The images shown above represent a cross section of works covering sculpture, textiles, assemblage, drawing, photography, prints, painting and electronic media as exhibited in VCE Top Arts.
Latoya BARTON
The sunset (detail)
9.0 x 9.0 cm each, oil on board

Tarkan ERTURK
Visage (detail)
201.0 x 170.0 cm
synthetic polymer paint, on cotton duck

Laura RASCHILLA
Teapot from the Crazy Alice set
19.0 x 22.0 x 22.0 cm
earthware, clear glaze, lustres

Nigel BROWN
Untitled physics (detail)
90.0 x 440.0 x 70.0 cm
composition board, steel, loudspeakers, CD player, amplifier, glass

Kate WOOLLEY
Sarah (detail)
76.0 x 101.0 cm, oil on canvas

Chris ELLIS
Tranquility (detail)
35.0 x 22.0 cm
gelatin silver photograph

Christian HART
Within without (detail)
digital film, 6 minutes

Kristian LUCAS
Me, myself, / and you (detail)
56.0 x 102.0 cm
oil on canvas

Meryn ALLEN
Japanese illusions (detail)
centre back: 74.0 cm, waist (flat): 42.0 cm
polyester cotton

Ping (Irene VINCENT)
Boxes (detail)
colour photograph

James ATKINS
Light cascades (detail)
three works, 32.0 x 32.0 x 5.0 cm each
gelatin silver photograph

Tim JOINER
14 seconds (detail)
digital film, 1.30 minutes

Lucy McNAMARA
Precariously (detail)
156.0 x 61.0 x 61.0 cm
painted wood, oil paint, egg shells, glue, stainless steel wire

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Edited by Ruth Learner
Cover designed by Chris Waldron of BrandHouse
Desktop published by Julie Coleman

Systems Engineering
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IMPORTANT INFORMATION

Accreditation period
Units 1–4: 1 January 2013 – 31 December 2018
Implementation of this study commences in 2013.

Other sources of information
The *VCAA Bulletin VCE, VCAL and VET* is the only official source of changes to regulations and accredited studies. The Bulletin, including supplements, 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 Victorian Curriculum and Assessment Authority’s website at: [www.vcaa.vic.edu.au](http://www.vcaa.vic.edu.au).

To assist teachers in assessing School-assessed Coursework in Units 3 and 4, the Victorian Curriculum and Assessment Authority publishes online an assessment handbook that includes advice on the assessment tasks and performance descriptors for assessment.


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.

Photocopying
VCE schools only may photocopy parts of this study design for use by teachers.
Introduction

SCOPE OF STUDY

VCE Systems Engineering involves the design, creation, operation and evaluation of integrated systems, which mediate and control many aspects of human experience. Integral to Systems Engineering is the identification and quantification of systems goals, the development of alternative system designs concepts, trial and error, design trade-offs, selection and implementation of the best design, testing and verifying that the system is well built and integrated, and evaluating how well the completed system meets the intended goals.

This study can be applied to a diverse range of engineering fields such as manufacturing, land, water, air and space transportation, automation, control technologies, mechanisms and mechatronics, electrotechnology, robotics, pneumatics, hydraulics, and energy management. Systems Engineering considers the interactions of these systems with society and natural ecosystems. The rate and scale of human impact on the global ecology and environment demands that systems design and engineering take a holistic approach by considering the overall sustainability of the systems throughout their life cycle. Key engineering goals include using a project management approach to attain efficiency and optimisation of systems through innovation. Lean engineering and lean manufacturing concepts and systems thinking are integral to this study.

RATIONALE

VCE Systems Engineering promotes innovative systems thinking and problem-solving skills through the Systems Engineering Process, which takes a project-management approach. It focuses on mechanical and electrotechnology 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, and learn to appreciate and apply technological systems.

VCE Systems Engineering integrates aspects of designing, planning, fabricating, testing and evaluating in a project management process. It prepares students for careers in engineering, manufacturing and design through either 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, manufacturing and evaluation techniques. These skills, and the ability to apply systems engineering processes, are growing in demand as industry projects become more complex and multidisciplinary.

**AIMS**

This study enables students to:

- develop an understanding of the Systems Engineering Process and the range of factors that influence the design, planning, production, evaluation and use of a system
- understand the concepts of and develop skills in the design, construction, fault-finding, diagnosis, performance analysis, maintenance, modification, and control of technological systems
- acquire knowledge of mechanical, electrical/electronic 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 use, security, health, education and transport
- acquire knowledge of new developments and innovations in technological systems
- develop skills in the safe use of tools, measuring equipment, materials, machines and processes, including using relevant information and communications technologies, and understand the risk management processes
- acquire knowledge of project management, and develop problem-solving and analytical skills
- gain an awareness of quality and standards, including systems reliability, safety and fitness for the intended purpose.

**STRUCTURE**

The study is made up of four units.

Unit 1: Introduction to mechanical systems
Unit 2: Introduction to electrotechnology systems
Unit 3: Integrated systems engineering and energy
Unit 4: Systems control and new and emerging technologies

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.

A glossary defining terms used across Units 1 to 4 in the *VCE Systems Engineering Study Design* is included on pages 43–47 under ‘Advice for teachers’.

**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 prior to undertaking Unit 4. 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 over the duration of a semester.

CHANGES TO THE STUDY DESIGN

During its period of accreditation minor changes to the study will be announced in the VCAA Bulletin VCE, VCAL and VET. 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 Victorian Curriculum and Assessment Authority 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

This study may involve the handling of potentially hazardous substances and the use of potentially hazardous equipment. 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. Teachers should refer to the Hazards guidance material within the OHS Management System on the DEECD Health and Wellbeing webpage: www.education.vic.gov.au/healthwellbeing/default.htm.


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’ on page 47.

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 that 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 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).


USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY

In designing courses for this study teachers should incorporate information and communications technology (ICT) where appropriate and applicable to the teaching and learning activities.

EMPLOYABILITY SKILLS

This study offers a number of opportunities for students to develop employability skills. The ‘Advice for teachers’ section 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 Information Privacy Act 2000 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 a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher’s assessment of the student’s performance on assessment tasks designated for the unit. Designated assessment tasks are provided in the details for each unit. The Victorian Curriculum and Assessment Authority publishes online an assessment handbook that includes advice on the assessment tasks and performance descriptors for assessment for Units 3 and 4.

Teachers must develop courses that provide opportunities for students to demonstrate achievement of outcomes. Examples of learning activities are provided in the ‘Advice for teachers’ section.

Schools will report a result for each unit to the Victorian Curriculum and Assessment Authority as S (Satisfactory) or N (Not Satisfactory).

Completion of a unit will be reported on the Statement of Results issued by the Victorian Curriculum and Assessment Authority as S (Satisfactory) or N (Not Satisfactory). Schools may report additional information on levels of achievement.

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.

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 Victorian Curriculum and Assessment Authority. Schools may choose to report levels of achievement using grades, descriptive statements or other indicators.
Units 3 and 4

The Victorian Curriculum and Assessment Authority will supervise the assessment of all students undertaking Units 3 and 4.

In VCE Systems Engineering students' level of achievement will be determined by School-assessed Coursework, a School-assessed Task and an end-of-year examination. The Victorian Curriculum and Assessment Authority will report students’ level of performance on each assessment component as a grade from A+ to E or UG (ungraded). To receive a study score, students 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
- Unit 3 and Unit 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.
Cross study specification

SYSTEMS ENGINEERING PROCESS

For the purposes of this study, the Systems Engineering Process illustrated below represents the stages in managing and developing a systems engineering project. The process is iterative in that students need to continuously re-evaluate their progress and make necessary modifications after having revisited an earlier stage or activity. When applying the Systems Engineering Process, students need to consider a range of factors that may influence the design, planning, production and use of a system, including function, user needs and requirements, appropriate materials and components, environment of use, safety, minimisation of waste and energy use, and associated costs. For details of these factors, refer to the ‘Advice for teachers’, page 39. The goal of the application of the Systems Engineering Process is to achieve an efficient, an optimum and a quality system.
Unit 1: Introduction to mechanical systems

This unit focuses on engineering fundamentals as the basis of understanding underlying principles and the building blocks that operate in simple to more complex mechanical devices.

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

Students apply their knowledge to design, construct, test and evaluate operational systems. The focus of the system should be mechanical; however, it may include some electronic components. The constructed operational systems demonstrate selected theoretical principles studied in this unit.

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

In this unit, students are introduced to the Systems Engineering Process. They are introduced to the fundamental mechanical engineering principles, including recognition of mechanical subsystems and devices, their motions, the elementary applied physics, and the 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’ on page 41.

AREA OF STUDY 1

Fundamentals of mechanical system design
In this area of study students learn about the fundamental mechanical engineering principles and the components and parts required to produce an operational system. The term ‘mechanical systems’ includes systems that utilise all forms of mechanical components and their linkages. Students learn the fundamental principles of how mechanisms and simple mechanical systems provide movement and mechanical advantage, and how the specific parts of a system or an entire mechanical system can be represented diagrammatically.

Students are introduced to the Systems Engineering Process and commence researching, designing, planning and modelling a functional (operational) mechanical or electro-mechanical system. Students consider relevant factors that influence the design, planning, production and use of their system and document their findings and the process they use.
Outcome 1
On completion of this unit the student should be able to describe and use basic engineering concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design and plan a mechanical or an electro-mechanical system.

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 including:
  − inclined planes and screws
  − levers, cranks and linkages, for example a ball joint linkage
  − pistons and cylinders
  − gear types: worm, bevel, pinion, spur; simple and compound gears
  − cams and followers
  − belts, pulleys, chains and sprockets
  − compression and tension springs
  − bearings
• mechanical engineering concepts and principles including:
  − energy sources and conversions
  − velocity ratio, pulley ratios and simple gear ratios
  − friction and its role
  − types of motion: linear, rotary, oscillating, and reciprocating and their transformation, for example rotary to reciprocating
  − first, second and third classes of levers
  − force and torque: tension, compression, torsion (twisting) and shear (cutting) and their combinations
• mechanical calculations and their measurement including:
  − speed = \frac{\text{distance}}{\text{time}}
  − force = \text{mass} \times \text{acceleration}
  − velocity ratio = \frac{\text{distance moved by effort}}{\text{distance moved by load}}
  − gear ratio = \frac{\text{number of teeth on driven}}{\text{number of teeth on driver}}
  − pulley ratio = \frac{\text{diameter of driven}}{\text{diameter of driver}}
  − gear or pulley ratio = \frac{\text{speed of driver (rpm)}}{\text{speed of driven (rpm)}}
  − mechanical advantage = \frac{\text{load}}{\text{effort}}
  − efficiency (%) = \frac{\text{useful energy output}}{\text{total energy input}} \times 100
  − work done = \text{force in direction moved} \times \text{distance}
  − SI units and engineering notation
• inputs, processes and outputs (IPO) diagrams to symbolically represent mechanical systems and the operation of open and closed loop systems
• the Systems Engineering Process and the relevant factors that influence the design, planning, production and use of a mechanical system
• system performance variations as a result of using different components or subsystems, for example substituting different gear types within a subsystem.

Key skills
• describe and explain how basic mechanical systems function, using appropriate engineering terms for the components and operational processes that make up these systems and subsystems
• identify and represent individual components and mechanical systems in symbolic form, using IPO diagrams, and simulation software
• identify and select appropriate components and subsystems that will form operational systems
• measure system parameters using appropriate measuring/testing equipment, and interpret results
• perform basic calculations on linkages, gear ratios and pulleys
• apply the Systems Engineering Process and identify relevant influencing factors on the development and use of a system to research, design and plan a functional mechanical or electro-mechanical system
• develop criteria to evaluate the finished operational system
• develop a suitably detailed workplan and components/materials list for the construction of a system using appropriate communication techniques.

