Accreditation Period
**Adjusted Study Design for 2020 only**

Key:
**Deletions** - red coloured text and ~~strikethrough~~
**Changes** - blue coloured text and highlight

Victorian Certificate of Education

# SYSTEMS ENGINEERING

## STUDY DESIGN

www.vcaa.vic.edu.au

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

VICTORIA State Government

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# Contents

# Important information

## Accreditation period

Units 1–4: 1 January 2020 – 31 December 2020

Implementation of this adjusted study design is for 2020.

## Other sources of information

The *VCAA Bulletin* is the only official source of changes to regulations and accredited studies. The Bulletin also regularly includes advice on VCE studies. It is the responsibility of each VCE teacher to refer to each issue of the Bulletin. The Bulletin is available as an e-newsletter via free subscription on the VCAA's website at: www.vcaa.vic.edu.au.

To assist teachers in developing courses, the VCAA publishes online the *Advice for teachers*, which includes teaching and learning activities for Units 1–4, and advice on assessment tasks and performance level descriptors for School-assessed Coursework in Units 3 and 4.

The current *VCE and VCAL Administrative Handbook* contains essential information on assessment processes and other procedures.

## VCE providers

Throughout this study design the term 'school' is intended to include both schools and other VCE providers.

## Copyright

# Introduction

## Scope of study

VCE Systems Engineering involves the design, production, operation, evaluation and iteration of integrated systems, which mediate and control many aspects of human experience. Integral to VCE Systems Engineering is the identification and quantification of systems goals, the generation of system designs, trial and error, justified design trade-offs, selection and implementation of the most appropriate design. Students test and verify that the system is well-built and integrated. They evaluate how well the completed system meets the intended goals and reflect on the systems engineering process to create a satisfactory design outcome.

This study can be applied to a diverse range of engineering fields such as manufacturing, transportation, automation, control technologies, mechanisms and mechatronics, electrotechnology, robotics, pneumatics, hydraulics, and energy management. VCE Systems Engineering considers the interactions of these systems with people, society and ecosystems. The rate and scale of human impact on global ecologies and environments demands that systems design and engineering take a holistic approach by considering the overall sustainability of any system throughout its life cycle. Key engineering goals include using a project management approach to maximise system efficiency and to optimise system performance through innovation processes. Lean, agile and fast prototyping engineering and manufacturing concepts and systems thinking are integral to this study.



## Rationale

VCE Systems Engineering promotes innovative systems thinking and problem-solving skills through the application of the systems engineering process. The study is based on integrated mechanical and electrotechnological engineered systems.

The study provides opportunities for students to learn about and engage with systems from a practical and purposeful perspective. Students gain knowledge and understanding about technological systems and their applications.

VCE Systems Engineering integrates aspects of designing, planning, producing, testing and evaluating in a project management process. It prepares students for careers in engineering, manufacturing and design through a university or TAFE vocational study pathway, employment, apprenticeships and traineeships. The study provides a rigorous academic foundation and a practical working knowledge of design strategies, production processes and evaluation practices. People with these skills, and the ability to apply systems engineering processes, are in increasing demand as participants in teams that are engaged with complex and multidisciplinary projects.

## Aims

This study enables students to:

- develop an understanding of the systems engineering process and factors that influence the creation and use of a system
- develop skills and conceptual understandings important to effective design, planning, production, diagnosis, performance analysis, maintenance, modification and control of technological systems
- acquire knowledge of mechanical, electrotechnological and control systems and apply this knowledge to solve technological problems
- develop an understanding of how technologies have transformed people's lives and can be used to solve challenges associated with climate change, efficient energy generation and use, security, health, education and transport

- deepen their knowledge of new developments and innovations in technological systems
- develop skills in the safe, efficient and effective use of tools, equipment, materials, machines and processes, including digital technologies
- critically engage in risk management processes
- extend knowledge of project management and develop problem-solving and analytical skills
- use virtual and physical modelling to develop designs
- gain an awareness of quality and mandated standards, including system's reliability, safety and fitness for the system's intended purpose.

## Structure

The study is made up of four units.

Unit 1: Mechanical systems

Unit 2: Electrotechnological systems

Unit 3: Integrated and controlled systems

Unit 4: Systems control

Each unit deals with specific content contained in areas of study and is designed to enable students to achieve a set of outcomes for that unit. Each outcome is described in terms of key knowledge and key skills.



## Entry

There are no prerequisites for entry to Units 1, 2 and 3. However, some additional preparatory work would be advisable for students entering Units 3 and 4 without completing Units 1 and 2. Students must undertake Unit 3 and Unit 4 as a sequence. Units 1 to 4 are designed to a standard equivalent to the final two years of secondary education. All VCE studies are benchmarked against comparable national and international curriculum.

## Duration

Each unit involves at least 50 hours of scheduled classroom instruction.

## Changes to the study design

During its period of accreditation minor changes to the study will be announced in the *VCAA Bulletin.* The Bulletin is the only source of changes to regulations and accredited studies. It is the responsibility of each VCE teacher to monitor changes or advice about VCE studies published in the Bulletin.

## Monitoring for quality

As part of ongoing monitoring and quality assurance, the VCAA will periodically undertake an audit of VCE Systems Engineering to ensure the study is being taught and assessed as accredited. The details of the audit procedures and requirements are published annually in the *VCE and VCAL Administrative Handbook*. Schools will be notified if they are required to submit material to be audited.

## Safety and wellbeing

It is the responsibility of the school to ensure that duty of care is exercised in relation to the health and safety of all students undertaking the study. This study may involve the handling of potentially hazardous substances and the use of potentially hazardous equipment. Teachers should refer to the Hazards substances information within the OHS Management System on the Department of Education and Training's advice about Chemical Management and Use of machinery in technology teaching. For additional information about risk assessment, refer to the WorkSafe website www.worksafe.vic.gov.au and the Safe Work Australia website http://safeworkaustralia.gov.au.

Where students incorporate wood and metal in systems engineering projects, teachers must be competent in the use of machinery associated with use of these materials, for example through completion of the 21820VIC Course in Safe Use of Machinery for Technology Teaching.

Details about appropriate equipment for use in this study are included in the *Advice for teachers*.

In Victoria, the relevant legislation for electrical safety is the *Electricity Safety Act 1998* and associated regulations.

Only persons who hold an appropriate current electrical licence are permitted to carry out electrical work on products or equipment that require voltage greater than 50 volts AC or 120 volts ripple-free DC.

This requirement means that students are not permitted to carry out any electrical work on electrical products or equipment that operate above 50 volts AC or 120 volts ripple-free DC.

