Aboriginal peoples and Torres Strait Islander peoples, including
 - structures, e.g. weirs and fish traps, permanent and semi-permanent housing
 - tools, e.g. boomerangs, stone and natural glass chisels, knives
 - mechanisms, e.g. woomera (throwing lever)
 - materials, e.g. thermoplastic resin.
- 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* (2022) for engineering practice.

Topic 2: Engineering communication

- Identify and describe different types of engineering communication, including annotations and callouts in sketches and engineering drawings, and report structure and format.
- Comprehend 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.

- Use sketching and basic drawing standards to represent ideas and a solution to a simple engineering problem, e.g. covered community seating, wheelchair 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.
- Recognise CAD and identify a number of software programs used to communicate various engineering information in 2D and 3D platforms.
- Contrast CAD with other methods of engineering communication, including sketching and hand 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 strength to weight ratio $\left(\frac{\text{weight held}}{\text{weight of project}}\right)$, weight and strength of materials.
- Represent data in tabular form.
- Generate a graph from multiple datasets.
- Represent information in the form of schemas, e.g. mind map, circuit diagram, mechanical schematic, process flow diagram, system architecture schema, network diagram, life cycle diagram, logic circuit.

Topic 3: Introduction to engineering mechanics

- Define engineering mechanics, engineering statics, engineering dynamics, mass, force and matter.
- Comprehend Newton's three laws.
- Recognise common engineering quantities, SI units and symbols as outlined in the table below.

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

- Define the characteristics of a force, including
 - $\text{force} = \text{mass} \times \text{acceleration}$
 - push or pull exerted by one body on another characterised by magnitude, direction, line of action and point of application.
- Recognise how force diagrams are used in the calculation of force vectors for bodies in equilibrium.

- Comprehend components of a force, including
 - differentiate and relate force, gravity, mass and weight
 - calculate unknown forces using Pythagoras' theorem

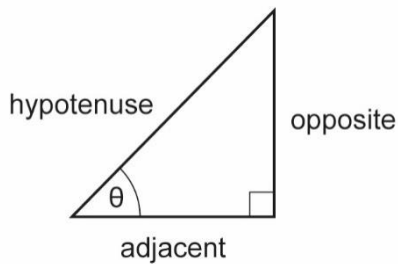
$$a^2 + b^2 = c^2$$

- calculate horizontal and vertical components using trigonometry and graphical methods

$$\text{horizontal component } F_H = F \cos \theta$$

$$\text{vertical component } F_V = F \sin \theta$$

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



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

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

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

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

$$M_T = M_1 + M_2 + M_3 + \dots$$
 - 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).
- Recognise axial compression and tension in a beam.
- Recognise basic truss types and their advantages and disadvantages under loading.
- Recognise axial compression and tension in truss members.
- Conduct experiments on simple truss frame forms to identify tensile and compressive forces.
- Determine how structures transfer forces.
- Comprehend types of loading, including tensile, compressive, bending, shear and torsion.

Topic 4: Introduction to engineering materials

- Classify materials, including recognising and describing how engineers classify materials into metals and alloys, composite materials, polymers, ceramics and natural materials.
- Comprehend the structure of the solid state of materials, including comparing solids, liquids and gases.
- Calculate density using the formula

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$
- Explain primary bonding, i.e. ionic, covalent, metallic.
- Appreciate the properties of engineering materials, including
 - physical: dimensions, shape, density or specific gravity, porosity, moisture content, macrostructure, microstructure
 - chemical: oxide or compound, composition, acidity or alkalinity, resistance to corrosion or weathering
 - physio-chemical: water-absorptive or water repellent action, shrinkage and swell due to moisture changes
 - acoustical: sound transmission, sound reflection
 - mechanical: strength — tension, compression, shear and flexure (under static, impact or fatigue conditions); stiffness, toughness, elasticity, plasticity, ductility, brittleness, hardness, wear resistance
 - thermal: specific heat, expansion, conductivity
 - electrical and magnetic: conductivity, magnetic permeability, galvanic action
 - optical: colour, light transmission, light reflection.
- Recognise types of tests, including routine tests, exploratory tests, destructive tests, non-destructive or 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.
- Recognise features of a stress–strain diagram, including stress, strain, stiffness, and elasticity (Young’s modulus), proportional limit (Hooke’s Law), ultimate tensile strength (UTS), toughness, resilience, ductility and yield stress.

Unit 2: Emerging technologies

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 using the problem-solving process in Engineering 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 objectives

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 determine the feasibility of the real-world solution.
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.