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 system. The operational system students produce will contain mechanical components and elements, but may integrate some electrotechnology components or subsystems.

Students can model their design or develop a prototype to test aspects of the chosen design. Once the design is confirmed, students fabricate their mechanical or electro-mechanical system using materials and components. They perform a risk assessment and select and safely use materials, tools, equipment, components and machines. 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 evaluation criteria. They review how they have applied the Systems Engineering Process and how they have taken account of the factors that influenced the design, planning, production and use of their system.

Outcome 2
On completion of this unit the student should be able to make, test and evaluate a mechanical or an electro-mechanical system using selected relevant aspects of 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**
- Systems Engineering Process
- Production processes used to implement a workplan such as joining, fabricating, cutting, filing, bending and shaping
- Risk assessment and management at all stages of production and the final use of the system
- Safe and correct use of appropriate tools, equipment, machines and components in accordance with OH&S requirements
- Measuring and testing methods and equipment
- Testing, measuring and fault finding in systems
- Evaluation and communication methods and procedures.

**Key skills**
- Select components, elements and materials that are appropriate for the system
- Use a range of processes to implement the workplan to make the system and to meet the requirements of the design brief
- Implement risk assessment and management processes
- Correctly select and safely use tools, equipment and machines in the production processes in accordance with OH&S requirements
- Undertake finishing techniques and processes
- Manage all aspects of the production process through to completion of the system, using ongoing evaluation; and record decision making, relevant data, changes and modifications
- Test, measure and record appropriate system parameters to evaluate system performance
- Use and evaluate the Systems Engineering Process.

**ASSESSMENT**

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher’s assessment of the student’s overall performance on assessment tasks designated for the unit. The key knowledge and key skills listed for each outcome should be used for course design and the development of learning activities. The key knowledge and key skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes.

Assessment 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. Teachers should select a variety of assessment tasks for their assessment program to reflect the key knowledge and key skills being assessed and to provide for different learning styles.

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

Demonstration of achievement of Outcomes 1 and 2 must be based on the student’s performance on a selection of assessment tasks. Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.
Assessment tasks for this unit are selected from the following:

- documentation of the Systems Engineering Process using one or more of:
  - multimedia presentation
  - folio
  - brochure
  - poster
  - report
- production work
- practical demonstrations
- test
- oral presentation.
Unit 2: Introduction to electrotechnology systems

In this unit students study fundamental electrotechnology engineering principles. Through the application of their knowledge and the Systems Engineering Process, students produce operational systems that may also include mechanical components. In addition, students conduct research and produce technical reports.

While this unit contains fundamental physics and theoretical understanding of electrotechnology systems and how they work, student focus remains on the construction of electrotechnology systems. The construction process draws heavily upon design and innovation.

Electrotechnology is experiencing rapid developments and changes through technological innovation. The contemporary design and manufacture of electronic equipment involves increased levels of automation and inbuilt control through the inclusion of microcontrollers. In this unit students explore some of these new and emerging technologies.

Students study fundamental electrotechnology principles including applied electrical theory, representation of electronic components and devices, elementary applied physics in electrical circuits, and mathematical calculations that can be applied to define and explain electrical characteristics of circuits. The unit offers opportunities for students to apply their knowledge in the design, construction, testing and evaluation of an operational system. The system should be predominately electrotech based, but would generally have electro-mechanical components within the system. The constructed system should provide a tangible demonstration of some of the theoretical principles studied in this unit.

A range of suitable systems for this unit is included in the ‘Advice for teachers’ on page 41.

AREA OF STUDY 1

Fundamentals of electrotechnology system design

In this area of study students focus on electrotechnology engineering principles and the elements that make operational electrotechnology systems. The term ‘electrotechnology’ encompasses systems that include electrical, electronic and microelectronic circuitry. Students develop understanding of commonly used components, their physical appearance, and how they can be represented in schematic circuit diagrams and in circuit simulation software. A table of electronic symbols is provided as support material on the Systems Engineering study page of the Victorian Curriculum and Assessment Authority website.
Using the Systems Engineering Process, students commence researching, designing, planning and modelling an operational electrotechnology system that may incorporate some mechanical components. They describe the factors that will influence the design, planning, production and use of the system.

Outcome 1
On completion of this unit the student should be able to investigate, represent, describe and use basic electrotechnology and basic control engineering concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design and plan an electrotechnology system.

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 electrical/electronic components including:
  – electric power sources: batteries and photovoltaic cells
  – generators and motors
  – printed circuit boards (PCBs)
  – switches: push button (normally open and normally closed) and toggle (combinations of single and double pole, single and double throw), single and ganged, micro, reed and mercury
  – resistors: fixed value, light dependent resistors (LDRs) and variable resistors, potentiometers and different wattage
  – fixed value and variable capacitors, and different types, for example ceramic and electrolytic polarised and non-polarised and ultra or super capacitors
  – diodes: signal, power, and light emitting diodes (LEDs)
  – NPN and PNP transistors
  – step-up and step-down transformers
  – relays and solenoids
  – integrated circuits (ICs): microcontrollers and their representations using simulation software
• electrical/electronic concepts and principles, and reference material including:
  – energy sources, their measurement and their conversions
  – alternating current (AC) and direct current (DC) waveforms and their use; AC power generation
  – components used in circuits and their common schematic diagrammatic representation
  – the resistor colour code
  – resistors in series and parallel combinations
  – open and closed loop systems
• electrical calculations and measurement including:
  – Ohm’s Law: DC and AC (purely resistive) calculation; voltage = current × resistance, and application of Ohm’s Law to calculate voltage, current and resistance
  – power calculations: DC and AC (purely resistive), power = voltage × current
  – resistors in series \( R_t = R_1 + R_2 + R_3 \)
  – resistors in parallel \( \frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \) or \( R_t = \frac{R_1 \times R_2}{R_1 + R_2} \) for two resistors only
  – energy = power × time
electrical energy efficiency (%) = \frac{\text{useful energy output (watts)}}{\text{total energy input (watts)}} \times 100

diagnostic testing equipment including digital multimeter

- the structure and function of electrotechnology systems and subsystems, including representation of the inputs, processes, outputs, with elements of control and feedback (closed loop systems) in block diagrams and flow charts
- the Systems Engineering Process and the factors that influence the design, planning, production and use of an electrotechnology system.

Key skills
- describe the operation of basic electrotechnology systems, open and closed loop systems and subsystems using appropriate engineering terminology
- identify and represent electrotechnology systems in diagrammatic and symbolic forms such as flow charts, block diagrams, open and closed loop diagrams, and commonly used electronic components in symbolic form as used in a circuit schematic diagram
- select appropriate electrotechnology subsystems, and electronic and mechanical components that will form operational systems and subsystems
- measure, test and evaluate electrotechnology system parameters using appropriate measuring/testing equipment; measure voltage, current and resistance and interpret the results
- apply formulas to solve and calculate electrical circuit parameters using Ohm’s Law and power calculations
- use information and communications technology, and simulation and demonstration software to represent and demonstrate electrotechnology principles
- read and interpret the resistor values in four and five colour band resistors with reference to a colour code chart
- describe the factors that influence the design, planning, production and use of their electrotechnology system
- apply the Systems Engineering Process to research, design and plan an operational electrotechnology system
- develop criteria to evaluate the finished functional system
- develop a suitably detailed workplan and components/materials list for the construction of a system using appropriate communication techniques.

AREA OF STUDY 2

Producing and evaluating electrotechnology systems
In this area of study students produce, test, diagnose and evaluate functional electrotechnology systems that may include some mechanical components or electro-mechanical subsystems. Using the Systems Engineering Process, students use a range of materials, tools, equipment, machines and components and manage identified risks while producing their 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 design, planning and production. Students suggest how the system could be further improved.
Outcome 2
On completion of this unit the student should be able to make, test and evaluate an electrotechnology system, using selected relevant aspects of 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 Systems Engineering Process and the factors that influence the design, planning, production and use of an electrotechnology system
• the role of specifications, data sheets, and technical data manuals
• a work plan including production processes such as joining, soldering, fabricating, cutting, filing and producing printed circuit boards
• risk assessment and management at all stages of production and the final use of the system
• the safe and correct use of appropriate tools, equipment, machines and components to construct and assemble the system and in accordance with OH&S requirements
• performance characteristics of the system, and the impact of substituting components
• measuring and testing equipment and methods; and fault finding in systems
• test and repair of systems
• methods of achieving quality and an operable electrotech system suitable for its intended purpose
• evaluation and communication methods and procedures.

Key skills
• identify and select components, elements and materials that are appropriate for the system
• use printed circuit boards and soldering and a range of other processes to implement the workplan to make the system
• implement risk assessment and management processes
• select, and correctly and safely use, materials, tools, equipment and machines in the production process in accordance with OH&S requirements
• undertake finishing techniques and processes
• manage all aspects of the manufacturing process through to completion of the system, using ongoing evaluation; and record decision making, relevant data, changes and modifications
• monitor quality related to the system and undertake appropriate repair and maintenance procedures
• test, measure and record appropriate system parameters to evaluate system performance
• evaluate the use of the Systems Engineering Process, and the system produced through interpretation of measurements and use of the previously established evaluation criteria
• suggest modifications and improvements; and identify how the factors that influenced the development and use of the system have been taken into account.
ASSESSMENT

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher’s assessment of the student’s overall performance on assessment tasks designated for the unit.

The key knowledge and key skills listed for each outcome should be used for course design and the development of learning activities. The key knowledge and key skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes.

Assessment 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. Teachers should select a variety of assessment tasks for their assessment program to reflect the key knowledge and key skills being assessed and to provide for different learning styles.

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

Demonstration of achievement of Outcomes 1 and 2 must be based on the student’s performance on a selection of assessment tasks. Where teachers allow students to choose between tasks they must ensure that the tasks they set are of comparable scope and demand.

Assessment tasks for this unit are selected from the following:

• documentation of the Systems Engineering Process using one or more of:
  – multimedia presentation
  – folio
  – brochure
  – poster
  – report
• production work
• practical demonstrations
• test
• oral presentation.
Unit 3: Integrated systems engineering and energy

In this unit students study the engineering principles that are used to explain the physical properties of integrated systems and how they work. Through the application of their knowledge, students design and plan an operational, mechanical-electrotechnology 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 design, planning and construction of one substantial controlled integrated system. This project has a strong emphasis on designing, manufacturing, testing and innovation. Students manage the project throughout the Systems Engineering Process, taking into consideration the factors that will influence the design, planning, production and use of their integrated system. The systems engineering principles underpin students’ understanding of the fundamental physics and applied mathematics needed to provide a comprehensive understanding of mechanical and electrotech 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 impacts of the use of renewable and non-renewable energy sources. Students learn about the 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’ on page 42.

AREA OF STUDY 1

Controlled and integrated systems engineering design

This area of study focuses on engineering knowledge associated with the integration and control of mechanical and electrotechnology 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. A table of electronic symbols is provided as support material on the Systems Engineering study page of the Victorian Curriculum and Assessment Authority website. Students use fundamental physics and applied mathematics to solve systems engineering problems. Using selected theoretical concepts and principles they apply the Systems Engineering Process to manage the design and planning of an integrated system and commence its construction. They investigate the factors that will influence the design, planning, production and use of their integrated system. Students demonstrate innovation and creativity as well as comprehensive project management skills. 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 use advanced mechanical-electrotechnology integrated and control systems concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design, plan and commence construction of an integrated and controlled system.