Students are permitted to work with approved apparatus, appliances and testing equipment that operate at mains power, including appliances such as electric drills or electric soldering irons. However, they must not access or modify any component on such apparatus or appliance.

Any product that requires installation and operation at voltages up to 50 volts AC or 120 volts ripple-free DC in a supervised environment must comply with the Australian/New Zealand Wiring Rules (AS/NZS 3000:2007). For all other requirements, reference should be made to the Australian/New Zealand Standard – General requirements for electrical equipment (AS/NZS 3100:2009) and the Australian/New Zealand Standard – In-service safety inspection and testing of electrical equipment (AS/NZS 3760:2010).

Energy Safe Victoria is the safety regulator responsible for electrical and gas safety in Victoria. www.esv.vic.gov.au/.



## Use of digital technologies

In designing courses for this study teachers should incorporate digital technologies where appropriate and applicable to the teaching and learning and assessment activities.

## Employability skills

This study offers a number of opportunities for students to develop employability skills. The *Advice for teachers* companion document provides specific examples of how students can develop employability skills during learning activities and assessment tasks.

## Legislative compliance

When collecting and using information, the provisions of privacy and copyright legislation, such as the Victorian *Privacy and Data Protection Act 2014* and *Health Records Act 2001*, and the federal *Privacy Act 1988* and Copyright Act 1968, must be met.

# Assessment and reporting

## Satisfactory completion

The award of satisfactory completion for a unit is based on the teacher's decision that the student has demonstrated achievement of the set of outcomes specified for the unit. Demonstration of achievement of outcomes and satisfactory completion of a unit are determined by evidence gained through the assessment of a range of learning activities and tasks.

Teachers must develop courses that provide appropriate opportunities for students to demonstrate satisfactory achievement of outcomes.

The decision about satisfactory completion of a unit is distinct from the assessment of levels of achievement. Schools will report a student's result for each unit to the VCAA as S (Satisfactory) or N (Not Satisfactory).

## Levels of achievement

### Units 1 and 2

Procedures for the assessment of levels of achievement in Units 1 and 2 are a matter for school decision. Assessment of levels of achievement for these units will not be reported to the VCAA. Schools may choose to report levels of achievement using grades, descriptive statements or other indicators.

### Units 3 and 4

The VCAA specifies the assessment procedures for students undertaking scored assessment in Units 3 and 4. Designated assessment tasks are provided in the details for each unit in VCE study designs.

The student's level of achievement in Units 3 and 4 will be determined by School-assessed Coursework (SAC), a School-assessed Task (SAT) and external assessment as specified in the VCE study design.

The VCAA will report the student's level of achievement on each assessment component as a grade from A+ to E or UG (ungraded). To receive a study score the student must achieve two or more graded assessments and receive S for both Units 3 and 4. The study score is reported on a scale of 0–50; it is a measure of how well the student performed in relation to all others who took the study. Teachers should refer to the current *VCE and VCAL Administrative Handbook* for details on graded assessment and calculation of the study score. Percentage contributions to the study score in VCE Systems Engineering are as follows:

- Units 3 and 4-School-assessed Coursework: 20 per cent
- Units 3 and 4 School-assessed Task: 50 per cent
- End-of-year examination: 30 per cent.

Details of the assessment program are described in the sections on Units 3 and 4 in this study design.

## Authentication

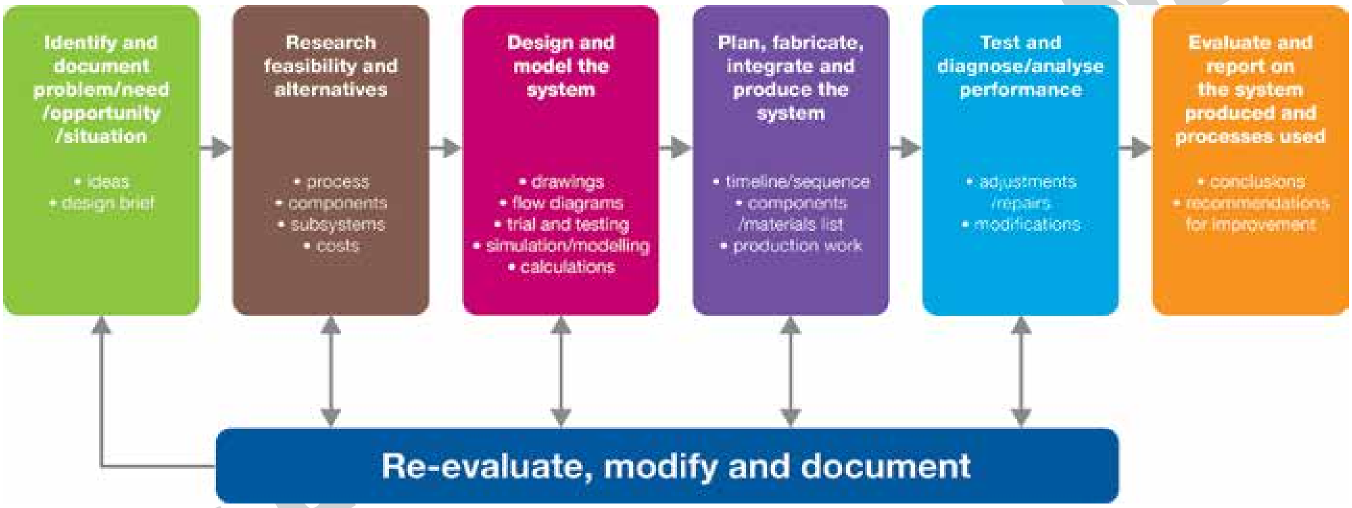
Work related to the outcomes of each unit will be accepted only if the teacher can attest that, to the best of their knowledge, all unacknowledged work is the student's own. Teachers need to refer to the current *VCE and VCAL Administrative Handbook* for authentication procedures.

# Cross-study specifications

Cross-study specifications provide details of the concepts that underpin Units 1 to 4 of the study design.

## Systems engineering process

The systems engineering process, illustrated below, represents the stages in creating a system. The process is iterative. Students must continuously re-evaluate their progress and make necessary modifications after having revisited an earlier stage or activity. The goal of the application of the systems engineering process is to achieve an efficient, optimised, quality system.




The stages of the systems engineering process for creating a system are:

### Identify and document problem/need/opportunity/situation

- The identification and exploration of a problem, need, opportunity or situation requiring a systems engineering solution. The context, and the constraints and considerations that apply to the problem, need, opportunity or situation, are articulated in a design brief. Criteria are developed to evaluate how well the system satisfies the design brief. Factors are described that influence the creation and use of a system.