Subject matter

Topic 1: Emerging needs in society

- Comprehend how the problem-solving process in Engineering can be applied to solve an emerging societal problem involving emerging technologies.
- Recognise current and future opportunities in engineering professions selected from micro-nano, chemical, aerospace, environmental, biomedical, space, processing, software and mechatronics engineering.
- Explore an emerging problem by identifying the scope, known and unknown variables, constraints and objectives, considering the social, economic and environmental issues. Examples of emerging 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.
- Comprehend the ethical, legal, social and economic impacts associated with current and emerging engineering contexts, e.g. biomedical advances, space colonisation, nanotechnology, robotics and biomimicry.
- Describe the importance of unmanned vehicles, drones, supersonic flight and hypersonic flight in emerging applications, including
 - dangerous occupations
 - repetitive processes
 - global enterprises.
- Contrast the benefits and the ethical, legal, social, economic and/or environmental risks of technologies (such as drones and self-driven vehicles) in contexts, 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.
- Compare alternative energy sources, including solar, geothermal, hydro, wind, tidal and biomass.

Topic 2: Emerging processes, machinery and automation

- 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.
- Consider 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 to solve linear motion problems involving displacement, velocity, time and acceleration using the formulas

$$v_{av} = \frac{s}{t}$$
$$a = \frac{v - u}{t}$$

- Comprehend mechanical advantage (MA) and velocity ratio (VR) including
 - Define mechanical advantage (MA) and velocity ratio (VR).
 - Calculate MA and VR using the formulas

$$MA = \frac{\text{load}}{\text{effort}} = \frac{F_L}{F_E}$$
$$VR = \frac{\text{distance moved by effort}}{\text{distance moved by load}} = \frac{d_E}{d_L}$$

- Describe emerging automation, including intelligent robotics, intelligent sensors, computer vision and industrial control systems.
- Explore unmanned vehicles, e.g. drones, cars, trucks and agricultural and space vehicles.
- Comprehend 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.
- Contrast alternating and direct current.
- Comprehend the relationships between power, energy, current, resistance and voltage, and calculate to solve problems using the formulas

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

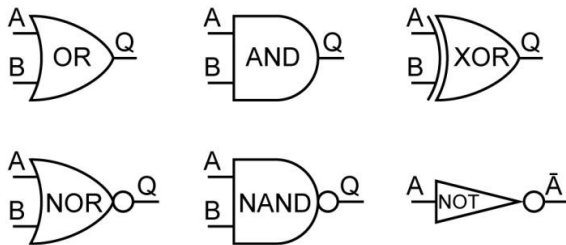
- Calculate to solve problems involving basic series circuits with two resistors using the formula
- Calculate to solve problems using basic parallel circuits with two resistors using the formula

$$R_T = R_1 + R_2$$
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

- 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 virtual or physical circuits.
- Create virtual or physical circuits using circuit diagrams.
- 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.

Topic 3: Emerging materials

- Interpret a copper–nickel thermal-equilibrium phase diagram by identifying key features, components and phases.
- Calculate percentages solid and liquid, along with composition solid and liquid, using the lever rule for binary alloys with complete solid solubility.
- Recognise and describe the materials processing and manufacturing techniques of the following (cold and hot working, annealing, casting and forging, welding, rolling and extrusion).
- 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.
- Contrast natural and synthetic polymers, including the mechanical properties and life cycle of
 - natural polymers, e.g. protein, cellulose (wood), resins, starch, shellac, silk, wood, DNA and lignin
 - synthetic polymers, e.g. low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polycarbonate (PC), polymethyl methacrylate (PMMA), polyamide (PA 6) and polytetrafluoroethylene (PTFE).

Unit 3: Civil structures

In Unit 3, students learn about engineering's role in solving global and local societal problems to improve the human condition using the problem-solving process in Engineering. 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 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.
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 determine the feasibility of the real-world solution.
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.

Subject matter

Topic 1: Civil structures in society

- Use the problem-solving process in Engineering to solve a complex open-ended structural problem involving truss structures.
- Explain the scope of civil engineering in two of the following sub-disciplines
 - coastal engineering
 - construction engineering
 - environmental engineering
 - water resource engineering
 - structural engineering
 - transport 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.
- 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, e.g.
 - 3D-printed buildings
 - micro-modular housing
 - prefabrication and assembly on site
 - smart structures
 - intelligent structural systems
 - automation.
- Identify the common construction and processing materials used in civil structures, including timber, rock, earth, brick, concrete and steel.
- Research and discuss the environmental implications from the use of common building materials in civil structures, including
 - loss of habitat
 - erosion
 - extractive industries/mining, e.g. rock, sand, loams
 - demolition, including recycling and disposal.
- Identify the ethical issues for sustainability, reliability and the environment applied to structures.
- Comprehend corrosion, including
 - corrosive environments
 - dry corrosion, wet corrosion, stress corrosion
 - corrosion protection methods (galvanising, sacrificial anode, coatings).

- Describe the effects on society and the environment that occur during the life cycle of one of timber, concrete, composite materials, glass, bricks or plastics in terms of
 - materials acquisition
 - processing materials
 - manufacture
 - transport
 - maintenance/operation
 - reuse/recycle/disposal.