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 including:
  – inclined planes and screws
  – levers, cranks, a ball joint linkage and other linkages
  – gear types: worm, bevel, pinion, spur, crown; simple and compound gears
  – pistons and cylinders
  – cams and followers
  – belts and pulleys
  – compression and tension springs
• mechanical engineering concepts and principles including:
  – energy sources and conversions
  – friction and its role
  – velocity ratio, pulley ratio, simple and compound gear ratios
  – types of motion: linear, rotary, oscillating, and reciprocating and their transformation (rotary to reciprocating)
  – first, second and third classes of levers
  – force and torque: tension, compression, torsion (twisting) and shear (cutting) and their combinations
  – basic hydraulic and pneumatic systems
  – pneumatic and hydraulic pressure
  – Newton’s first, second and third laws of motion
• mechanical calculations and their measurement including:
  – speed = \frac{\text{distance}}{\text{time}}
  – force = \text{mass} \times \text{acceleration}
  – velocity ratio = \frac{\text{distance moved by effort}}{\text{distance moved by load}}
  – gear ratio = \frac{\text{number of teeth on driven}}{\text{number of teeth on driver}}
  – pulley ratio = \frac{\text{diameter of driven}}{\text{diameter of driver}}
  – gear or pulley ratio = \frac{\text{speed of driver (rpm)}}{\text{speed of driven (rpm)}}
  – total gear ratio = \text{gear ratio } 1 \times \text{gear ratio } 2 \times \ldots
  – mechanical advantage = \frac{\text{load}}{\text{effort}}
  – efficiency (%) = \frac{\text{useful energy output}}{\text{total energy input}} \times 100
– power = \frac{\text{work done}}{\text{time}}
– energy = \text{power} \times \text{time}
– work done = \text{force in direction moved} \times \text{distance}
– pressure = \frac{\text{force}}{\text{area}}
– moments about a point (moment = \text{force} \times \text{perpendicular distance to turning point})
– action and reaction forces and torque
  \quad (\text{torque} = \text{twisting force} \times \text{perpendicular distance to turning point})

• the function and operation of electrical/electronic components and commonly used symbolic representation including:
  – electric power sources: alternating current (AC), generators and direct current (DC), batteries, and photovoltaic cells (PV cells)
  – printed circuit boards (PCBs) and other component mounting techniques
  – switches: push button (normally open and normally closed) and toggle (combinations of single and double pole, single and double throw), single and ganged, micro, reed and mercury
  – relays, solenoids and fuses
  – resistors: fixed value and variable resistors, potentiometers, light dependent resistors (LDRs), thermistors (temperature variable) and different wattages
  – fixed value and variable capacitors, and different types: ceramic and electrolytic polarised and non-polarised, and ultra or super capacitors
  – diodes: signal, power, bridge rectifier and light emitting diodes (LEDs), zener
  – fixed and variable voltage regulators
  – transistors: NPN, PNP, and phototransistors
  – step-up and step-down transformers
  – liquid crystal displays (LCDs)
  – wound armatures motors and DC motors
  – input transducer and control devices: microphones, speakers and audio transducers and piezo buzzers
  – aerial or antenna and earth connection
  – simulation software to represent integrated circuits (ICs) and microcontrollers

• electrical/electronic concepts and principles including:
  – energy sources and their conversions
  – AC and DC waveforms and where they are used
  – components used in circuits and their common schematic diagrammatic representation
  – the resistor colour code
  – component data sheets
  – digital and analogue signals and data storage
  – logic gates and truth tables: NOT, AND, NAND, OR, NOR, XOR

• electrical calculations and their measurement including:
  – Ohm’s Law: DC and AC (purely resistive) calculations, \text{voltage} = \text{current} \times \text{resistance}, and application of Ohm’s Law to calculate voltage, current and resistance
  – power calculations: DC and AC (purely resistive), \text{power} = \text{voltage} \times \text{current}, to calculate power, voltage and current
  – electrical energy efficiency (%) = \frac{\text{useful energy output (watts)}}{\text{total energy input (watts)}} \times 100
– energy = power (watts) × time
– frequency = \( \frac{1}{\text{period}} \)
– resistor networks – resistors in series \( R_s = R_1 + R_2 + \ldots \),
  \[ R_s = R_1 + R_2 + \ldots \] or \( R_s = \frac{R_1 \times R_2}{R_1 + R_2} \) for two resistors only
– capacitors in series – for capacitors in parallel \( C_p = C_1 + C_2 + C_3 + \ldots \),
  \[ C_p = C_1 + C_2 + \ldots \] or \( C_p = \frac{C_1 \times C_2}{C_1 + C_2} \) for two capacitors only
– digital multimeter and other diagnostic testing equipment

• SI units and engineering notation
• diagrammatic and symbolic representation and representations using simulation software of both integrated and controlled systems including mechanical and electrotechnology systems and subsystems (both open and closed loop) and their components
• the Systems Engineering Process and the factors that influence the design, planning, production and use of an integrated controlled system.

**Key skills**

• describe the operation of mechanical and electrotechnology systems, open and closed loop systems and subsystems using appropriate engineering terminology
• identify and represent mechanical and electrotechnology systems in diagrammatic and symbolic forms such as flow charts, block diagrams, open and closed loop diagrams, and commonly used electronic components in symbolic form as used in circuit schematic diagrams
• select appropriate mechanical, electrotechnology subsystems, materials, components and elements that will form functional systems and subsystems
• measure and diagnose mechanical and electrotechnology system parameters using appropriate measuring/testing equipment; measure electrical waveforms – both time-base and amplitude (as viewed on a cathode ray oscilloscope or simulation), voltage, current, resistance and capacitance
• apply formulas to calculate and determine mechanical and electrical parameters, work done, mechanical advantage, pressure, efficiency, Ohm’s Law and power calculations on DC or purely resistive AC circuits
• use information and communications technology, simulation and demonstration software to represent and demonstrate mechanical and electrotechnology principles
• read and interpret the resistor values in four and five colour band resistors with reference to a colour code chart and interpret component data sheets
• explain the factors that influence the design, planning, production and use of the integrated system
• apply the Systems Engineering Process to research, design and plan an operational controlled integrated system
• develop a suitably detailed workplan and components/materials list for the construction of a system using appropriate communication techniques, and develop criteria to evaluate the finished operational 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. Societal 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. 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, including gains in efficiency through the transformation of non-renewables to other types of energy such as electricity, reduction of CO2 emissions with non-renewable fuel technologies and hybrid technologies. Students look at examples of improvements in energy systems, such as the rankine cycle and brayton cycles and associated technologies.

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
- modern industrial societies’ 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.

Key skills

- describe the forms of non-renewable and renewable energy sources
- compare the advantages and disadvantages of non-renewable energy sources with renewable energy sources
- explain recent technological developments to improve environmental credentials of non-renewable resources
- describe and diagrammatically represent the technologies and processes used to harness, generate and store renewable energy sources
- describe the 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.

**ASSESSMENT**

The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher’s assessment of the student’s overall performance on assessment tasks designated for the unit. The Victorian Curriculum and Assessment Authority publishes online an assessment handbook for this study that includes advice on the assessment tasks and performance descriptors for assessment.

The key knowledge and key skills listed for each outcome should be used for course design and the development of learning activities. The key knowledge and key skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes.

**Assessment of levels of achievement**

The student’s level of achievement in Unit 3 will be determined by School-assessed Coursework, a School-assessed Task and an end-of-year examination.

**Contribution to final assessment**

School-assessed Coursework for Unit 3 will contribute 10 per cent.

The level of achievement for Units 3 and 4 is also assessed by a School-assessed Task, which will contribute 50 per cent, and an end-of-year examination, which will contribute 30 per cent.

**School-assessed Coursework**

Teachers will provide to the Victorian Curriculum and Assessment Authority a score representing an assessment of the student’s level of achievement.

The score must be based on the teacher’s rating of performance of each student on the tasks set out in the following table and in accordance with the assessment handbook published online by the Victorian Curriculum and Assessment Authority. The assessment handbook also includes advice on the assessment tasks and performance descriptors for assessment.

Assessment 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 assessment task, they should ensure that the options are of comparable scope and demand. Teachers should select a variety of assessment tasks for their program to reflect the key knowledge and key skills being assessed and to provide for different learning styles.
Outcomes | Marks allocated* | Assessment tasks |
--- | --- | --- |
Outcome 2 | 50 | Any one or a combination of:  
• a test (short and/or extended responses)  
• a short written report  
• a report in multimedia format  
• a media analysis  
• a case study  
• an oral presentation. |

Total marks | 50 |

*School-assessed Coursework for Unit 3 contributes 10 per cent.

School-assessed Task

Assessment of Systems Engineering includes a School-assessed Task worth 50 per cent of the study score. For this assessment teachers will provide to the Victorian Curriculum and Assessment Authority 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 Victorian Curriculum and Assessment Authority. Details of the School-assessed Task for Units 3 and 4 are provided on pages 33 and 34 of this study design.
Unit 4: Systems control and new and emerging technologies

In this unit, students complete the production work and test and evaluate the integrated controlled system they designed in Unit 3. Students investigate new and emerging technologies, consider reasons for their development and analyse their impacts.

Students use their investigations, design and planning to continue the fabrication of their mechanical-electrotechnology integrated and controlled system using the Systems Engineering Process. They use project and risk management methods through the construction of the system and use a range of materials, tools, equipment, and components. In the final stages of the Systems Engineering Process, students test, diagnose and analyse the performance of the system. They evaluate their processes and the system.

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

AREA OF STUDY 1

Producing, testing and evaluating integrated technological systems

In this area of study, students apply their knowledge and skills to manage and construct the integrated and controlled system they designed and developed in Unit 3, Area of Study 1, through to its final stages of construction, testing, and evaluation. The completed operational system demonstrates selected theoretical concepts and principles studied in Units 3 and 4 of this study. Students support the production, testing, diagnosis and evaluation of their system with appropriate documentation, with reference to technical data. In their evaluation they refer to the Systems Engineering Process and the factors that have influenced the design, planning, production and use of the system, and consider improvements that could be made to both the system and processes.

Outcome 1

On completion of this unit, the student should be able to produce, test and diagnose an advanced mechanical-electrotechnology integrated and controlled system using selected relevant aspects of the Systems Engineering Process, and manage, document and evaluate the system and processes.
To achieve this outcome the student will draw on key knowledge and key skills outlined in Area of Study 1.

**Key knowledge**
- the Systems Engineering Process and the factors that influence the design, planning, production and use of an integrated and controlled system
- the role of standards, specifications, data sheets, and technical data manuals
- production processes used to implement a workplan, including joining, soldering, PCB manufacture, fabricating, cutting, filing, bending and shaping as appropriate
- risk assessment and management at all stages of production and the final use of the integrated system
- the safe and correct use of appropriate tools, equipment, machines and components in accordance with OH&S requirements
- performance characteristics of the system, and the impact of substituting components
- measuring and testing equipment and methods, and fault finding in systems
- diagnostic practices, maintenance procedures and repair of systems
- methods of achieving quality and an operational integrated and controlled system suited to its intended purpose
- evaluation and communication methods and procedures.

**Key skills**
- select components, elements and materials that are appropriate for the system with reference to technical data and specifications
- use machining, fabrication, assembly, manufacture of printed circuit boards and soldering and a range of other processes as appropriate to implement the workplan to make the system
- implement risk assessment and project management processes
- select, and correctly and safely use, materials, tools, equipment and machines in the production process and in accordance with OH&S requirements
- undertake finishing techniques and processes
- manage all aspects of the manufacturing process through to completion of the system, using ongoing evaluation; and record decision making, relevant data, changes and modifications
- monitor quality related to the system and undertake appropriate repair and maintenance procedures
- test, measure, diagnose, repair or modify, and record appropriate system parameters to optimise system performance
- evaluate the use of the Systems Engineering Process, and the system through interpretation of measurements, and use of the previously established evaluation criteria
- suggest modifications and improvements; and identify how the factors that influenced the development of the system and its use have been taken into account.

**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 to assist their research of new and emerging systems. They consider factors that led to the development
of the new or emerging technology and gain 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 information and communications technology. The component/s, system or innovation 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 describe and evaluate a range of new or emerging technologies, and analyse the likely impacts of a selected innovation.