### Research feasibility and alternatives

- Researching the problem, need, opportunity or situation to consider how it can be addressed. This will involve exploring subsystems, components, processes and any associated costs, and generation of various design options with the selection of the most appropriate systems design.

### Design and model the system

- Designing and modelling the potential system, which requires the execution of drawings, flow diagrams, and testing and trialling possibilities using simulation or actual components. Calculations may need to be made to determine functionality and performance. Components and materials that are appropriate for the system or subsystem are selected with reference to technical data and specifications, including online sources.

### Plan, fabricate, integrate and produce system

- Planning determines how the proposed system will be produced, and involves careful consideration of the sequential steps required to fabricate components that form the system and subsystems. Initially a work plan is developed that includes a sequence and timeline and identifies and sources the required components and materials.
- Once the planning is completed, assembly and fabrication of the system and subsystems is undertaken using a range of production processes, and tools, equipment, components and materials compliant with OH&S requirements.

### Test and diagnose/analyse performance

- The system, subsystem or components are then tested and diagnosed throughout production. If necessary, adjustments, modifications or repairs are made to the system to ensure optimal performance.

### Re-evaluate, modify and document

- When creating the system, students must continuously refer to the systems engineering process. They may need to trial and test subsystems and components. This may involve commencing the creation of the system, re-evaluating and then returning to planning and initiating a more appropriate selection of components or materials.

### Evaluate and report on the system produced and processes used

- Evaluation of the system occurs after it has been produced. The findings of diagnostic testing are reported and include conclusions about how successfully the system performed in relation to its problem, need, opportunity or situation using the pre-determined evaluation criteria. Recommendations for improvements to the system and processes used are reported in the evaluation.



## Factors that influence the creation and use of a system

Factors that may influence the creation and use of a system are described in the table below. As part of the systems engineering process, students must consider the factors in the shaded section of the table; the additional factors may be considered if relevant to the system being created.

| Factors | Description |
|---|---|
| Function | Understanding what the system will be used for or what it will need to do. |
| User needs and requirements | The system will need to be suitable for and appealing to the users/customers (the market). |
| Materials and components | Appropriate materials and components must be selected that will meet user requirements and performance expectations. |
| Environment use | Understanding where the system will be used and the conditions to which it will be subjected. |
| Safety | Safety must be considered at all stages of creation and use of the system. The risk assessment and management process is used to identify and minimise risk or harm for the maker or user. |
| Cost | The system should be cost-effective. Users/customers expect both quality and value. The cost of components, housings and ongoing running and maintenance costs must be considered. |
| Waste and energy | Waste produced during creation and use should be minimised. Energy used in the production of the system and running costs also need to be kept to a minimum. |

| **Additional factors** | |
|---|---|
| Quality standards | • Physical characteristics of the system being created and its safety features. |
| Styling and appearance | • The system and its covering/housing.<br>• Colour, shape and/or surface finish of the covering/housing.<br>• Components are joined neatly and wires tied and trimmed. |
| Performance and durability | • The system works or performs a task or number of tasks.<br>• The system is long-lasting and durable. |
| Size | • Size is appropriate to how it will be used, for example portability. |
| Maintenance | • Layout and accessibility to serviceable components will allow the system to be fixed, repaired and have its components changed from time to time. |
| Production methods | • The design will allow efficient production of the system.<br>• It is important to know what particular types of machinery and equipment are available to produce the system and how this equipment is used. |
| Regulations | • The system is required to meet guidelines, legal obligations or restrictions that may relate to the use of materials, or safety regulations such as age restrictions. |



## Risk assessment and management

Students need to demonstrate risk assessment and management at all stages of production and use of the system. They need to demonstrate safe and correct use of appropriate tools, equipment, machines and components to fabricate and assemble the system, ensuring it is compliant with OH&S requirements.

## Calculations

**Mechanical**

– $\text{efficiency (\%)} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\ (\%)$

– energy = power × time

– force = mass × acceleration

– $\text{gear or pulley ratio} = \frac{\text{speed of driver (rpm)}}{\text{speed of driven (rpm)}}$

– $\text{gear ratio} = \frac{\text{number of teeth on driven}}{\text{number of teeth on driver}}$

– $\text{mechanical advantage} = \frac{\text{load}}{\text{effort}}$

– moment = force × perpendicular distance to pivot point

– $\text{power} = \frac{\text{work done}}{\text{time}}$

– $\text{pressure} = \frac{\text{force}}{\text{area}}$

- pulley ratio = $\frac{\text{diameter of driven}}{\text{diameter of driver}}$
- speed = $\frac{\text{distance}}{\text{time}}$
- torque = twisting force × perpendicular distance to pivot point
- velocity ratio = $\frac{\text{distance moved by effort}}{\text{distance moved by load}}$
- work done = force in direction moved × distance

**Electrical**

- capacitor networks – for capacitors in parallel $C_t = C_1 + C_2 + C_3 + \ldots\ldots,$
- capacitors in series $\frac{1}{C_t} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots\ldots$ or $C_t = \frac{C_1 \times C_2}{C_1 + C_2}$ for two capacitors only
- electrical energy efficiency (%) = $\frac{\text{useful energy output (watts)}}{\text{total energy input (watts)}} \times 100$ (%)
- energy = power × time
- frequency = $\frac{1}{\text{period}}$
- power = voltage × current
- resistors in parallel $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$ or $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$ for two resistors only
- resistors in series $R_t = R_1 + R_2 + \ldots\ldots,$
- voltage = current × resistance (Ohm's Law)



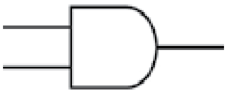
## Units in calculations

The units to be used in calculations are the International System of Units (SI), i.e. metric units and engineering notation.

## Resistor colour code

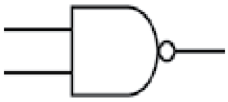
| Colour | Value | Tolerance |
|---|---|---|
| black | 0 | brown 1% |
| brown | 1 | red 2% |
| red | 2 | gold 5% |
| orange | 3 | silver 10% |
| yellow | 4 | |
| green | 5 | |
| blue | 6 | |
| violet | 7 | |
| grey | 8 | |
| white | 9 | |

# Logic gates



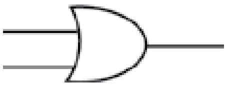
AND

| input A | input B | output Q |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |



NAND

| input A | input B | output Q |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

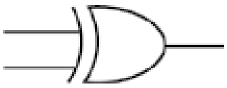


OR

| input A | input B | output Q |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

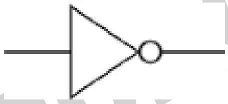
NOR

| input A | input B | output Q |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |



XOR

| input A | input B | output Q |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |



NOT

| input | output |
|---|---|
| 0 | 1 |
| 1 | 0 |

# Unit 1: Mechanical systems

This unit focuses on engineering fundamentals as the basis of understanding concepts, principles and components that operate in mechanical systems. The term 'mechanical systems' includes systems that utilise all forms of mechanical components and their linkages.