Topic 2: Civil structures and forces

- Calculate to solve beam reactions at different types of supports (pin and roller) for vertical, horizontal and angled forces.
- Interpret 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).
- Comprehend bending stress induced by point loads, including
 - concept of shear force and bending moment
 - construction of shear force and bending moment diagrams for vertical point loads only (at the end or the middle).
- Comprehend factor of safety.

Topic 3: Civil engineering materials

- 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.

- Calculate for a range of materials suitable for civil structures, e.g. steel, timber, laminates and concrete, using the formulas

$$\text{stress } (\sigma) = \frac{F}{A}$$
$$\text{strain } (\varepsilon) = \frac{\text{change in length}}{\text{original length}} = \frac{\Delta L}{L}$$

Note: Strain is a ratio and is therefore without units

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

E = Young's modulus in pascals (Pa)

F = applied load (force) in newtons (N)

L = gauge length (original length) in metres (m)

A = cross sectional area in square metres (m²)

ΔL = change in length in metres (m)

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

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

- Compare and contrast stress–strain diagrams for timber (soft and hardwood) and low-carbon steel, including
 - shear, compressive and tensile stress
 - yield stress, proof stress, toughness, resilience, ductility, stiffness and elasticity (Young's modulus), proportional limit (Hooke's law), ultimate tensile strength (UTS), engineering applications in civil structures.
- Contrast tension, compression, transverse and shear tests.
- Conduct materials testing (physically or virtually) — include a minimum of two tests selected from tension, compression, hardness, transverse, shear, impact, fatigue and torsion.
- Investigate engineering materials as used to construct various civil structures, including
 - concrete composition
 - concrete reinforcement
 - pre- and post-tensioning.

Unit 4: Machines and mechanisms

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 uniformly 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 using the problem-solving process in Engineering 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 objectives

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 determine the feasibility of the real-world solution.
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.

Subject matter

Topic 1: Machines in society

- Use the problem-solving process in Engineering to solve a complex open-ended machines and mechanism problem involving machines and mechanisms.
- Comprehend the scope of knowledge required in engineering careers that involve machines and mechanisms, including mechanical, mechatronic and biomechanical engineering.
- Analyse community problems involving machines as solutions to comprehend how engineers use their expertise and knowledge of technology, mechanics, materials science and control technologies to benefit communities, e.g. engineers without borders, human interface, disaster response and safety.

Topic 2: Machines, mechanisms and control

- Comprehend the function and purpose of basic machines, including
 - bicycle
 - car jack
 - crowbar.
- Identify four types of motion, including linear, rotary, oscillatory and reciprocal.
- Calculate MA and VR using the formulas

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

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

- Comprehend and calculate the function and operation of mechanical components, using mechanical advantage and velocity ratio, including
 - inclined planes and screws
 - levers (first, second and third order)
 - simple pulley systems (fixed and moveable, using one continuous rope) where the MA or VR is determined by addition of the number of ropes supporting the load.
- Comprehend and calculate the function and operation of belts (flat and V) connecting a driver and a driven pulley using the formulas

$$VR = \frac{\text{radius, diameter, circumference of driven pulley}}{\text{radius, diameter, circumference of driver pulley}}$$

$$VR = \frac{\text{input speed}}{\text{output speed}}$$

- Comprehend and calculate the function and operation of spur, worm, and rack and pinion gears using the formulas

$$GR \text{ or } VR \text{ for gears} = \frac{\text{radius, diameter, circumference or number of teeth on driven gear}}{\text{radius, diameter, circumference or number of teeth on driver gear}}$$

$$GR \text{ or } VR \text{ for gears} = \frac{\text{angular movement of driver gear (effort)}}{\text{angular movement of driven gear (load)}}$$

- Calculate to solve problems involving mechanical engineering concepts and principles, including
 - work (done) using the formula

$$W = \text{force} \times \text{displacement (distance moved in direction of force)} = F s$$

- power (rate of doing work) using the formula

$$P = \frac{\text{work done}}{\text{time taken}} = \frac{W}{t}$$

- Calculate for energy sources and conversions (i.e. total mechanical energy is the sum of kinetic energy and potential energy), using the formulas

$$KE = \frac{1}{2}mv^2$$

$$PE = mgh$$

- Calculate energy efficiency, using the formula

$$\eta = \frac{MA}{VR} = \frac{\text{useful output}}{\text{input}}$$

- Calculate to solve problems involving the equations of uniformly accelerated motion along a straight line, in one dimension (including vertical or horizontal movement), using the formulas

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = ut + \frac{1}{2}at^2$$

- Recognise that friction is a force opposing motion.
- Calculate to solve problems using coefficient of friction, normal force and angle of repose, using the formulas

$$\mu_s = \tan \theta$$

$$F_f = \mu F_N$$

- Distinguish between and solve integrated linear motion problems involving static and kinetic friction, using the formulas

$$F_f = \mu_s F_N$$

$$F_f = \mu_k F_N$$

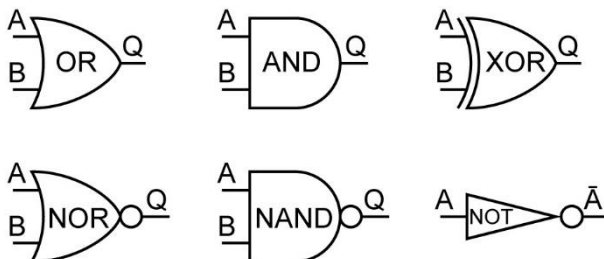
- Calculate to solve problems involving one-body systems in motion on an inclined plane, including uniform velocity and uniform acceleration.