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 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 describe 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.

ASSESSMENT
The award of satisfactory completion for a unit is based on a decision that the student has demonstrated achievement of the set of outcomes specified for the unit. This decision will be based on the teacher’s assessment of the student’s overall performance on assessment tasks designated for the unit. The Victorian Curriculum and Assessment Authority publishes online an assessment handbook for this study that includes advice on the assessment tasks and performance descriptors for assessment.

The key knowledge and key skills listed for each outcome should be used for course design and the development of learning activities. The key knowledge and key skills do not constitute a checklist and such an approach is not necessary or desirable for determining the achievement of outcomes.

Assessment of levels of achievement
The student’s level of achievement for Unit 4 will be determined by School-assessed Coursework, a School-assessed Task and an end-of-year examination.
Contribution to final assessment

School-assessed Coursework for Unit 4 will contribute 10 per cent.

The level of achievement for Units 3 and 4 is also assessed by a School-assessed Task, which will contribute 50 per cent, and an end-of-year examination, which will contribute 30 per cent.

School-assessed Coursework

Teachers will provide to the Victorian Curriculum and Assessment Authority a score representing an assessment of the student’s level of achievement.

The score must be based on the teacher’s rating of performance of each student on the tasks set out in the following table and in accordance with the assessment handbook published online by the Victorian Curriculum and Assessment Authority. The assessment handbook also includes advice on the assessment tasks and performance descriptors for assessment.

Assessment 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 assessment task, they should ensure that the options are of comparable scope and demand. Teachers should select a variety of assessment tasks for their program to reflect the key knowledge and key skills being assessed and to provide for different learning styles.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Marks allocated*</th>
<th>Assessment tasks</th>
</tr>
</thead>
</table>
| Outcome 2 | 50               | Any one or a combination of:  
• a test (short and/or extended responses)  
• a short written report  
• a report in multimedia format  
• a media analysis  
• a case study  
• an oral presentation. |

Total marks 50

*School-assessed Coursework for Unit 4 contributes 10 per cent.

School-assessed Task

Assessment of Systems Engineering includes a School-assessed Task worth 50 per cent of the study score. For this assessment teachers will provide to the Victorian Curriculum and Assessment Authority 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 Victorian Curriculum and Assessment Authority.
Unit 3
Outcome 1
Investigate, analyse and use advanced mechanical-electrotechnology integrated and control systems concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design, plan and commence construction of an integrated and controlled system.

Outcomes Assessment tasks

Unit 4
Outcome 1
Produce, test and diagnose an advanced mechanical-electrotechnology integrated and controlled system using selected relevant aspects of the Systems Engineering Process, and manage, document and evaluate the system and processes.

End-of-year examination

Description
The examination will be set by a panel appointed by the Victorian Curriculum and Assessment Authority. 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 Victorian Curriculum and Assessment Authority.
• Victorian Curriculum and Assessment Authority 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 Victorian Curriculum and Assessment Authority.

Contribution to final assessment
The examination will contribute 30 per cent.

Further advice
The Victorian Curriculum and Assessment Authority publishes specifications for all VCE examinations on the Victorian Curriculum and Assessment Authority 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 Units 3 and 4 sequence together with any sample material.
Advice for teachers

EMPLOYABILITY SKILLS

Units 1 to 4 of the Systems Engineering study provide students with the opportunity to engage in a range of learning activities. In addition to demonstrating their understanding and mastery of the content and skills specific to the study, students may also develop employability skills through their learning activities.

The nationally agreed employability skills’ are: Communication; Planning and organising; Teamwork; Problem solving; Self-management; Initiative and enterprise; Technology; and Learning.

Each employability skill contains a number of facets that have a broad coverage of all employment contexts and are designed to describe all employees. The table below links those facets that may be understood and applied in a school or non-employment related setting, to the types of assessment commonly undertaken within the VCE study.

<table>
<thead>
<tr>
<th>Assessment task</th>
<th>Employability skills: selected facets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record of investigation, design, planning and production</td>
<td>Communication (reading independently; using numeracy)</td>
</tr>
<tr>
<td></td>
<td>Problem solving (developing practical creative, innovative solutions; showing independence and initiative in identifying problems and solving them; applying a range of strategies to problem solving)</td>
</tr>
<tr>
<td></td>
<td>Planning and organising (establishing clear project goals and deliverables; planning the use of resources including time management; collecting, analysing and organising information)</td>
</tr>
<tr>
<td></td>
<td>Technology (having a range of basic IT skills)</td>
</tr>
<tr>
<td>Multimedia presentation</td>
<td>Communication (speaking clearly and directly; persuading effectively, sharing information; listening and understanding)</td>
</tr>
<tr>
<td></td>
<td>Technology (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data)</td>
</tr>
</tbody>
</table>

*The employability skills are derived from the Employability Skills Framework (Employability Skills for the Future, 2002), developed by the Australian Chamber of Commerce and Industry and the Business Council of Australia, and published by the (former) Commonwealth Department of Education, Science and Training.
<table>
<thead>
<tr>
<th>Assessment task</th>
<th>Employability skills: selected facets</th>
</tr>
</thead>
</table>
| Folio                                               | **Communication** (reading independently; using numeracy)  
**Problem solving** (showing independence and initiative in identifying problems and solving them)  
**Self management** (articulating own ideas and visions)  
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data) |
| Brochure                                            | **Communication** (writing to the needs of the audience; sharing information; listening and understanding; reading independently)  
**Technology** (having a range of basic IT skills; using IT to organise data)                                                                                     |
| Poster                                              | **Communication** (writing to the needs of the audience; sharing information; listening and understanding; reading independently)  
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data)                                                   |
| Written report                                      | **Communication** (writing to the needs of the audience; persuading effectively; reading independently)                                                                                                                                |
| A report in multimedia format                       | **Communication** (writing to the needs of the audience; persuading effectively; sharing information; listening and reading independently)  
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data)                                                   |
| Production work accompanied by a record of progress and modifications | **Technology** (having the OHS knowledge to apply technology; being willing to learn new IT and practical skills)  
**Learning** (manifesting own learning; having enthusiasm for ongoing learning; being open to new ideas and techniques; acknowledging the need to learn in order to accommodate change)  
**Problem solving** (showing independence and initiative in identifying problems and solving them)  
**Planning and organising** (managing time and priorities – setting time lines; co-ordinating tasks for self and with others; establishing clear project goals and deliverables; planning the use of resources including time management)  
**Initiative and enterprise** (adapting to new situations; being creative; identifying opportunities not obvious to others; generating a range of options; initiating innovative solutions)  
**Teamwork** (working as an individual and as a member of a team) |
| Practical demonstration                             | **Communication** (speaking clearly and directly; persuading effectively; sharing information; listening and understanding)                                                                                                           |
| Test                                                | **Problem solving** (showing independence and initiative in identifying problems and solving them)                                                                                                                                       |
| Oral presentation (supported by visual presentation) | **Communication** (speaking clearly and directly; persuading effectively; sharing information; listening and understanding; reading independently)  
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data)                                                   |
| Case study                                          | **Communication** (writing to the needs of the audience; reading independently; listening and understanding)  
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data)                                                     |
Assessment task | Employability skills: selected facets
---|---
A report of diagnostic testing and performance data | **Communication** (writing to the needs of the audience; reading independently)
**Learning** (managing own learning; having enthusiasm for ongoing learning; being open to new ideas and techniques; acknowledging the need to learn in order to accommodate change)
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data; having the OHS knowledge to apply technology)

Evaluation report | **Communication** (writing to the needs of the audience; reading independently)
**Technology** (having a range of basic IT skills; being willing to learn new IT skills; using IT to organise data)

Media analysis | **Communication** (writing to the needs of the audience; reading independently)

**DEVELOPING A COURSE**

A course outlines the nature and sequence of teaching and learning necessary for students to demonstrate achievement of the set of outcomes for a unit. The areas of study broadly describe the learning context and the knowledge required for the demonstration of each outcome. Outcomes are introduced by summary statements and are followed by the key knowledge and key skills which relate to the outcomes.

Teachers must develop courses that include appropriate learning activities to enable students to develop the key knowledge and key skills identified in the outcome statements in each unit.

For Units 1 and 2, teachers must select assessment tasks from the list provided. Tasks should provide a variety and the mix of tasks should reflect the fact that different types of tasks suit different knowledge and skills and different learning styles. Tasks do not have to be lengthy to make a decision about student demonstration of achievement of an outcome.

In Units 3 and 4, assessment is more structured. For some outcomes, or aspects of an outcome, the assessment tasks are prescribed. The contribution that each outcome makes to the total score for School-assessed Coursework is also stipulated.

Unit 3, Outcome 1 and Unit 4, Outcome 1 are assessed by a School-assessed Task. The School-assessed Task will initially be assessed by teachers using criteria published by the Victorian Curriculum and Assessment Authority.

One of the most important issues for teachers to consider when planning a course is to ensure that practical activities are embedded into the course to engage students in learning.
THE CROSS STUDY SPECIFICATION

The Systems Engineering Process

The Systems Engineering Process is integral to all units of this study and includes a range of factors that may influence the design, planning, production and use of a system (see page 12 of the study design). The Systems Engineering Process outlines stages that students work through when seeking a solution, and reflects the way engineers develop solutions in the field of engineering. In industry, solutions are often reached through evaluation at each stage of the process, which in turn leads to re-visiting previous stages of the process until the best possible alternative is found. In this study the Systems Engineering Process provides students with a structure that can be worked through, allowing for modifications to initial plans that come about as a result of a series of cognitive and physical activities.

The first stage of the Systems Engineering Process requires the identification and documentation of a problem, need, opportunity or situation requiring a systems engineering solution. An understanding of the problem and its background is explored. The context, and the constraints and considerations that apply to the problem, need, opportunity or situation are articulated in a design brief.

The next stage of the process is to research the problem or need and consider how it can be addressed. This will involve exploring processes, components, subsystems and any associated costs. The potential system is then designed and modelled in the third stage, which requires the execution of drawings, flow diagrams, testing and trialling possibilities using simulation or actual components. At this stage, calculations may need to be made to determine functionality and performance.

The fourth stage of the Systems Engineering Process requires planning how the proposed system will be produced. This requires careful consideration of the sequential steps to fabricate the systems components to form the systems and subsystems. The components and materials required need to be identified and sourced. Once the planning is completed, the subsystems and systems can be assembled, built and fabricated. This requires safe use of tools, equipment, system components and materials. Depending on the complexity of the system, and students’ prior experience, the length of time required to complete the planning stage and move on to producing the system may vary.

Throughout production, the components, subsystem or system may need to be tested or diagnosed. This requires the use of appropriate measuring devices. Adjustments, modifications or repairs are made to the system to ensure optimal performance. Once the system has been produced it is tested and evaluated. The findings of diagnostic testing are reported and should include conclusions about how successfully the system performed in relation to the problem or need that was initially identified. Recommendations for improvements to the system are provided.

Once students begin planning for construction it is essential that they continuously refer to the Systems Engineering Process. The Systems Engineering Process takes into account the variation in student skills and knowledge. It is expected that students may need to trial and test components and subsystems to develop effective plans and grasp key knowledge. This may involve commencing construction and upon re-evaluation returning to planning and initiating more appropriate selection of parts, components or materials.
Factors that influence design, planning, production and use of a system

To help students understand the factors that may influence the design, planning, production and use of a system, a suggested exercise is to turn each factor into a question and provide examples. For instance, function, user needs and requirements, materials and components, and environment of use could be developed into the following questions:

- What is the function of the system?
- What is its expected level of performance?
- Who will be using it?
- Which materials and components are able to provide and sustain performance?
- In what type of environment will the system be used?
- Will the system be able to operate in the environment in which it will be used?