While this unit contains the fundamental physics and theoretical understanding of mechanical systems and how they work, the focus is on the creation of a system. The creation process draws heavily upon design and innovation processes.

Students create an operational system using the systems engineering process. The focus is on a mechanical system; however, it may include some electrotechnological components.

All systems require some form of energy to function. Students research and quantify how systems use or convert the energy supplied to them.

Students are introduced to mechanical engineering principles including mechanical subsystems and devices, their motions, elementary applied physics, and related mathematical calculations that can be applied to define and explain the physical characteristics of these systems.

A range of suitable systems for this unit is included in the *Advice for teachers*.



## Area of Study 1

### Mechanical system design

In this area of study students learn about fundamental mechanical engineering principles and the components required when producing an operational system. Students learn fundamental principles of how mechanisms and simple mechanical systems provide movement and mechanical advantage, and how the specific components of a system or an entire system can be represented diagrammatically.

Using the systems engineering process students research, design and plan a mechanical system. They consider relevant factors that influence the creation and use of their system and document their findings and process.

## Outcome 1

On completion of this unit the student should be able to describe and apply basic engineering concepts and principles, and use components to design and plan a mechanical system using the systems engineering process.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 1.

**Key knowledge**

- the function and operation of mechanical components:
  - inclined planes and screws
  - levers, cranks and linkages
  - basic hydraulic and pneumatic systems
  - pistons and cylinders
  - simple and compound gears
  - gear types: worm, bevel, pinion, spur, crown
  - cams and followers
  - belts, pulleys, chains and sprockets
  - compression and tension springs
  - bearings

- mechanical engineering concepts and principles:
  - energy sources and conversions
  - ratios: pulley and simple gear
  - friction and its role
  - types of motion: linear, rotary, oscillating, and reciprocating, and their transformation
  - classes of levers: first, second, third
  - force and torque: tension, compression, torsion and shear, and their combinations
- mechanical calculations:
  - speed
  - force
  - ratio: velocity, gear, pulley, and gear or pulley
  - mechanical advantage
  - efficiency
  - work done
- input-process-output (IPO) diagrams to represent mechanical systems and the operation of open and closed loop systems
- system performance variations as a result of using different subsystems or components
- stages of the systems engineering process and factors that influence the creation and use of a mechanical system.



**Key skills**

- explain, using appropriate engineering terms, how mechanical systems function
- identify and represent components and mechanical systems in symbolic form using input-process-output (IPO) diagrams and simulation software
- identify and select appropriate subsystems and components that will form operational systems
- test, measure and record appropriate system parameters to evaluate system performance
- perform basic calculations on linkages, gear ratios and pulleys
- apply the systems engineering process to:
  - identify and document the problem, need, opportunity or situation
  - research, design and plan the operational integrated and controlled system
- describe the factors that influence the creation and use of the system.

# Area of Study 2

## Producing and evaluating mechanical systems

This area of study provides students with the opportunity to produce, test and evaluate an operational mechanical system.

Students make a model or develop a prototype to test aspects of their design. They perform a risk assessment and select and safely use materials, tools, equipment, components and machines. Once the design is confirmed, students fabricate their mechanical system using materials and components. Students document their processes, including decisions made in relation to the production of the system. They test and modify the system, aiming to achieve optimum performance, and report on its success by responding to their previously established evaluation criteria. They review how they have applied the systems engineering process and how they have taken account of the factors that influenced the creation and use of their system.

## Outcome 2

On completion of this unit the student should be able to produce, test, diagnose and evaluate a mechanical system using the systems engineering process.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 2.

**Key knowledge**

- production processes such as joining, cutting, filing, bending and shaping
- risk assessment and management at all stages of creation and use of the system
- use of tools, equipment, machines and components compliant with OH&S requirements
- measuring and testing equipment and methods, and fault finding in systems, subsystems and components
- evaluation methods in systems.

**Key skills**

- apply the systems engineering process to produce, test, diagnose, evaluate and report on the system by:
  - implementing the work plan using a range of production processes
  - implementing and documenting risk assessment and management processes
  - using tools, equipment, machines and components compliant with OH&S requirements
  - managing production work using ongoing evaluation and recording, and reflecting on decision making, relevant data and modifications
  - monitoring quality and undertaking appropriate repair and maintenance procedures
  - testing, measuring, recording and diagrammatically representing appropriate system parameters
  - interpreting measurements and using previously established criteria
  - suggesting modifications and improvements
- identify how the factors that influenced the creation and use of the system have been taken into account
- evaluate the use of the systems engineering process.



## Assessment

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks that provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study, including the key knowledge and key skills listed for the outcomes, should be used for course design and the development of learning activities and assessment tasks. Assessment must be a part of the regular teaching and learning program and should be completed mainly in class and within a limited timeframe.

All assessments at Units 1 and 2 are school-based. Procedures for assessment of levels of achievement in Units 1 and 2 are a matter for school decision.

For this unit students are required to demonstrate two outcomes. As a set these outcomes encompass the areas of study in the unit.

Recommended assessment tasks for this unit are:

- documentation of the systems engineering process using one or more of:
  - a multimedia/simulation presentation
  - an electronic portfolio
  - a brochure
  - a poster
  - a written report
- production work to create a mechanical system.

Additionally, suitable tasks for assessment for this unit are:

- practical demonstrations
- an oral presentation.

Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

# Unit 2: Electrotechnological systems

In this unit students study fundamental electrotechnological engineering principles. The term 'electrotechnological' encompasses systems that include electrical/electronic circuitry including microelectronic circuitry. Through the application of the systems engineering process, students create operational electrotechnological systems, which may also include mechanical components or electro-mechanical subsystems.

While this unit contains fundamental physics and theoretical understanding of electrotechnological systems and how they work, the focus is on the creation of electrotechnological systems, drawing heavily upon design and innovation processes.