- 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, e.g.
 - 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.

- Calculate to solve problems involving basic series circuits, using the formulas

$$R_{total} = R_1 + R_2 + R_3 + R_4 + \dots \dots \dots$$

$$V_{total} = V_1 + V_2 + V_3 + V_4 + \dots \dots \dots$$

$$I_{total} = I_1 + I_2 + I_3 + I_4 + \dots \dots \dots$$

$$V = IR$$

- Calculate to solve problems involving basic parallel circuits, using the formulas

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \dots \dots \dots$$

$$I_{total} = I_1 + I_2 + I_3 + I_4 \dots \dots \dots$$

$$V = IR$$

- Calculate to solve problems involving electrical power, using the formulas

$$P = VI$$

$$E = Pt$$

- Calculate to solve problems involving electrical power efficiency, using the formula

$$\eta = \frac{P_{out}}{P_{in}} = \frac{\text{power output}}{\text{power input}}$$

- Calculate to solve problems involving electrical energy efficiency, using the formula

$$\eta = \frac{E_{out}}{E_{in}} = \frac{\text{energy output}}{\text{energy input}}$$

Topic 3: Materials

- Explain key features, components and phases of a lead-tin thermal-equilibrium phase diagram, including the
 - eutectic reaction, including composition and temperature
 - single- and two-phase regions at different temperatures and compositions
 - chemical composition of the phases
 - hypoeutectic and hypereutectic compositions.
- Calculate the percentages solid and liquid, along with composition solid and liquid, using the lever rule for binary alloys with complete solid insolubility and partial solid solubility.
- Identify and comprehend the microstructures of the steel portion of an iron–carbon equilibrium phase diagram (i.e. iron with approximately 2.1% or less carbon content), including austenite, cementite, ferrite and pearlite for eutectoid, hypoeutectoid and hypereutectoid steel.
- Comprehend that the chemical composition of plain-carbon steels contributes to their physical and mechanical properties and therefore to usability in industrial/mechanical applications for
 - low-carbon steel
 - 0.07% to 0.30% carbon: automobile body parts, wire products, structural plates and sections, seamless tubes and boiler plate
 - medium-carbon steel
 - 0.30% to 0.60% carbon: automotive components, including shafts, axles, gears and crankshafts, stampings and forgings, train rails, wheels and axles
 - high-carbon steel
 - 0.60% to 2.0% carbon: high-strength spring materials and wires, cutting tools, punches, dies and industrial knives.
- Identify and explain the effects of materials processing and manufacturing techniques on ferrous metal grain structure in the context of
 - hot and cold working, including rolling and forging
 - full annealing and process annealing
 - normalising
 - hardening, e.g.
 - water quenched, oil quenched, air cooled and furnace cooled
 - the martensitic reaction and the rate of cooling for eutectoid steel (0.83% carbon)
 - tempering, i.e. tempered martensite structure.

- Comprehend the mechanical properties of and current uses for engineering plastics, including
 - acrylonitrile butadiene styrene (ABS)
 - high heat resistance, good low-temperature resistance, high impact resistance, high chemical resistance, excellent electrical insulation, good dimensional stability
 - automobile parts, personal protective equipment (e.g. face shields, hard hats, helmets), electrical equipment (e.g. power tools housings, printers, vacuum cleaners) and high-strength applications in the construction industry
 - polycarbonate (PC)
 - high transparency, good toughness, high impact strength, good chemical resistance, high heat resistance, good electrical properties, high dimensional stability
 - lenses and shields (e.g. automotive headlamps, security windows, motorcycle face shields and windscreens, prescription lenses, safety glasses, machinery guards, skylights, and streetlamps) and electrical and electronic device housings
 - polyamide (PA6/nylon 6)
 - high strength, high abrasion resistance, good thermal resistance, good chemical resistance, good electrical properties, good fatigue resistance
 - machine parts (e.g. gears, rollers, guides, bearings, wear pads and wheels), medical implants, electrical connectors and fishing line.

Assessment

Internal assessment 1: Engineered solution (25%)

Students document the application of the problem-solving process in response to an identified real-world problem that requires an engineered solution.

Assessment objectives

2. Symbolise and explain ideas and a solution in relation to structures.
4. Determine solution success criteria for the structural problem.
5. Synthesise information and ideas to predict a possible structural real-world solution.
6. Generate a structural prototype solution to provide data to determine the feasibility of the structural real-world solution.
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 structural real-world solution.