Students will need to refer to the factors relating to the Systems Engineering Process and address appropriate questions when they write design briefs, research feasibility and alternatives and as they design and model systems in all units. By keeping the factors in mind through the Systems Engineering Process, students can continually focus and reflect on, and re-evaluate their objectives.

In all units, the factors that may influence the design, planning, production and use of a system are described in the table below. Students must include factors listed in the shaded section of the table as they work through the Systems Engineering Process; however, the other factors listed as ‘Additional factors’ may also be considered, depending on the type of system being designed. Note that the factors may be interrelated.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Understanding what the product will be used for, or will need to do.</td>
</tr>
<tr>
<td>User needs and requirements</td>
<td>The system will need to be suitable and appealing for the users/customers (the market).</td>
</tr>
<tr>
<td>Materials and components</td>
<td>Appropriate materials and components must be selected that will meet user requirements and performance expectations.</td>
</tr>
<tr>
<td>Environment use</td>
<td>Understanding where the product will be used and the conditions it will be subjected to; for example, a water craft will need to be a specific shape to move through the water, as well as being water-proof.</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety must be considered at all stages of design, production and use of the systems. The risk assessment and management process is used to identify and minimise risk or harm for the maker or user.</td>
</tr>
<tr>
<td>Cost</td>
<td>Systems should be made so they are cost-effective. Users/customers expect both quality and value. The cost of components, housings and ongoing running and maintenance costs must be considered.</td>
</tr>
<tr>
<td>Waste and energy</td>
<td>Waste produced during production and use should be minimised. Energy used in the production of the system and running costs also need to be kept to a minimum. It is preferable to use non-polluting waste and energy.</td>
</tr>
</tbody>
</table>
Additional factors

<table>
<thead>
<tr>
<th>Quality standards</th>
<th>Systems need to meet standards of quality that relate to the physical characteristics of the item being produced or its safety features.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styling and appearance</td>
<td>The system and its covering/housing should be visually pleasing to the user. The colour, shape or surface finish of the housing should be attractive. Components should be joined neatly and wires tied and trimmed.</td>
</tr>
<tr>
<td>Performance and durability</td>
<td>The system needs to work or perform a task or number of tasks, and should be long lasting and durable.</td>
</tr>
<tr>
<td>Size</td>
<td>The size of the system may be important and relates to how it will be used, for example portability.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Systems may need to be fixed, repaired or have their components changed from time to time. The layout and accessibility to serviceable parts must be considered.</td>
</tr>
<tr>
<td>Production methods</td>
<td>The design of the system may affect production, and the way the system is produced may affect its design. It is important to know what particular types of machinery and equipment is available to make the product and how this equipment is used.</td>
</tr>
<tr>
<td>Regulations</td>
<td>Many systems are required to meet guidelines, legal obligations or restrictions that may relate to the use of materials, or safety regulations such as age restrictions.</td>
</tr>
</tbody>
</table>

Table 1: Explanation of the factors that influence the design, planning, production and use of a system.

As part of the Systems Engineering Process, students must consider the factors in the shaded section of the table above; the additional factors may be considered if relevant to the system being designed and produced.

Risk management, key principles and timelines

Students need to include risk management throughout the Systems Engineering Process and in relation to the factors that influence design, planning, production and use of a system. In addition, they must consider safety of the end-user of the product.

Units 1 and 2, Area of Study 1, key knowledge lists fundamental principles. These fundamental principles are sequential in that they can be considered core knowledge for students continuing with Systems Engineering in Units 3 and 4. Further principles are added to the foundation principles in Units 3 and 4; therefore, a more indepth coverage of the fundamental principles will be required for students who do not have prior understanding of these principles.

Teachers should refer to the Table of Electronic symbols on the Systems Engineering page of the Victorian Curriculum and Assessment Authority website when covering the key knowledge and skills related to symbolic representation of electrotechnology systems in Units 2 and 3.

As with planning any course of study, the structure and timelines that a teacher uses are critical to the smooth running of the course. It is suggested that a timeline is prepared for all units and used both by the students and teachers. The timeline should indicate when learning activities and assessment tasks will be done (including aspects of outcomes that will be covered concurrently), and helps to manage the time available in the semester. As a planning tool, the timeline can be as detailed or as simple as needed and can include topic headings, reminders, public holidays, curriculum days and so on. A sample delivery schedule for Units 3 and 4 is included on pages 60–62.
# Systems projects

The following themes and projects are provided as possible prompts for systems projects.

## UNIT 1

<table>
<thead>
<tr>
<th>Suggested theme</th>
<th>Suggested projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Measuring equipment</td>
</tr>
<tr>
<td>Transport</td>
<td>Model boat, hovercraft</td>
</tr>
<tr>
<td></td>
<td>Model car</td>
</tr>
<tr>
<td></td>
<td>Model train</td>
</tr>
<tr>
<td></td>
<td>Model aircraft</td>
</tr>
<tr>
<td>Robotics</td>
<td>Kits and models</td>
</tr>
<tr>
<td>Social – Educational, games</td>
<td>Pinball machine</td>
</tr>
<tr>
<td></td>
<td>Model bowling alley</td>
</tr>
<tr>
<td>Social – Health, medical, wellbeing,</td>
<td>Mechanical systems products for people with special needs, for example elderly, disabled</td>
</tr>
<tr>
<td>safety</td>
<td>Safety device for a piece of equipment</td>
</tr>
</tbody>
</table>

## UNIT 2

<table>
<thead>
<tr>
<th>Suggested theme</th>
<th>Suggested projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic systems</td>
<td>Alarm systems</td>
</tr>
<tr>
<td></td>
<td>Electronic lighting systems</td>
</tr>
<tr>
<td></td>
<td>Micro controller projects</td>
</tr>
<tr>
<td>Measurement</td>
<td>Electronic counter systems</td>
</tr>
<tr>
<td></td>
<td>Fluid level sensor systems</td>
</tr>
<tr>
<td></td>
<td>Micro controller projects</td>
</tr>
<tr>
<td></td>
<td>Model weather monitor stations</td>
</tr>
<tr>
<td>Music/sound</td>
<td>Audio systems</td>
</tr>
<tr>
<td></td>
<td>Micro controller projects</td>
</tr>
<tr>
<td></td>
<td>Musical instruments</td>
</tr>
<tr>
<td>Transport</td>
<td>Electronic line tracker</td>
</tr>
<tr>
<td></td>
<td>Remote control vehicles</td>
</tr>
<tr>
<td>Social – Health, medical, wellbeing,</td>
<td>Electronic systems products for people with special needs, for example elderly, disabled</td>
</tr>
<tr>
<td>safety</td>
<td>Safety device</td>
</tr>
<tr>
<td></td>
<td>Model security system</td>
</tr>
</tbody>
</table>
### UNITS 3 AND 4

<table>
<thead>
<tr>
<th>Suggested theme</th>
<th>Suggested projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic/environment systems</td>
<td>Thermostatically controlled incubator</td>
</tr>
<tr>
<td></td>
<td>Radio frequency identification security access and control</td>
</tr>
<tr>
<td></td>
<td>Thermostatically controlled cooking system/BBQ machine</td>
</tr>
<tr>
<td></td>
<td>Low power wind generator</td>
</tr>
<tr>
<td></td>
<td>Sun tracking systems for solar panels</td>
</tr>
<tr>
<td></td>
<td>Solar powered devices (battery chargers, model vehicles, lighting systems)</td>
</tr>
<tr>
<td></td>
<td>Light sensor operated roller/venetian blind</td>
</tr>
<tr>
<td>Measurement</td>
<td>Weather station/monitoring system</td>
</tr>
<tr>
<td>Social – Health, medical, wellbeing,</td>
<td>System to solve a safety problem</td>
</tr>
<tr>
<td>safety</td>
<td>Integrated systems products for people with special needs,</td>
</tr>
<tr>
<td></td>
<td>for example elderly, disabled</td>
</tr>
<tr>
<td></td>
<td>Remote bomb or dangerous object disposal</td>
</tr>
<tr>
<td></td>
<td>Security systems</td>
</tr>
<tr>
<td></td>
<td>Integrated safety systems for equipment</td>
</tr>
<tr>
<td>Social – Educational, games</td>
<td>Electro/mechanical games, for example air hockey table, pinball game, bowling game,</td>
</tr>
<tr>
<td></td>
<td>skill tester</td>
</tr>
<tr>
<td></td>
<td>Cricket/tennis ball bowling machine</td>
</tr>
<tr>
<td>Music/sound</td>
<td>Audio/amplification systems</td>
</tr>
<tr>
<td></td>
<td>Musical instruments (electric guitar/guitar pedal)</td>
</tr>
<tr>
<td>Transport</td>
<td>Remote control models (cars, planes, tanks)</td>
</tr>
<tr>
<td></td>
<td>Low powered ride-on vehicles</td>
</tr>
<tr>
<td></td>
<td>Conveyor systems (luggage, food or drink vending machines, lift/elevator)</td>
</tr>
<tr>
<td>Robotics</td>
<td>Micro controller projects</td>
</tr>
<tr>
<td></td>
<td>Robots (for industrial applications)</td>
</tr>
<tr>
<td></td>
<td>Robots (for domestic applications, for example vacuum cleaner)</td>
</tr>
<tr>
<td></td>
<td>Animatronics</td>
</tr>
</tbody>
</table>
GLOSSARY