Electrotechnology is a creative field that responds to, and drives rapid developments and change brought about through technological innovation. Contemporary design and manufacture of electronic equipment involves increased levels of automation and inbuilt control through the inclusion of microcontrollers and other logic devices. In this unit students explore some of these emerging technologies.

Students study fundamental electrotechnological principles including applied electrical theory, standard representation of electronic components and devices, elementary applied physics in electrical circuits and mathematical processes that can be applied to define and explain the electrical characteristics of circuits.

This unit offers opportunities for students to develop, apply and refine their knowledge in the creation of an operational system. A range of suitable systems for this unit is included in the *Advice for teachers*.



## Area of Study 1

### Electrotechnological systems design

In this area of study students focus on electrotechnological engineering principles and the components and materials that make operational electrotechnological systems. Students develop their understanding of commonly used components, including their typical performance, physical appearance, implementation and how they should be represented in schematic circuit diagrams and in circuit simulation software.

Using the systems engineering process, students research, design, plan and model an operational electrotechnological system. They describe and reflect on the factors that may influence the creation and use of the system.

## Outcome 1

On completion of this unit the student should be able to investigate, represent, describe and use basic electrotechnological and basic control engineering concepts, principles and components, and design and plan an electrotechnological system using the systems engineering process.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 1.

**Key knowledge**

- the function, typical operation and basic implementation of electrotechnological components:
  - electric power sources: cells, batteries and photovoltaic cells
  - generators and dynamos
  - motors: AC/DC, stepper, servo
  - solenoids: push, pull and dual
  - switches: momentary (normally open and normally closed) and toggle (normally open and normally closed, combinations of single and double pole, single and double throw), single and ganged, micro, reed and mercury

  - relays: normally open and normally closed including their voltage and current rating
  - resistors: fixed value, light dependent (LDRs) and variable (potentiometers), their value tolerance and power ratings
  - capacitors: AC/DC, fixed value and variable, polarised and non-polarised and ultra or super, and their voltage ratings
  - diodes: signal, power, light emitting (LEDs) and photo
  - transformers: step-up and step-down
  - integrated circuits (ICs) including microcontrollers, their representations and simulated implementation using simulation software
- electrotechnological concepts and principles, and reference material:
  - energy sources, their measurement and their conversions from one source to another
  - alternating current (AC) and direct current (DC) waveforms and their use and the work restrictions detailed in the *Electricity Safety Act 1998*
  - AC power generation
  - printed circuit boards (PCB) artwork, breadboard and Veroboard
  - components used in circuits and their formal schematic diagrammatic representation
  - the resistor colour code
  - resistors in series and parallel combinations
  - open and closed loop systems
- electrical calculations:
  - Ohm's Law: DC and AC (purely resistive) calculation
  - power calculations: DC and AC (purely resistive)
  - resistors: in series, in parallel
  - energy
  - electrical energy efficiency
  - diagnostic testing equipment including digital multimeter and oscilloscope, real or virtual
- the structure and function of electrotechnological systems and subsystems including representation of the inputs, processes and outputs, with elements of control and feedback (closed loop systems) in both block diagram and flow chart representations
- stages of the systems engineering process and factors that influence the creation and use of an electrotechnological system.



**Key skills**

- describe, using appropriate engineering terminology, the operation of electrotechnological systems
- identify and represent electrotechnological systems in diagrammatic and symbolic forms
- select appropriate electrotechnological subsystems and electronic components that will form operational systems and subsystems
- construct and interpret circuit diagrams, schematics, PCB artwork, breadboard and Veroboard representations of electrical circuits, and be able to transform one representation into another
- measure, test and evaluate the electrotechnological system parameters using appropriate measuring and testing equipment, measure voltage, current and resistance, and represent and interpret the results
- apply formulas to solve and calculate electrical circuit parameters using Ohm's Law and power calculations
- use digital technologies to simulate and demonstrate electrotechnological principles
- interpret the resistor values in four and five colour band resistors with reference to a colour code chart

- apply the systems engineering process to:
  - identify and document the problem, need, opportunity or situation
  - research, design and plan the operational integrated and controlled system
- describe the factors that influence the creation and use of the system.

# Area of Study 2

## Producing and evaluating electrotechnological systems

In this area of study students produce, test, diagnose and evaluate operational electrotechnological systems. Using the systems engineering process, students use a range of materials, tools, equipment, machines and components and manage identified risks while producing the system designed in Area of Study 1. They use appropriate equipment to test the system and diagnose its performance, making necessary modifications and adjustments. They record progress and evaluate the integrated system and their use of the systems engineering process, referring to the factors that influence their creation of the system. Students suggest how the system and their utilisation of the systems engineering process could be improved.

# Outcome 2

On completion of this unit the student should be able to produce, test and evaluate an electrotechnological system, using the systems engineering process.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 2.

**Key knowledge**

- the role of specifications, data sheets, safety data sheets and technical data manuals
- risk assessment and management at all stages of production and use of the system
- the use of tools, equipment, machines and components to produce a system compliant with OH&S requirements
- performance characteristics of a system and the impact of substituting components
- measuring and testing equipment and methods, and fault finding in systems, subsystems and components
- evaluation methods in systems.

**Key skills**

- apply the systems engineering process to produce, test, diagnose, evaluate and report on the system by:
  - implementing the work plan using a range of production processes
  - implementing and documenting risk assessment and management processes
  - using appropriate materials, tools, equipment and machines compliant with OH&S requirements
  - managing production work, using ongoing evaluation, and recording and reflecting on decision making, relevant data, changes and modifications
  - monitoring quality and undertaking appropriate repair and maintenance procedures
  - testing, measuring, recording and diagrammatically representing appropriate system parameters
  - interpreting measurements and using previously established criteria
  - suggesting modifications and improvements
- identify how the factors that influenced the creation and use of the system have been taken into account
- evaluate the systems engineering process.

## Assessment

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks that provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study, including the key knowledge and key skills listed for the outcomes, should be used for course design and the development of learning activities and assessment tasks. Assessment must be a part of the regular teaching and learning program and should be completed mainly in class and within a limited timeframe.

All assessments at Units 1 and 2 are school-based. Procedures for assessment of levels of achievement in Units 1 and 2 are a matter for school decision.

For this unit students are required to demonstrate two outcomes. As a set these outcomes encompass the areas of study in the unit.

Recommended assessment tasks for this unit are:

- documentation of the systems engineering process using one or more of:
  - a multimedia/simulation presentation
  - an electronic portfolio
  - a brochure
  - a poster
  - a written report
- production work to create an electrotechnological system.

Additionally, suitable tasks for assessment for this unit are:

- practical demonstrations
- an oral presentation.

Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

# Unit 3: Integrated and controlled systems

In this unit students study engineering principles used to explain physical properties of integrated systems and how they work. Students design and plan an operational, mechanical and electrotechnological integrated and controlled system. They learn about the technologies used to harness energy sources to provide power for engineered systems.

Students commence work on the creation of an aspect of an integrated and controlled system using the systems engineering process. This production work has a strong emphasis on innovation, designing, producing, testing and evaluating. Students manage the project, taking into consideration the factors that will influence the creation and use of an aspect of their integrated and controlled system. Students' understanding of fundamental physics and applied mathematics underpins the systems engineering process, providing a comprehensive understanding of mechanical and electrotechnological systems and how they function.

Students learn about sources and types of energy that enable engineered technological systems to function. Comparisons are made between the use of renewable and non-renewable energy sources and their impacts. Students develop their understanding of technological systems developed to capture and store renewable energy and technological developments to improve the credentials of non-renewables.

A range of suitable systems for Units 3 and 4 is included in the *Advice for teachers*.



## Area of Study 1

### Integrated and controlled systems design

This area of study focuses on engineering knowledge associated with the integration, calibration and control of mechanical and electrotechnological systems, how they work and can be adjusted, as well as how their performance can be calculated and represented diagrammatically in a range of forms. Students use fundamental physics and applied mathematics to solve systems engineering problems. They apply theoretical concepts and principles and use the systems engineering process to manage the design and planning of an integrated and controlled system and to commence production of an aspect of this system. They investigate the factors that influence the creation and use of an aspect of their integrated and controlled system. Students demonstrate innovation and creativity as well as project management skills. ~~The~~ An aspect of the system commenced in Unit 3 is completed and evaluated in Unit 4, Area of Study 2.

## Outcome 1

On completion of this unit the student should be able to investigate, analyse and apply concepts and principles, and use components to design, plan and commence production of an integrated and controlled aspect of the mechanical and electrotechnological system using the systems engineering process.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 1.

**Key knowledge**

- the function and operation of mechanical components:
  - inclined planes and screws
  - levers, cranks, a ball joint linkage and other linkages
  - gear types: worm, bevel, pinion, spur, crown, and simple and compound
  - pistons and cylinders
  - cams and followers
  - belts and pulleys
  - compression and tension springs

- mechanical engineering concepts and principles:
  - energy sources and conversions
  - friction and its role
  - ratio: velocity, pulley, simple and compound gear
  - types of motion: linear, rotary, oscillating, and reciprocating and their transformation
  - classes of levers: first, second and third
  - force and torque: tension, compression, torsion and shear and their combinations
  - basic hydraulic and pneumatic systems
  - pneumatic and hydraulic pressure
  - application of Newton's first, second and third laws of motion
- mechanical calculations:
  - speed
  - force
  - ratio: velocity, gear, pulley, gear or pulley, total gear
  - mechanical advantage
  - efficiency
  - power
  - energy
  - work done
  - pressure
  - moments about a point
  - action and reaction forces and torque
- the function and operation of electrotechnological components and commonly used symbolic representation:
  - electric power sources: alternating current (AC), including generators, direct current (DC), including batteries and photovoltaic cells (PV cells)
  - generators and dynamos
  - motors: AC/DC, stepper, servo, brushless and brushed DC
  - solenoids: push, pull and dual
  - switches: momentary (normally open and normally closed) and toggle (normally open and normally closed, combinations of single and double pole, single and double throw), single and ganged, and micro, reed and mercury
  - relays: normally open and normally closed, including their voltage and current rating
  - resistors: fixed value, light dependent resistors (LDRs), thermistors and variable resistors (potentiometers), including their value tolerance and power ratings
  - capacitors: AC/DC, fixed value and variable capacitors, polarised and non-polarised and ultra or super capacitors, including their voltage ratings
  - diodes: signal, power, light emitting diodes (LEDs), photo diodes and Zener
  - fixed and variable voltage regulators
  - transistors: NPN, PNP, and phototransistors
  - step-up and step-down transformers
  - liquid crystal displays (LCDs)
  - input transducer and control devices: microphones, speakers and audio transducers and piezo buzzers
  - simulation software to represent integrated circuits (ICs) and microcontrollers

- electrotechnological concepts and principles, and reference material:
  - energy sources, their measurement and their conversions from one source to another
  - alternating current (AC) and direct current (DC) waveforms and their use and the work restrictions detailed in the *Electricity Safety Act 1998*
  - AC power generation
  - components used in circuits and their formal schematic diagrammatic representation
  - the resistor colour code
  - resistors in series and parallel combinations
  - open and closed loop systems
- electrical calculations:
  - Ohm's Law: DC and AC (purely resistive)
  - voltage
  - power: DC and AC (purely resistive)
  - resistors: in series, in parallel
  - energy
  - electrical energy efficiency
  - diagnostic testing equipment including digital multimeter and oscilloscope, real or virtual
  - structure and function of electrotechnology systems and subsystems including representation of the inputs, processes and outputs, with elements of control and feedback (closed loop systems) in both block diagram and flow chart representations
- diagrammatic and symbolic representation and representations using simulation software of both integrated and controlled systems including mechanical and electrotechnological systems and subsystems (both open and closed loop) and their components
- stages of the systems engineering process and factors that influence the creation and use of an integrated and controlled system.



**Key skills**

- apply Ohm's Law to calculate voltage, current and resistance
- calculate power using voltage and current
- describe the operation of mechanical and electrotechnological systems using appropriate engineering terminology
- identify and represent mechanical and electrotechnological systems in diagrammatic and symbolic forms
- select appropriate mechanical and electrotechnological subsystems, materials and components and produce operational systems and subsystems
- measure and diagnose mechanical and electrotechnological system parameters using appropriate measuring and testing equipment
- construct and interpret circuit diagrams, schematics, PCB artwork, breadboard and Veroboard representations of electrical circuits, and transform one representation into another
- apply formulas to calculate mechanical and electrical parameters, work done, mechanical advantage, pressure, efficiency, Ohm's Law and power calculations on DC, or purely resistive AC circuits
- use digital technologies to simulate and demonstrate mechanical and electrotechnological principles
- interpret the resistor values in four and five colour band resistors with reference to a colour code chart and interpret component data sheets
- explain factors that influence the creation and use of the integrated system
- apply the systems engineering process to:
  - identify and document the problem, need, opportunity or situation
  - research, design, plan and commence production of an aspect of the ~~operational~~ integrated and controlled system.