Specifications

This task requires students to:

- symbolise and explain ideas and the solution to the structural problem using, e.g. annotated sketching, drawings including basic drawing standards (hand or CAD), force vectors, free-body diagrams, graphs, tables and/or schemas
- determine solution success criteria, considering the identified elements, components and features, and their relationship to the structural problem, including for example, beam performance index
- synthesise engineering mechanics, materials science, technology and ideas to predict a possible real-world solution to the structural problem
- evaluate and refine ideas and solution development using solution success criteria and data, including
 - test of materials and processes, e.g. cross-beam experiment to determine beam performance index, compression testing
 - calculate using mechanics concepts and principles to predict prototype and real-world solution performance
 - evaluate prototype solution performance data and the reliability of the prototype solution, including use of the beam performance index
 - resolve uncertainties to refine the prototype solution
 - evaluate the real-world solution using solution success criteria and prototype performance data

- generate the prototype solution for testing, including
 - virtual and/or physical prototyping processes, e.g. 3D modelling and simulation, scaled modelling, 3D printing, laser cutting or manual processes
 - annotations on photographs or screen captures of the prototype solution prior to and after testing
 - performance of destructive or non-destructive testing of the prototype solution to provide performance data to determine the feasibility of the structural real-world solution
- recommend and justify modifications to ideas and the solution to the structural problem
- communicate
 - the development of ideas and the solution for the structural problem using written and visual features, e.g. annotations, PMI (plus, minus, interesting) charts, sketches, drawings, diagrams, photographs, graphs, tables and/or schemas
 - data using diagrams, tables, graphs and/or spreadsheets.

It is recommended that this task is designed so that students can develop a response in approximately 10 hours of class time.

Stimulus specifications

The teacher provides an appropriate real-world structural problem context.

Conditions

- Students can develop their responses in class time and their own time.
- This is an individual task.

Response requirements

Written and visual (including images, graphs, calculations and diagrams): up to 10 A4 pages, up to 2000 words

Mark allocation

Criterion	Assessment objectives	Marks
Symbolising and Communicating	2, 8	7
Determining and Generating	4, 6	9
Synthesising and Evaluating	5, 7	9
Total marks:		25

Instrument-specific marking guide

Symbolising and Communicating	Marks
The student response has the following characteristics:	
<ul style="list-style-type: none"> • adept symbolisation and discerning explanation of ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas • discerning decision-making about, and proficient use of <ul style="list-style-type: none"> – written and visual features to communicate about a solution – language for a technical audience – grammatically accurate language structures – referencing conventions 	6–7
<ul style="list-style-type: none"> • effective symbolisation and considered explanation of ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas • effective decision-making about, and fluent use of <ul style="list-style-type: none"> – written and visual features to communicate about a solution – language for a technical audience – grammatically accurate language structures – referencing conventions 	4–5
<ul style="list-style-type: none"> • competent symbolisation and appropriate explanation of some ideas and a solution in relation to structures with sketches, drawings, diagrams, graphs, tables and/or schemas • appropriate decision-making about, and use of <ul style="list-style-type: none"> – written and visual features to communicate about a solution – suitable language – grammatically accurate language structures – referencing conventions 	2–3
<ul style="list-style-type: none"> • inconsistent symbolisation or superficial explanation of aspects of ideas or a solution in relation to structures • inconsistent decision-making about, and inconsistent use of <ul style="list-style-type: none"> – written and visual features – grammar and language structures – referencing conventions. 	1
The student response does not match any of the descriptors above.	0

Determining and Generating	Marks
The student response has the following characteristics:	
<ul style="list-style-type: none"> • astute determination of essential solution success criteria for the structural problem • purposeful generation of a structural prototype solution to provide valid performance data • critical determination of the feasibility of the structural real-world solution 	8–9
<ul style="list-style-type: none"> • reasoned determination of effective solution success criteria for the structural problem • effective generation of a structural prototype solution to provide valid performance data • effective determination of the feasibility of the structural real-world solution 	6–7
<ul style="list-style-type: none"> • logical determination of appropriate solution success criteria for the structural problem • adequate generation of a structural prototype solution to provide relevant performance data • determination of the feasibility of the structural real-world solution 	4–5
<ul style="list-style-type: none"> • reasonable determination of some solution success criteria for the structural problem • partial generation of a structural prototype solution to provide elements of performance data • partial determination of the feasibility of the structural real-world solution 	2–3
<ul style="list-style-type: none"> • statements about some solution success criteria for the structural problem • generation of elements of a structural prototype solution. 	1
The student response does not match any of the descriptors above.	0