For the purposes of this study design the following definitions will apply.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternating Current (AC)</td>
<td>Alternating Current (AC) is a form of electricity where electrons rapidly change direction. AC current varies over time, creating a sine-wave waveform.</td>
</tr>
<tr>
<td>AC and DC waveforms</td>
<td><img src="image" alt="Waveform Diagram" /></td>
</tr>
<tr>
<td>Acceleration (A)</td>
<td>The rate of change in velocity.</td>
</tr>
<tr>
<td>Amperes (A)</td>
<td>The unit of current measurement (often referred to as amps). The amount of electric charge flowing through a circuit.</td>
</tr>
<tr>
<td>Belt and pulley</td>
<td>A continuous loop (usually of rubber) used to connect two pulleys over a distance in order to transfer rotary motion.</td>
</tr>
<tr>
<td>Cam and follower</td>
<td>An elliptical piece (cam) that rotates on a shaft that lifts and drops a rod (follower).</td>
</tr>
<tr>
<td>Capacitor</td>
<td>A device that stores an electric charge.</td>
</tr>
<tr>
<td>Closed loop (control) system</td>
<td>A system that uses self-monitoring or feedback and self-adjustment to alter or maintain a predetermined level of output. The use of a thermostat can provide a basic closed loop system, with a set temperature output.</td>
</tr>
<tr>
<td>Compression control system</td>
<td>A force that tends to shorten or squeeze something, decreasing its volume. A system which manages or manipulates an output through direct, predetermined or programmed instruction.</td>
</tr>
<tr>
<td>Crank</td>
<td>A handle with a lever used to provide mechanical advantage.</td>
</tr>
<tr>
<td>Diode</td>
<td>A device that allows current to flow in one direction only.</td>
</tr>
<tr>
<td>Direct Current (DC)</td>
<td>Direct Current (DC) is a form of electricity where all electrons move in the same direction. DC current does not vary with time, creating a flat waveform.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>A measure of how well energy is used, determined by Energy out/Energy in.</td>
</tr>
<tr>
<td>Effort</td>
<td>An applied force.</td>
</tr>
<tr>
<td>Electrical charge (Q–Coulomb)</td>
<td>Amount of stored electrons (Charge = Capacitance × Voltage) (Q = C × V).</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Element</td>
<td>A distinct part of a process or actual part of a system that can be identified, that is generally not considered a component.</td>
</tr>
<tr>
<td>Feedback</td>
<td>A monitoring or sampling of the output which is directed back to the input controls. A system with feedback is a closed loop system.</td>
</tr>
<tr>
<td>Force (F)</td>
<td>A push or a pull (Force = Mass × Acceleration) (F = M × A).</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>Decayed matter over millennia from which chemical fuels are derived, including coal, oil and natural gas.</td>
</tr>
<tr>
<td>Frequency (f)</td>
<td>The number of cycles, oscillations, or vibrations of a wave motion or oscillation in unit time.</td>
</tr>
<tr>
<td>Friction</td>
<td>A force resisting motion related to the rubbing between surfaces.</td>
</tr>
<tr>
<td>Fuel cell</td>
<td>Cell that produces electricity by oxidation of fuel (hydrogen and oxygen or zinc and air). Can be used in electric cars.</td>
</tr>
<tr>
<td>Gear</td>
<td>A toothed component that meshes with another to transfer motion in mechanical systems.</td>
</tr>
<tr>
<td>Simple gear train</td>
<td>Two or more gears that mesh, used to increase or decrease speed, and to change direction.</td>
</tr>
<tr>
<td>Compound gear</td>
<td>A compound gear is made up of two or more gears that are joined together and share the same shaft.</td>
</tr>
<tr>
<td>Compound gear train</td>
<td>A compound gear train is a combination of gears and axles or shafts that have at least one axle or shaft with a compound gear.</td>
</tr>
<tr>
<td>Gear ratio</td>
<td>The relationship of the number of turns between two gears expressed as a ratio, that is, the number of turns of the driver to one turn of the driven (x:1). For example, (for a reduction gear box) a driver gear has 40 teeth and the driven gear has 80 teeth; using the formula driven ÷ driver the ratio is expressed as 2:1 or for two turns of the driver gear the driven gear turns once.</td>
</tr>
<tr>
<td>Inclined plane</td>
<td>A wedge, ramp or slope.</td>
</tr>
<tr>
<td>Infrared transmitter and receiver</td>
<td>Data transmission and reception via non visible light, e.g. as used in a television remote control.</td>
</tr>
<tr>
<td>Input</td>
<td>The starting point, where the raw elements are applied, such as energy, material, data or physical action.</td>
</tr>
<tr>
<td>Integrated circuit (IC)</td>
<td>A single electronic component that contains within it circuitry to perform a set of functions.</td>
</tr>
<tr>
<td>Integrated system</td>
<td>A system that contains mechanical, pneumatic or hydraulic functions together with electrical or electronic (electrotechnology) function/s.</td>
</tr>
<tr>
<td>Lever</td>
<td>A simple machine that provides mechanical advantage.</td>
</tr>
<tr>
<td>Light dependent resistor (LDR)</td>
<td>A device that increases in resistance with decreasing light.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Light emitting diode (LED)</td>
<td>A specific diode designed to give off light when current flows through it.</td>
</tr>
<tr>
<td>Linear motion</td>
<td>Straight line movement in one direction.</td>
</tr>
<tr>
<td>Load (N – Newton) (mechanical)</td>
<td>A force or burden (Load = Mass × Acceleration) (N = M × A).</td>
</tr>
<tr>
<td>Load (Ω – Ohms) r (R) (electrical)</td>
<td>A resistive device at the output where the electrical power is dissipated.</td>
</tr>
<tr>
<td>Logic gates</td>
<td>A configuration of transistors that performs a defined switching sequence or logic function.</td>
</tr>
<tr>
<td>Mass (M)</td>
<td>The amount of matter in an object.</td>
</tr>
<tr>
<td>Mechanical advantage (MA)</td>
<td>The ratio of the force performing the work done by a mechanism to the input force, e.g. as provided by a lever.</td>
</tr>
<tr>
<td>Micro-controller</td>
<td>A micro-controller is an electronic device that contains a combination of processor, memory and input/output facilities.</td>
</tr>
<tr>
<td>Moments about a point</td>
<td>A turning or twisting force at a distance from a turning point.</td>
</tr>
<tr>
<td>Motion</td>
<td>The act of changing position. The types of motion or movement of mechanisms are linear, rotary, reciprocating and oscillating.</td>
</tr>
<tr>
<td>Ohm’s Law</td>
<td>The rules of the relationship between voltage, current and resistance in DC circuits (Voltage = Current × Resistance) (V = I × R).</td>
</tr>
<tr>
<td>Ohms (Ω) or (R)</td>
<td>The unit of electrical resistance measurement.</td>
</tr>
<tr>
<td>Open loop system</td>
<td>A system that has no monitoring or self adjustment, which results in an output unaffected by the inputs; its function can be altered only by human intervention.</td>
</tr>
<tr>
<td>Oscillating motion</td>
<td>Circular motion in two directions – backwards and forwards.</td>
</tr>
<tr>
<td>Output</td>
<td>The derived outcome produced by the process that occurs within a system.</td>
</tr>
<tr>
<td>Piston</td>
<td>A mechanism that provides the compression of gases within a cylinder.</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>The use of air pressure to transfer force or motion.</td>
</tr>
<tr>
<td>Polarity</td>
<td>The condition of a body or system in which it has opposing physical properties at different points, especially magnetic poles or electric charge.</td>
</tr>
<tr>
<td>Power (P – Watts)</td>
<td>The rate at which work is done or energy used.</td>
</tr>
<tr>
<td></td>
<td>Electrical term: (Power = Voltage × Current), (P = V × I)</td>
</tr>
<tr>
<td></td>
<td>1 horsepower (hp) = 746 Watts of power.</td>
</tr>
<tr>
<td>Printed circuit boards (PCBs)</td>
<td>A circuit board usually made of fibreglass on which copper tracks are “printed” to make an orderly connection of components.</td>
</tr>
<tr>
<td>Process</td>
<td>How the inputs of a system work together in a system to achieve a desired output.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Programmable Interface Controller, also known as Programmable Integrated Circuit (PIC)</td>
<td>An electronic component which can be externally programmed to perform a series of functions.</td>
</tr>
<tr>
<td>Prototype</td>
<td>An electronic component which can be externally programmed to perform a series of functions.</td>
</tr>
<tr>
<td>Pulley</td>
<td>A mechanical component that together with a belt transfers rotary motion.</td>
</tr>
<tr>
<td>Reciprocating motion</td>
<td>Motion alternately backward and forward, or up and down, as of a piston rod.</td>
</tr>
<tr>
<td>Rectifier</td>
<td>A device that converts alternating current (AC) to direct current (DC) (unregulated).</td>
</tr>
<tr>
<td>Relay</td>
<td>An electromagnetic switch.</td>
</tr>
<tr>
<td>Renewable energy sources</td>
<td>Sources of energy that will never run out or that can be replenished within a span of time, through natural ecological cycles or sound management practices, e.g. wind, solar, wave, bio-fuels, firewood. Non-renewable energy sources are fossil fuels (coal, oil and gas).</td>
</tr>
<tr>
<td>Resistance (Ω or R – Ohms)</td>
<td>The degree to which electron flow is impeded.</td>
</tr>
<tr>
<td>Resistor</td>
<td>A device that provides a specified amount of opposition to the flow of current. Resistance is measured in Ohms.</td>
</tr>
<tr>
<td>Rotary motion</td>
<td>Circular movement in one direction.</td>
</tr>
<tr>
<td>Schematic</td>
<td>A structural or procedural diagram, especially of an electrical or a mechanical system.</td>
</tr>
<tr>
<td>Screw</td>
<td>A mechanical device consisting of a cylinder or cone that has one or more helical (advancing spiral) ridges winding around it. Not only used as a fixing device, the screw principle is applied in machinery such as a worm gear or a grain lifter.</td>
</tr>
<tr>
<td>Shaft</td>
<td>A rod, bar or tube that connects two rotating components.</td>
</tr>
<tr>
<td>Speed</td>
<td>The rate of change of position over time.</td>
</tr>
<tr>
<td>Spring</td>
<td>A device, such as a coil or strip of steel, that stores potential energy when it is compressed, stretched, or bent and releases it when the restraining force is removed.</td>
</tr>
<tr>
<td>Sprocket</td>
<td>A toothed mechanical component that when combined with a chain, transfers rotary motion over a distance.</td>
</tr>
<tr>
<td>Switch</td>
<td>A device which closes (turns on) or opens (turns off) a circuit, to interrupt current flow.</td>
</tr>
<tr>
<td>Tension</td>
<td>A force tending to stretch or elongate something.</td>
</tr>
<tr>
<td>Thermistor</td>
<td>A device that changes resistance with a change in temperature, available as both a positive or negative coefficient type.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Thermostat</td>
<td>A device that closes (turns on) or opens (turns off) a circuit according to</td>
</tr>
<tr>
<td>Torque</td>
<td>temperature.</td>
</tr>
<tr>
<td>Trade-off</td>
<td>A technological system or process which has benefit, but also has the</td>
</tr>
<tr>
<td></td>
<td>potential for detriment to society or the environment.</td>
</tr>
<tr>
<td>Transducers</td>
<td>A device that transforms one form of energy to another form.</td>
</tr>
<tr>
<td>Transformer</td>
<td>A device which can step up (increase) or step down (decrease) AC voltage.</td>
</tr>
<tr>
<td>Transistor</td>
<td>A semiconductor device which can control current flow, used as an amplifier</td>
</tr>
<tr>
<td></td>
<td>or switch.</td>
</tr>
<tr>
<td>Velocity</td>
<td>The rate of change of displacement over time.</td>
</tr>
<tr>
<td>Voltage (V)</td>
<td>The electromagnetic force (EMF) at which electrons are moved.</td>
</tr>
<tr>
<td>Voltage regulator</td>
<td>A device which provides a stable DC voltage power source within the</td>
</tr>
<tr>
<td></td>
<td>specified current range of the device.</td>
</tr>
<tr>
<td>Volts (V)</td>
<td>The unit of voltage measurement.</td>
</tr>
</tbody>
</table>

**EQUIPMENT REQUIREMENTS**

Students are expected to experience a range of processes, from simple to more complex. They will be required to use hand tools, equipment and portable and fixed machines safely, and to execute these processes in ways that are relevant to their choice of materials and systems components and their assembly. In designing courses and developing learning activities for Systems Engineering, teachers should make use of applications of information and communications technology and learning technologies, where appropriate and applicable to teaching and learning activities.

Tools, equipment and machines may include but are not restricted to:

- CAD/CAM equipment for designing, shaping, cutting, routing
- gauges, multimeters, stop watches, tape measures and other marking and measuring tools and testing equipment
- saws, drills, metal guillotine and other cutting tools for removal of material
- hammers, mallets, forming equipment, lathe and other hammering, hitting and forming tools
- equipment for making circuit boards
- soldering iron, welder, glue gun, riveter and other construction, assembly and fabrication tools, equipment and machines
- spray gun, sander and other finishing equipment.

Note: Teachers must check relevant workplace safety regulations and requirements prior to students using specific equipment or plant, the use of which may be restricted to qualified teachers. See pages 8 and 9 for information under Safety and Wellbeing.
SUITE RESOURCES

Courses must be developed within the framework of the study design: the areas of study, outcome statements, and key knowledge and key skills.

A list of suitable resources for this study has been compiled and is available on the Systems Engineering study page of the Victorian Curriculum and Assessment Authority website: www.vcaa.vic.edu.au/vce/studies/index.html

LEARNING ACTIVITIES

Implementation advice and example learning activities for each unit are provided below. Examples in the shaded boxes are explained in detail in accompanying boxes.

Teachers should consider these activities in conjunction with the key knowledge and key skills identified for each outcome within the study.

**Unit 1: Introduction to mechanical systems**

This unit introduces students to mechanical systems and the engineering concepts and principles associated with their construction and use. Students are also introduced to the Systems Engineering Process in a mechanical context. This begins with the selection of a project and continues with students investigating basic engineering concepts, principles and components listed in the Area of Study 1 key knowledge that is linked to that project. For example, in Unit 1 a student may have chosen to plan the construction of a model crane using a small electric motor connected to a gearbox. They would then need to identify and observe the mechanical principles associated with the device, drawing on those listed in the key knowledge. Usually, not all mechanical concepts and principles listed in the key knowledge will apply to one type of project. Teachers must choose learning activities with this in mind ensuring that students are given opportunity to acquire the key knowledge listed.