# Area of Study 2

## Clean energy technologies

In this area of study students gain an understanding of energy sources and the application of technologies to convert energy sources into power for engineered systems. They consider the relevance of designing systems that are beneficial to the economy, environment and society. Demand for energy to produce electricity, heating and propulsion has sharply increased in recent years. However, current use of non-renewable energy cannot be sustained. Focus has increased on the need for efficient, safe, environmentally-friendly and economical extraction, generation, conversion, transportation, storage and use of power. Students analyse and compare the benefits, limitations and impacts of using different forms of energy sources, including the wastes that are produced and cradle-to-cradle (C2C) analysis. They investigate and evaluate the technologies used to harness, generate and store non-renewable and renewable energy sources. Students consider the technological systems developed to capture and store renewable energy and technological developments to improve the credentials of non-renewables. These developments include gains in efficiency through the transformation of non-renewables to other types of energy such as electricity, reduction of carbon dioxide emissions with non-renewable fuel technologies and hybrid technologies. Students look at examples of improvements in energy systems.

## Outcome 2

On completion of this unit the student should be able to discuss the advantages and disadvantages of renewable and non-renewable energy sources, and analyse and evaluate the technology used to harness, generate and store non-renewable and renewable energy.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 2.

**Key knowledge**

- forms of non-renewable energy sources including fossil fuels
- dependence on non-renewable fossil fuels as the main source of energy supply and electricity production
- forms of renewable energy sources including wind, solar, tidal, wave, hydro, geothermal and biomass
- energy transformations through the life cycle of power supply including harnessing or extraction, generation, conversion, transportation, storage and use
- technological developments to reduce carbon emissions and improve efficiency of fossil fuels including oil, natural gas and coal
- technologies used to harness, generate, store and transmit renewable energy sources including wind turbine systems, solar systems, hybrid fuel cells, and the combinations of these technologies
- factors that determine the efficiency of energy conversion
- advantages and disadvantages of solar and wind power technologies
- optimisation and efficiency of solar and wind power technologies.

**Key skills**

- describe forms of non-renewable and renewable energy sources
- discuss advantages and disadvantages of non-renewable energy sources and renewable energy sources, including cradle-to-cradle analysis
- explain recent technological developments to improve environmental credentials of non-renewable resources
- evaluate the technologies and processes used to harness, generate and store renewable energy sources
- describe factors that determine the efficiency of energy conversion
- evaluate solar and wind power technologies and compare these methods of harnessing energy with non-renewable energy methods.

# School-based assessment

## Satisfactory completion

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks to provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study and key knowledge and key skills listed for the outcomes should be used for course design and the development of learning activities and assessment tasks.

## Assessment of levels of achievement

The student's level of achievement in Unit 3 will be determined by School-assessed Coursework and a School-assessed Task.



# School-assessed Coursework

School-assessed Coursework tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe.

Where teachers provide a range of options for the same School-assessed Coursework task, they should ensure that the options are of comparable scope and demand.

The types and range of forms of School-assessed Coursework for the outcomes are prescribed within the study design. The VCAA publishes *Advice for teachers* for this study, which includes advice on the design of assessment tasks and the assessment of student work for a level of achievement.

Teachers will provide to the VCAA a numerical score representing an assessment of the student's level of achievement. The score must be based on the teacher's assessment of the performance of each student on the tasks set out in the following table.

### Contribution to final assessment

School-assessed Coursework for Unit 3 will contribute ~~10~~ 12.5 per cent to the study score.

| Outcomes | Marks allocated | Assessment tasks |
|---|---|---|
| **Outcome 2**<br>Discuss the advantages and disadvantages of renewable and non-renewable energy sources, and analyse and evaluate the technology used to harness, generate and store non-renewable and renewable energy. | 50 | Any one or a combination of:<br>• a short written report in the form of a media analysis or a case study or based on structured questions<br>• a multimedia/simulation presentation or report<br>• an oral presentation. |
| **Total marks** | **50** | |

## School-assessed Task

Assessment of Systems Engineering includes a School-assessed Task which contributes 50 per cent to the study score. For this assessment teachers will provide to the VCAA a score representing an assessment of the student's level of performance in achieving Outcome 1 in Unit 3 and Outcome 1 in Unit 4 according to criteria published by the VCAA. Details of the School-assessed Task for Units 3 and 4 are provided on page 31 of this study design.

## External assessment

The level of achievement for Units 3 and 4 is also assessed by an end-of-year examination, which will contribute 30 per cent to the study score.

# Unit 4: Systems control

In this unit students complete the creation of the mechanical and electrotechnological integrated and controlled system they researched, designed, planned and commenced production of in Unit 3. Students investigate new and emerging technologies~~, consider reasons for their development and analyse their impacts~~.

Students continue producing their mechanical and electrotechnological integrated and controlled system using the systems engineering process. Students develop their understanding of the open-source model in the development of integrated and controlled systems, and document its use fairly. They effectively document the use of project and risk management methods throughout the creation of the system. They use a range of materials, tools, equipment and components. Students test, diagnose and analyse the performance of the system. They evaluate their process and the system.

Students expand their knowledge of emerging developments and innovations through their investigation and analysis of a range of engineered systems. ~~They analyse a specific emerging innovation, including its impacts.~~



## Area of Study 1

### Producing and evaluating integrated and controlled systems

In this area of study students continue the development of the integrated and controlled system they researched, designed, planned and commenced production of in Unit 3, Area of Study 1. The completed operational system will demonstrate a range of theoretical concepts and principles studied in Units 3 and 4. Students support the production, testing, diagnosis and evaluation of their systems, subsystems and use of components with appropriate documentation, and with reference to technical data. In their evaluation they refer to the systems engineering process and the factors that have influenced the creation and use of the system. They also consider improvements that could be made to both the system and the process.

## Outcome 1

On completion of this unit the student should be able to finalise production, test and diagnose a mechanical and electrotechnological integrated and controlled system using the systems engineering process, and manage, document and evaluate the system and the process, as well as their use of it.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 1.

**Key knowledge**

- the role of Australian and international standards, specifications, data sheets, safety data sheets and technical data manuals
- the role of the open-source model in the development of integrated and controlled systems and fair acknowledgment
- production processes used to implement a work plan including simple and complex operations including joining, soldering, PCB manufacturing, fabricating, cutting, filing, bending and shaping as appropriate
- risk assessment and management at all stages of production and the intended use of the system
- ways of using appropriate tools, equipment, machines and components compliant with OH&S obligations
- performance characteristics of the system and the impact of substituting subsystems or components
- measuring and testing equipment and methods, and fault finding in systems, subsystems and components
- diagnostic practices, maintenance procedures and repair of systems and subsystems
- methods of evaluating systems.