Synthesising and Evaluating	Marks
The student response has the following characteristics:	
<ul style="list-style-type: none"> • coherent and logical synthesis of relevant engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • critical evaluation of ideas and a solution using success criteria • discerning refinement of ideas and a solution to make astute recommendations for enhancements justified by data and research evidence 	8–9
<ul style="list-style-type: none"> • logical synthesis of relevant engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • reasoned evaluation of ideas and a solution using success criteria • effective refinement of ideas and a solution to make considered recommendations for enhancements justified by data and research evidence 	6–7
<ul style="list-style-type: none"> • simple synthesis of engineering mechanics, materials science, technology and research information, and ideas to predict a possible structural solution • feasible evaluation of ideas and a solution using some success criteria • adequate refinement of ideas and a solution to make fundamental recommendations for enhancements justified by data and research evidence 	4–5
<ul style="list-style-type: none"> • rudimentary synthesis of partial engineering mechanics, materials science, technology or research information, or ideas to predict a structural solution • superficial evaluation of ideas or a solution using some success criteria • superficial refinements to make elementary recommendations for enhancements 	2–3
<ul style="list-style-type: none"> • unclear combinations of information or ideas • identification of a change about an idea or the solution. 	1
The student response does not match any of the descriptors above.	0

Internal assessment 2: Examination — combination response (25%)

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.

Specifications

The teacher provides an examination that includes:

- questions that may ask students to
 - respond using multiple choice, single words or sentences
 - sketch or draw graphs, tables and diagrams
 - calculate using concepts and principles from Unit 3 subject matter
 - respond to seen or unseen stimulus materials
- a balance of questions across the assessment objectives
- instructions to write in full sentences where required.

Question specifications

The examination must be aligned to the specifications provided in the table below.

Focus of question	Mark allocation ($\pm 2\%$)	Objectives	In these questions, students:
Simple familiar	60%	Typically these questions focus on Objectives 1, 3, 5 and can also provide evidence for Objective 2.	respond to situations where: <ul style="list-style-type: none"> relationships and interactions are obvious and have few elements; and all of the required information to solve the problem identifiable, that is <ul style="list-style-type: none"> the required procedure is clear from the way the question is posed, or is in a context that has been a focus of prior learning
Complex familiar	20%	These questions can focus on any of the objectives.	respond to situations where: <ul style="list-style-type: none"> relationships and interactions have a number of elements, such that connections are made with knowledge, concepts and principles in relation to structures; and all of the required information to solve the problem is identifiable, that is <ul style="list-style-type: none"> the required procedure is clear from the way the question is posed, or is in a context that has been a focus of prior learning
Complex unfamiliar	20%	Typically these questions focus on Objectives 3, 5 and can also provide evidence for Objectives 1, 2.	respond to situations where: <ul style="list-style-type: none"> relationships and interactions have a number of elements, such that connections are made with knowledge, concepts and principles in relation to structures; and all of the information to solve the problem is not immediately identifiable, that is <ul style="list-style-type: none"> 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.

Stimulus specifications

- The teacher provides stimulus that when unseen
 - must not be copied from information or texts that students have previously been exposed to or have used directly in class
 - is succinct enough to allow students sufficient time to engage with them.
- The teacher provides stimulus that when seen (due to its length, complexity or volume of data) is shared with students prior to the administration of the assessment instrument.

Conditions

- This is an individual supervised task.
- Time allowed
 - Perusal time: 5 minutes
 - Working time: 120 minutes
- The teacher must provide the QCAA Engineering formula sheet.
- Students may use
 - a non-programmable scientific calculator
 - a protractor and a ruler.
- Students must not bring notes into the examination.

Mark allocation

Criterion	Assessment objectives	Marks
Engineering knowledge and problem-solving	1, 2, 3, 5	25
Total marks:		25

Instrument-specific marking guide

Engineering knowledge and problem-solving	Cut-off	Marks
The student response has the following characteristics:		
<ul style="list-style-type: none"> • across the full range of simple familiar, complex familiar and complex unfamiliar situations <ul style="list-style-type: none"> – 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 	> 96%	25
	> 93%	24
<ul style="list-style-type: none"> • in a comprehensive range of simple familiar, complex familiar and complex unfamiliar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in a comprehensive range of simple familiar situations, and in complex familiar and complex unfamiliar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in a range of simple familiar situations, and in complex familiar and complex unfamiliar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in a range of simple familiar situations and in complex familiar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in a range of simple familiar situations and in some complex familiar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in simple familiar situations <ul style="list-style-type: none"> – 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

Engineering knowledge and problem-solving	Cut-off	Marks
<ul style="list-style-type: none"> • in simple familiar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in some simple familiar situations <ul style="list-style-type: none"> – 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
<ul style="list-style-type: none"> • in a limited range of simple familiar situations <ul style="list-style-type: none"> – 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; unclear combination of information and ideas 	> 28%	7
	> 24%	6
<ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> • 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
<ul style="list-style-type: none"> • isolated and unclear statements about aspects of structural problems, knowledge, concepts and principles. 	> 0%	1
The student response does not match any of the descriptors above.		0

Internal assessment 3: Engineered solution (25%)

Students document the application of the problem-solving process in response to an identified real-world problem that requires an engineered solution.