Teachers should refer students to the Systems Engineering Process by having them document each stage and re-evaluate their work as it develops. For example, a student in the ‘design and model the system’ stage will usually need to return to the ‘research feasibility and alternatives’ stage upon discovering through testing that the original choice of a process or component could be improved. When documenting the development of a project, reference to the factors that may influence the design, planning, production and use of a system in the Systems Engineering Process is important.

Re-evaluation, modification and documentation are equally as important in Outcome 2 as in Outcome 1. Students begin Area of Study 2 once they have covered all concepts and principles listed in Area of Study 1 and have moved into production of their project. However, the Systems Engineering Process allows students to revisit and modify the planning stage during Area of Study 2 if necessary.

Unit 1, Area of Study 2 involves producing, testing and evaluating the system and the processes used in its production. Once again, constant reference should be made to the Systems Engineering Process at various stages of production. Examples of possible projects for Unit 1 production work are provided on page 41 of the ‘Advice for teachers’.
AREA OF STUDY 1: Fundamentals of mechanical system design

Outcome 1

Describe and use basic engineering concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design and plan a mechanical or an electro-mechanical system.

Examples of learning activities

- present a report that identifies and demonstrates the applications of a range of mechanisms evident in a bicycle
- use appropriate software to model and simulate created mechanical systems diagrams, e.g. Yenka Crocodile Clips – mechanisms
- perform calculations (e.g. mechanical advantage, velocity ratio, moments about a point) on the different mechanisms found within a selected mechanical system
- produce a range of models to demonstrate how motion and force is changed or converted by using mechanisms
- select a system used to lift heavy loads, e.g. jack or winch, and demonstrate an understanding of the system using a visual presentation
- consult catalogues and websites to choose appropriate materials and parts for a mechanical system
- using CAD software, draft designs for parts for a mechanical system
- following development of a design brief and evaluation criteria, conduct research and produce a workplan detailing the construction of a mechanical/electro-mechanical system
- conduct an investigation into a mechanical system listing all its mechanical components and explaining their operational concepts
- referring to factors that influence the design, planning, production and use of a system in the System Engineering Process, analyse an existing system in terms of its suitability for its intended purpose
- produce a materials list for a project, including costs and detailed quantities
- map stages of a production plan in a sequence of operations using a Gantt chart
- assemble a prototype of a proposed lever or linkage system and using the Systems Engineering Process evaluate its effectiveness and recommend modifications based on findings
- test and measure the performance of a range of similar mechanical systems

Detailed example

DEVELOPING A WORKPLAN

After developing a design brief and evaluation criteria based on choice of production, begin to conduct research to make appropriate choices for components and materials to be used. This will involve experimentation with components, elements, parts and some materials.

Develop sketches and working drawings. Develop a materials/components list and a sequence of production processes. Select and document appropriate test procedures ensuring required test equipment is readily available. Apply the Systems Engineering Process throughout.
AREA OF STUDY 2: Producing and evaluating mechanical systems

Outcome 2

Make, test and evaluate a mechanical or an electro-mechanical system or subsystem using selected relevant aspects of the Systems Engineering Process.

Examples of learning activities

- produce, test and evaluate a method of picking up litter safely and hygienically
- produce, test and evaluate an alternative braking system for a bicycle or scooter
- using appropriate kits and/or components and materials, assemble a system that will demonstrate gearing systems
- having carried out testing procedures, prepare a report that explains the reasons for a performance problem, failure or breakage in a mechanical system
- use the CADCAM process to manufacture precision parts for a mechanical system
- demonstrate how to use a piece of workshop equipment, outlining all relevant health and safety risks and detailing precautions and all applicable personal protection measures
- write an evaluation report referring to previously developed evaluation criteria; include references to the Systems Engineering Process and how it was used to re-evaluate and modify the system and/or the production processes

Detailed example

WRITING A TESTING REPORT

Having successfully chosen and assembled materials and components, students select appropriate test procedures. A well set out and comprehensive report includes the following points:

- the method of testing
- the purpose of the test
- equipment needed to perform the test
- safety measures to be taken while conducting the test
- expected results.

With these points in mind students need to conduct the test and record actual results, considering and documenting the following:

- Quantitative (numerical) data showing results using correct units and formulas.
- Qualitative (written) responses explaining the data and giving reasons for consistency with or inconsistency between expected results and actual results.
Unit 2: Introduction to electrotechnology systems

This unit can be approached in much the same way as Unit 1: Introduction to mechanical systems, with the focus on the key knowledge and skills listed for Unit 2 being electrical and electronic.

To ensure that key knowledge and skills are covered, teachers may select from a range of activities and tasks, depending on the level of knowledge and skills covered in the planning process. As with Unit 1, Area of Study 1, it is critical that students’ progress is guided by the Systems Engineering Process in this unit.

Electronic theory tends to present students with more challenges than mechanical theory. Teachers need to exercise careful judgment when helping students to select projects because of the short time available to cover the key knowledge and skills in Area of Study 1.

The complexity of circuits designed by students need not be high; however, students need to have input into the circuit design process so that they are able to fully apply the Systems Engineering Process and the factors that influence the design, planning, production and use of the system.

Unit 2, Area of Study 2, involves the production process including testing and evaluating the product and the processes used in its production. Once again, reference should be made to the Systems Engineering Process and the factors that influence the design, planning, production and use of the system at various stages of production.

Possible projects for Unit 2 include simple electronic kits with a control function, programmable kits that incorporate the use of microcontrollers such as Picaxe, electromechanical models such as remote controlled vehicles and robotic models. A more comprehensive list of suitable projects for Unit 2 is provided on page 41 of the ‘Advice for teachers’.

It should be remembered that a degree of integration at both Units 1 and 2 is acceptable and indeed encouraged. However, the emphasis should remain on mechanical knowledge and skills in Unit 1 and electrotechnology knowledge and skills in Unit 2.
Area of study 1: Fundamentals of electrotechnology system design

Outcome 1

Investigate, represent, describe and use basic electrotechnology and basic control engineering concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design and plan an electrotechnology system.

Examples of learning activities

- Use an Ohm meter to measure a range of fixed resistors; produce a chart that displays the value, tolerance and colour code of each.
- Use appropriate software to show relationships between a system’s subsystem elements and components; do this for both open and closed loop systems.
- Using a simulation program, design basic series and parallel circuits; model them and take measurements of the circuits under different situations; compare the results with the simulation.
- Compare a range of electrical systems used for similar applications; evaluate the effectiveness of each.
- Based on findings of research and selected learning activities, produce a workplan detailing the construction of an electrotechnology system.
- Produce a wiring diagram showing how to link circuits, power supplies and transducers.
- Design a system that utilises a microcontroller such as Picaxe, to control the outputs of an electrically powered device.
- Develop a production plan for making a selected system; list and justify the parts, components, materials, processes, tools and equipment to be used in production.
- Use a solderless circuit board (breadboard) to model an electronic circuit and using the Systems Engineering Process evaluate, and where necessary, modify circuitry to better suit a specific need or purpose.
- Use CAD software to design and produce PCB artwork for an electronic circuit.

Detailed example

Designing simple circuits

Using a simulation program such as Yenka Crocodile Technology, students build simple circuits that demonstrate correct placement and operation of the principles and components listed below:
- Resistors in series
- Resistors in parallel
- Diodes
- LEDs.

When the circuits are completed, students use breadboards to create a real circuit and test and compare its operation to the simulation.

When the circuits are completed, students use a multimeter to measure and record voltage and current under different operating conditions.
AREA OF STUDY 2: Producing and evaluating electrotechnology systems

Outcome 2

Make, test and evaluate an electrotechnology system using selected relevant aspects of the Systems Engineering Process.

Examples of learning activities

- using a range of resources including the Internet, research relevant technical information and data on a selected system, its subsystems and operational components
- use appropriate software to incorporate design ideas or modifications to the selected system
- produce, test and evaluate a functional integrated system for counting objects
- identify a range of fault finding and diagnostic procedures, and assess their effectiveness
- test the completed system and evaluate its effectiveness in achieving the intended outcome
- write a report that evaluates the effective use of the Systems Engineering Process and the factors that may influence the design, planning, production and use of a system; students should respond to previously developed evaluation criteria

Detailed example

COUNTING ELECTRONICALLY

Counting objects is well suited to a systems solution using the Systems Engineering Process. Examples of this include counting stock in a warehouse, scoring points with games such as air hockey or a pinball machine or counting ping pong balls rolling down a tube.

Alternatively, a smaller counting system could form a subsystem for a larger project, depending on the level of input the student has in the design of the electronic circuitry.
Unit 3: Integrated systems engineering and energy

Unit 3, Area of Study 1 focuses on the planning and commencement of construction of the School-assessed Task. This task is completed in Unit 4. Students may take a similar approach to that taken in Units 1 and 2, Areas of Study 1. However in Unit 3 the emphasis must be placed on the integration of both mechanical and electrical/electronic systems. Ideally the integrated and controlled system should incorporate a closed loop control. The key knowledge and skills for this unit build on Units 1 and 2.

Unit 3, Area of Study 2 focuses on the relationship between energy, the environment and systems. This may be approached primarily through research and investigative work. A link could be made to the School-assessed Task, depending on whether the product uses an alternative energy source to batteries or transformers, for example solar or wind powered. Whichever approach is taken, it will need to involve significant research encompassing current and evolving sources of energy, as this area is undergoing rapid change. For example, transport, both public and private, and related energy use and environmental effects is going through a period of change. Consequently, a vast amount of resources for both teachers and students is available. Other areas to focus on could include electricity generation, bio-fuels, solar and hydrogen fuel cells.

When commencing Units 3 and 4 it is important to recognise that time management is integral to the students’ success. Although they are two distinct units it is helpful to prepare a timeline for the whole school year. The timeline should show the key dates for assessment tasks, outcomes, exams (Systems Engineering and others), public holidays, curriculum days, term breaks and any other relevant school information. It can be a valuable planning tool for teachers and students alike. A sample delivery schedule for Units 3 and 4 is on pages 61 to 63.

As part of Outcome 1 students are required to design and produce one significant integrated controlled system over Units 3 and 4. When students begin planning for the School-assessed Task it is important for teachers to adequately advise and monitor students on their selection. One approach could be for teachers to offer head start classes at the end of Unit 2 to allow students to begin making informed decisions when choosing projects. The inclusion of control will present the greatest challenge. Some suggestions for systems are thermostatically controlled systems or systems that incorporate the use of micro controllers such as Picaxe. Given the fixed timeframe for this task, the degree of difficulty of the selected system must be within the student’s ability. This is particularly important if the student is undertaking Units 3 and 4 without having undertaken Units 1 and 2. In this situation, tasks that involve the integration of kit-based subsystems can provide opportunities for the student to complete an operational integrated controlled system that meets the requirements of the outcome. The design phase involves correct identification and selection of subsystems needed to work together to form a solution to the student’s design brief. The selection of a suitable system needs careful consideration to ensure the student has ample opportunity to meet all the requirements of the task including suitable diagnostic practices. Wherever possible, teachers are encouraged to integrate practical work with theoretical knowledge to provide opportunities for students to enhance their understanding of key knowledge through practical application of skills.
AREA OF STUDY 1: Controlled and integrated systems engineering design

**Outcome 1**
Investigate, analyse and use advanced mechanical-electrotechnology integrated and control systems concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design, plan and commence construction of an integrated and controlled system.