**Key skills**

- apply the systems engineering process to produce, test, diagnose, evaluate and report on the system by:
  - implementing the work plan using a range of production processes
  - implementing and documenting risk assessment and management processes
  - selecting and using materials, tools, equipment and machines compliant with OH&S obligations
  - interpreting circuit diagrams, schematics, PCB artwork, breadboard and Veroboard representations of electrical circuits, and transforming one representation into another
  - managing production of the system, using ongoing reflection and evaluation, and documenting decision making, relevant data, changes and modifications
  - testing, measuring, diagnosing, repairing or modifying and recording appropriate system parameters to monitor quality and optimise system and subsystem performance
  - interpreting measurements and using previously established criteria
  - suggesting modifications and improvements
- identify how the factors that influenced the creation of the system and its use have been taken into account
- evaluate the use of the systems engineering process.



# Area of Study 2

## New and emerging technologies

In this area of study students focus on new or emerging systems engineering technologies and processes that have been developed within the last eight years preceding the year of study, or that are in the developmental stages and may not yet be commercially available. Students source recent publications and/or undertake site visits to assist their research of new and emerging systems. They consider scientific, technological, environmental, economic and societal and human factors that led to the development of the new or emerging technology and develop an understanding of how it operates and is used. Students consider ~~the likely impacts and resulting~~ advantages and disadvantages of the systems in relation to social, economic and environmental factors. The new and emerging developments may be exhibited in, or intended for use in, defence operations, aerospace, health, sports and enhancement of human physical capabilities, security and intelligence gathering, robotics and automation, metrology, transportation and education, or combinations of these. Many of these developments are made possible through the use of digital technologies. The new or emerging technology must not be the same as that studied in Unit 3, Area of Study 2.

# Outcome 2

On completion of this unit the student should be able to evaluate a range of new or emerging systems engineering technologies ~~and analyse the likely impacts of a selected technology~~.

To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 2.

**Key knowledge**

- new or emerging developments in systems engineering products and components, how they work and their applications
- new or emerging developments in systems engineering processes that improve economic and environmental sustainability, efficiency and risk management.
- ~~reasons for and drivers of the development of the new and emerging technologies, including discoveries, new materials, technology convergence and new manufacturing methods and processes~~
- ~~positive and negative impacts and the potential of the new and emerging developments.~~

**Key skills**

- research and evaluate the operations and applications of new and emerging developments in systems engineering processes and products
- ~~explain reasons for and drivers of the development of new and emerging technologies~~
- ~~analyse impacts and the potential of the new and emerging developments~~
- ~~present and analyse information about a specific new or emerging systems engineering innovation.~~

# School-based assessment

## Satisfactory completion

The award of satisfactory completion for a unit is based on whether the student has demonstrated the set of outcomes specified for the unit. Teachers should use a variety of learning activities and assessment tasks to provide a range of opportunities for students to demonstrate the key knowledge and key skills in the outcomes.

The areas of study and key knowledge and key skills listed for the outcomes should be used for course design and the development of learning activities and assessment tasks.

## Assessment of levels of achievement

The student's level of achievement in Unit 4 will be determined by School-assessed Coursework and a School-assessed Task.

# School-assessed Coursework

School-assessed Coursework tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe.

Where teachers provide a range of options for the same School-assessed Coursework task, they should ensure that the options are of comparable scope and demand.

The types and range of forms of School-assessed Coursework for the outcomes are prescribed within the study design. The VCAA publishes *Advice for teachers* for this study, which includes advice on the design of assessment tasks and the assessment of student work for a level of achievement.

Teachers will provide to the VCAA a numerical score representing an assessment of the student's level of achievement. The score must be based on the teacher's assessment of the performance of each student on the tasks set out in the following table.

**Contribution to final assessment**

School-assessed Coursework for Unit 4 will contribute ~~10~~ 7.5 per cent to the study score.

| Outcomes | Marks allocated | Assessment tasks |
|---|---|---|
| **Outcome 2**<br>Evaluate a range of new or emerging systems engineering technologies ~~and analyse the likely impacts of a selected technology~~. | ~~50~~ 30 | Any one or a combination of:<br>• a written report in the form of a case study or a media analysis or based on structured questions<br>• a multimedia/simulation presentation or report<br>• an oral presentation. |
| **Total marks** | ~~50~~ 30 | |

## School-assessed Task

The student's level of achievement in Outcome 1 in Unit 3 and Outcome 1 in Unit 4 will be assessed through a School-assessed Task.

The School-assessed Task contributes 50 per cent to the study score.

| Outcomes | Assessment tasks |
|---|---|
| **Unit 3**<br>**Outcome 1**<br>Investigate, analyse and apply concepts and principles, and use components to design, plan and commence production of an integrated and controlled aspect of the mechanical and electrotechnological system using the systems engineering process. | A record of investigation, design, planning and production.<br>AND<br>Preliminary production work to create a mechanical and electrotechnological integrated and controlled system. |
| **Unit 4**<br>**Outcome 1**<br>Finalise production, test and diagnose ~~a~~ an integrated and controlled aspect of the mechanical and electrotechnological ~~integrated and controlled~~ system using the systems engineering process, and manage, document and evaluate the system and processes, as well as their use of it. | Completion of production work accompanied by a record of progress and modifications (images and text material).<br>AND<br>A record of diagnostic testing and performance data.<br>AND<br>A report that evaluates and suggests improvements to the system with reference to the factors that influenced its creation and to the student's use of the systems engineering process. |



## External assessment

The level of achievement for Units 3 and 4 is also assessed by an end-of-year examination.

### Contribution to final assessment

The examination will contribute 30 per cent to the study score.

## End-of-year examination

### Description

The examination will be set by a panel appointed by the VCAA. All the key knowledge and key skills that underpin the outcomes in Units 3 and 4 are examinable.

### Conditions

The examination will be completed under the following conditions:

- Duration: one and a half hours.
- Date: end-of-year, on a date to be published annually by the VCAA.
- VCAA examination rules will apply. Details of these rules are published annually in the *VCE and VCAL Administrative Handbook*.
- The examination will be marked by assessors appointed by the VCAA.

### Further advice

The VCAA publishes specifications for all VCE examinations on the VCAA website. Examination specifications include details about the sections of the examination, their weighting, the question format/s and any other essential information. The specifications are published in the first year of implementation of the revised Unit 3 and 4 sequence together with any sample material.