Assessment objectives

2. Symbolise and explain ideas and a solution in relation to machines and mechanisms.
4. Determine solution success criteria for the machine and mechanism problem.
5. Synthesise information and ideas to predict a possible real-world machine and mechanism solution.
6. Generate a machine and mechanism prototype solution to provide data to determine the feasibility of the real-world solution.
7. Evaluate and refine ideas and a solution to make justified recommendations for future modifications to a real-world machine or mechanism solution.
8. Make decisions about and use mode-appropriate features, language and conventions to communicate development of the real-world machine and mechanism solution.

Specifications

The teacher provides an assessment task that directs students to:

- symbolise and explain ideas and the solution to the machine and mechanism problem using, e.g. annotated sketching, drawings including basic drawing standards (hand or CAD), logic and electrical circuit diagrams, free-body diagrams, graphs, tables and/or schemas
- determine solution success criteria, considering the identified elements, components and features, and their relationship to the structure of the machine and mechanism problem, e.g. strength to weight ratio, speed, weight, power and efficiency
- synthesise engineering mechanics, materials science, control technologies, technology and research information and ideas to predict a possible real-world solution to the machine and mechanism problem
- evaluate and refine ideas and solution development using solution success criteria, including
 - test materials and processes e.g. pulleys and gear testing, friction, solar panel tracking efficiency, motor efficiency
 - calculate using mechanics concepts and principles to predict prototype and real-world solution performance, including predicted mass, velocity, acceleration and efficiency
 - evaluate prototype solution performance data and the reliability of the prototype solution, including use of the strength to weight ratio, speed, weight, power and efficiency
 - resolve uncertainties to refine the prototype solution
 - evaluate the real-world solution using solution success criteria and prototype performance data

- generate the prototype solution for testing, including
 - virtual and/or physical prototyping processes, e.g. 3D modelling and simulation, scaled modelling, 3D printing, laser cutting or manual processes
 - annotations on photographs or screen captures of the prototype solution prior to and after testing
 - performance of destructive or non-destructive testing of the prototype solution to provide performance data to determine the feasibility of the real-world machine and mechanism solution
- recommend and justify modifications to ideas and the real-world solution to the machine and mechanism problem
- communicate
 - the development of ideas and the solution for the machine and mechanism problem using written and visual features, e.g. PMI (plus, minus, interesting) charts, sketches, drawings, diagrams, graphs, tables and/or schemas
 - data using diagrams, tables and/or spreadsheets.

It is recommended that this task is designed so that students can develop a response in approximately 10 hours of class time.

Stimulus specifications

The teacher provides an appropriate real-world machine and mechanism problem context.

Conditions

- Students can develop their responses in class time and their own time.
- This is an individual task.

Response requirements

Written and visual (including images, graphs, calculations and diagrams) : up to 10 A4 pages, up to 2000 words

Mark allocation

Criterion	Assessment objectives	Marks
Symbolising and Communicating	2, 8	7
Determining and Generating	4, 6	9
Synthesising and Evaluating	5, 7	9
Total marks:		25

Instrument-specific marking guide

Symbolising and Communicating	Marks
The student response has the following characteristics:	
<ul style="list-style-type: none"> • adept symbolisation and discerning explanation of ideas and a solution in relation to machines and mechanisms with sketches, drawings, diagrams, graphs, tables and/or schemas • discerning decision-making about, and proficient use of <ul style="list-style-type: none"> – written and visual features to communicate about a solution – language for a technical audience – grammatically accurate language structures – referencing conventions 	6–7
<ul style="list-style-type: none"> • effective symbolisation and considered explanation of ideas and a solution in relation to machines and mechanisms with sketches, drawings, diagrams, graphs, tables and/or schemas • effective decision-making about, and fluent use of <ul style="list-style-type: none"> – written and visual features to communicate about a solution – language for a technical audience – grammatically accurate language structures – referencing conventions 	4–5
<ul style="list-style-type: none"> • competent symbolisation and appropriate explanation of some ideas and a solution in relation to machines and mechanisms with sketches, drawings, diagrams, graphs, tables and/or schemas • appropriate decision-making about, and use of <ul style="list-style-type: none"> – written and visual features to communicate about a solution – suitable language – grammatically accurate language structures – referencing conventions 	2–3
<ul style="list-style-type: none"> • inconsistent symbolisation or superficial explanation of aspects of ideas or a solution in relation to machines and mechanisms • inconsistent decision-making about, and inconsistent use of <ul style="list-style-type: none"> – written and visual features – grammar and language structures – referencing conventions. 	1
The student response does not match any of the descriptors above.	0

Determining and Generating	Marks
The student response has the following characteristics:	
<ul style="list-style-type: none"> • astute determination of essential solution success criteria for the machines and mechanisms problem • purposeful generation of a machines and mechanisms prototype solution to provide valid performance data • critical determination of the feasibility of the real-world solution 	8–9
<ul style="list-style-type: none"> • reasoned determination of effective solution success criteria for the machines and mechanisms problem • effective generation of a machines and mechanisms prototype solution to provide valid performance data • effective determination of the feasibility of the real-world solution 	6–7
<ul style="list-style-type: none"> • logical determination of appropriate solution success criteria for the machines and mechanisms problem • adequate generation of a machines and mechanisms prototype solution to provide relevant performance data • determination of the feasibility of the real-world solution 	4–5
<ul style="list-style-type: none"> • reasonable determination of some solution success criteria for the machine and mechanism problem • partial generation of a machine and mechanism prototype solution to provide elements of performance data • partial assessment of the accuracy of predictions 	2–3
<ul style="list-style-type: none"> • statements about some solution success criteria for the machines and mechanisms problem • generation of elements of a machines and mechanisms prototype solution. 	1
The student response does not match any of the descriptors above.	0

Synthesising and Evaluating	Marks
The student response has the following characteristics:	
<ul style="list-style-type: none"> • coherent and logical synthesis of relevant engineering mechanics, materials science, control technologies, technology and research information, and ideas to predict a possible machine and mechanism solution • critical evaluation of ideas and a solution using success criteria • discerning refinement of ideas and a solution to make astute recommendations for modifications justified by generated data and research evidence 	8–9
<ul style="list-style-type: none"> • logical synthesis of relevant engineering mechanics, materials science, control technologies, technology and research information, and ideas to predict a possible machine and mechanism solution • reasoned evaluation of ideas and a solution using success criteria • effective refinement of ideas and a solution to make considered recommendations for modifications justified by generated data and research evidence 	6–7
<ul style="list-style-type: none"> • simple synthesis of engineering mechanics, materials science, control technologies, technology and research information, and ideas to predict a possible machine and mechanism solution • feasible evaluation of ideas and a solution using some success criteria • adequate refinement of ideas and a solution to make fundamental recommendations for modifications justified by data and research evidence 	4–5
<ul style="list-style-type: none"> • rudimentary synthesis of partial engineering mechanics, materials science, control technologies, technology or research information, or ideas to predict a machine and mechanism solution • superficial evaluation of ideas or a solution using some success criteria • superficial refinements to make elementary recommendations for modifications 	2–3
<ul style="list-style-type: none"> • unclear combinations of information or ideas • identification of a change about an idea or the solution. 	1
The student response does not match any of the descriptors above.	0

External assessment: Examination — combination response (25%)

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

Assessment objectives

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.
5. Synthesise information and ideas to predict possible machine and mechanism solutions.

Specifications

This examination:

- consists of a number of different types of questions relating to Unit 4
- may ask students to respond using
 - multiple choice
 - single words
 - sentences or paragraphs (up to 150 words per question)
- may ask students to
 - sketch, draw, graph, create tables and/or diagrams
 - calculate using formulas drawn from across Unit 4 subject matter
 - interpret unseen stimulus materials.

Question specifications

The examination will be aligned to the specifications provided in the table below.

Focus of question	Mark allocation ($\pm 2\%$)	Objective	In these questions, students:
Simple familiar	60%	Typically these questions focus on Objectives 1, 3, 5 and can also provide evidence for Objective 2.	respond to situations where: <ul style="list-style-type: none">relationships and interactions are obvious and have few elements; andall of the required information to solve the problem identifiable, that is<ul style="list-style-type: none">the required procedure is clear from the way the question is posed, oris in a context that has been a focus of prior learning
Complex familiar	20%	These questions can focus on any of the objectives.	respond to situations where: <ul style="list-style-type: none">relationships and interactions have a number of elements, such that connections are made with knowledge, concepts and principles in relation to structures; andall of the required information to solve the problem is identifiable, that is<ul style="list-style-type: none">the required procedure is clear from the way the question is posed, oris in a context that has been a focus of prior learning
Complex unfamiliar	20%	Typically these questions focus on Objectives 3, 5 and can also provide evidence for Objectives 1, 2.	respond to situations where: <ul style="list-style-type: none">relationships and interactions have a number of elements, such that connections are made with knowledge, concepts and principles in relation to structures; andall of the information to solve the problem is not immediately identifiable, that is<ul style="list-style-type: none">the required procedure is not clear from the way the question is posed; andin a context in which students have had limited prior experience.

Conditions

- Time allowed
 - Perusal time: 5 minutes
 - Working time: 120 minutes
- The QCAA provides the QCAA Engineering formula sheet.
- Students may use
 - a non-programmable scientific calculator
 - a protractor and a ruler.
- Students must not bring notes into the examination.

Glossary

The syllabus glossary is available at www.qcaa.qld.edu.au/downloads/senior-qce/common/snr_glossary_cognitive_verbs.pdf.

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Version history

Version	Date of change	Information
1.0	January 2024	Released for familiarisation and planning (with implementation starting in 2025)