**Examples of learning activities**
- use a range of resources to give a group demonstration on the operating principles of an integrated system
- describe a selected integrated system including its inputs, processes, outputs and means of control
- simulate performance of electric motors powered by solar cells under a range of conditions
- describe a controlled closed loop integrated system using notes and diagrams that incorporate the use of microcontrollers such as Picaxe; explain the concepts of monitoring and feedback while researching the concept of utilising them in a controlled integrated system
- use the Internet to research commercial systems similar to the one selected in class
- collect images (digital or other) of similar systems or subsystems to enhance the selected design
- use appropriate software to produce diagrams for selected systems; these should include accurate symbolic representation of components and parts to be used in the production plan
- apply the Systems Engineering Process by prototyping and modelling a gear and/or lever system for use in a controlled integrated system
- apply the Systems Engineering Process by using experimenter boards and simulation software to develop electronic circuit designs for use in a controlled integrated system
- use computer-aided design (CAD) applications to prepare designs
- develop a production plan for making a selected controlled integrated system; list and justify the parts, components, elements, materials, processes, tools and equipment to be used in its production
- conduct research to determine appropriate selection of mechanical and electrical/electronic components and subsystems for use in the manufacture of a controlled integrated system
- prepare a workplan that documents and describes an appropriate sequence of operations and processes
- conduct a risk assessment into the process of manufacturing a controlled integrated system including a tools/machines list showing hazards and precautions
- demonstrate skills with tools, machines and processes
- select and design appropriate diagnostic and testing procedures
As part of the design and production task, students test and diagnose components, subsystems, operation and/or performance. Selecting and performing suitable diagnostic procedures is very important to the process.

**What makes a suitable diagnostic procedure?**

List the areas of the system being designed and produced that are measurable.

Select three measurable aspects of the system and for each of the three areas, answer the following questions:

1. What is the principle and unit that can be measured?
2. What tools and/or instruments will be used to take the measurements?
3. Describe the process of taking the measurement.
4. What technical references will be used to find correct values?

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**Detailed example**

**SELECTING AND PLANNING DIAGNOSTICS**

**Outcome 2**

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.

**Examples of learning activities**

- Conduct research into a selected renewable energy source and produce a written report giving details of benefits of its use for the environment and society.
- Conduct a survey among family/friendship groups to determine systems usage and suggest ways to reduce energy consumption based on the data collected.
- Using the Internet, research and compare a range of energy alternatives for use in transport systems.
- Develop an input, process, output (IPO) systems diagram to represent one of the technologies used to reduce carbon emissions.
- Produce a poster or presentation on a type of system used to harness renewable energy; include photographs and labelled diagrams describing the mechanical and electrical components within the system (e.g., aerofoil blades and rotor, generator, turbine, transformers and photovoltaic cells).
- Conduct a feasibility study to determine energy consumption of the system being built for the School-assessed Task.
- Using the Internet, research and select one renewable source of energy and prepare a detailed report on its development, current use and future prospects.
- Select a media article or program on a range of energy sources and effects of their use, and prepare a report that highlights the major points; research and then refute or agree with its claims.
- Conduct research into technologies utilised in the process of improving the environmental credentials of non-renewable energy sources.
While the process of developing renewable sources of energy gains momentum, addressing the issue of carbon emissions from non-renewable energy sources such as oil, natural gas and coal remains an important scientific and technological pursuit.

With this in mind, students conduct research into technological systems such as the CSIRO’s Integrated Rankine Cycle project. Other developing systems include solar air turbines that generate electricity from air and sunshine alone (almost all current systems require water as well as fossil fuel) using the ‘Brayton Cycle’. Based on their research, students give an oral report to the class using multimedia. Students should describe types of non-renewable energy sources and the methods used to reduce their harmful outputs. Students also describe ways that these technologies utilise wasted energy through inefficiencies thus reducing required fuel inputs.

**Detailed example**

**REDUCING CARBON EMISSIONS AND IMPROVING THE EFFICIENCY OF FOSSIL FUEL TECHNOLOGY**

While the process of developing renewable sources of energy gains momentum, addressing the issue of carbon emissions from non-renewable energy sources such as oil, natural gas and coal remains an important scientific and technological pursuit.

With this in mind, students conduct research into technological systems such as the CSIRO’s Integrated Rankine Cycle project. Other developing systems include solar air turbines that generate electricity from air and sunshine alone (almost all current systems require water as well as fossil fuel) using the ‘Brayton Cycle’. Based on their research, students give an oral report to the class using multimedia. Students should describe types of non-renewable energy sources and the methods used to reduce their harmful outputs. Students also describe ways that these technologies utilise wasted energy through inefficiencies thus reducing required fuel inputs.
**Unit 4: Systems control and new and emerging technologies**

Unit 4, Area of Study 1, is the continuation of the production commenced in Unit 3, Area of Study 1, and the diagnostic testing and evaluation of that project. This includes the documentation associated with these activities. It is advisable for students to have their project ready for testing by no later than mid-term 3 to allow time for modifications to be made and the subsequent documentation of test procedures to be properly covered.

Unit 4, Area of Study 2, focuses on new and emerging technologies. There are a range of resources listed in the Resources list on the Systems Engineering study page of the Victorian Curriculum and Assessment Authority website to assist research in this area. Topics that could be investigated by students include battery powered transport technology and super capacitors.

**AREA OF STUDY 1: Producing, testing and evaluating integrated technological systems**

**Outcome 1**

Produce, test and diagnose an advanced mechanical-electrotechnology integrated and controlled system using selected relevant aspects of the Systems Engineering Process, and manage, document and evaluate the system and processes.

**Examples of learning activities**

- safely manage and use selected tools, equipment and processes to construct systems or subsystems
- using the correct procedures, perform diagnostic tests
- assemble subsystems correctly to achieve desired outputs
- utilise relevant technical information using the Internet to assist assembly, testing, repair and diagnosis
- make adjustments to the system’s input, process and control devices, and observe how the output is affected
- apply the Systems Engineering Process including consideration of the factors that influence the design, planning, production and use of the system by maintaining a detailed record of the production and diagnostic activities undertaken (e.g. web log); include images
  - produce an interactive instruction manual demonstrating a testing procedure
  - produce a multimedia report that addresses evaluation criteria, the design and production process and the completed system’s performance

**Detailed example**

**TESTING INSTRUCTIONS**

As part of design and production activities, students complete a range of tests on their system. Each student presents a diagnostic procedure that will form part of an interactive instruction manual.

Use appropriate applications (for example, PowerPoint, FrontPage, Dreamweaver, Photo Story) to develop a ‘How to’ manual for a simple diagnostic task.

The procedure manual includes:

- text
- pictures
- graphics
- sound
- short video clips
- links to other areas.
AREA OF STUDY 2: New and emerging technologies

Outcome 2
Describe and evaluate a range of new or emerging technologies, and analyse the likely impacts of a selected innovation.

Examples of learning activities
visit the website of a commercial manufacturer and prepare a PowerPoint presentation that highlights key points in the development of one of their recently developed systems products
select a new or emerging material used in a system and research the background to its discovery and motivation behind its development; present findings in a multimedia presentation
select a recently developed consumer system and prepare a demonstration that describes its development and its future
using the Internet, research recent changes in battery technology and discuss and compare the types of devices using the technology
research the laser cutting process, which has become a popular method for accurately cutting a range of materials, and its other applications; present findings in a written report
select a new or emerging technology that is being developed to effect change and innovation in the automotive industry
select a subsystem that is being developed to enhance a larger system of which it is a part, and describe how it is integrated into the system to enhance use or performance

Detailed example
SYSTEMS OF THE FUTURE FOR TODAY
In today’s world there is increasing pressure to make systems much more energy efficient, which has led to new directions in systems development and innovation. Students develop a report with visual annotated displays that identifies a new or emerging technology that is being developed within the automotive industry
Examples of suitable technologies to focus on include:
Better Place
http://betterplace.com
Corning: A day made of glass on Youtube
www.youtube.com/watch?v=6Cf7IL_eZ38&noredirect=1

Reports should include:
• details of the mechanical components of the system
• details of the electrical/electronic components of the system
• details of any control devices utilised in the system
• annotated diagrams of components explaining how the system compares with existing automotive technology, showing advantages and disadvantages of each.
### UNITS 3 AND 4 DELIVERY SCHEDULE

Note: Where reference is given to key knowledge in single periods, teachers need to ensure that they provide learning activities for students that cover all concepts and principles contained in the key knowledge for each outcome.

<table>
<thead>
<tr>
<th>Week no.</th>
<th>Work to be done/outcomes due</th>
<th>Single period</th>
<th>Double periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unit 3 Area of Study 2 begins&lt;br&gt;Teacher led discussion on energy systems</td>
<td>Unit 3 Outcome 1&lt;br&gt;Introduction to the Systems Engineering Process&lt;br&gt;Introduction to the factors influencing design, planning, production and use of a system&lt;br&gt;(School-assessed Task)&lt;br&gt;Identify and document problem/need/opportunity situation for an integrated controlled system&lt;br&gt;Acceptance of topic</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Research for Area of Study 2</td>
<td>Identify and document: initial ideas, writing design brief for School-assessed Task</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Check progress on research for Area of Study 2&lt;br&gt;Key knowledge: mechanical components, concepts and principles. Teacher led discussion on the Systems Engineering Process</td>
<td>Research feasibility/alternatives for system for School-assessed Task&lt;br&gt;Re-evaluate</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Key knowledge: mechanical components, concepts and principles</td>
<td>Design/exploration, folio ideas</td>
<td></td>
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<tr>
<td>5</td>
<td>DVD and discussion on solar and wind energy systems&lt;br&gt;Key knowledge: mechanical components, concepts and principles</td>
<td>Research feasibility and alternatives of components and processes&lt;br&gt;Design and model the system&lt;br&gt;Re-evaluate, make modifications and document changes</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Research for Unit 3 Outcome 2&lt;br&gt;Key knowledge: mechanical components, concepts and principles.</td>
<td>Design and model the system&lt;br&gt;Re-evaluate, make modifications and document changes</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Outcome 2 assessment task (School-assessed Coursework)&lt;br&gt;Key knowledge: mechanical components, concepts and principles OH&amp;S in systems</td>
<td>Design and model the system&lt;br&gt;Plan timeline and sequence&lt;br&gt;Develop components and materials list&lt;br&gt;Re-evaluate, make modifications and document progress and changes</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Key knowledge: function of mechanical components; concepts and principles /operation of integrated systems</td>
<td>Commence building and fabricating, design and model&lt;br&gt;Re-evaluate, make modifications and document progress and changes</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Key knowledge: function and electrical components, concepts and principles / operation of integrated systems</td>
<td>Plan, build and fabricate the system&lt;br&gt;Re-evaluate, modify and document progress and changes</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Key knowledge: function of electrical components, concepts and principles / operation of integrated systems</td>
<td>Plan, build and fabricate the system&lt;br&gt;Re-evaluate, modify and document progress and changes</td>
<td></td>
</tr>
</tbody>
</table>

| Holidays |  |  |  |

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<table>
<thead>
<tr>
<th>Week no.</th>
<th>Work to be done/outcomes due</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Single period</strong></td>
</tr>
<tr>
<td>11</td>
<td>Design, production and testing work relating to Unit 4</td>
</tr>
<tr>
<td></td>
<td>(School-assessed Task)</td>
</tr>
<tr>
<td>12</td>
<td>Key knowledge: measurement of electrical components; concepts and principles/calculations for</td>
</tr>
<tr>
<td></td>
<td>integrated systems including SI units</td>
</tr>
<tr>
<td>13</td>
<td>Key knowledge: measurement of electrical components outputs; concepts and principles/calculations for integrated systems (specialised equipment multimeter/oscilloscope lesson)</td>
</tr>
<tr>
<td>14</td>
<td>Key knowledge: symbolic representation/electrical components, concepts and principles</td>
</tr>
<tr>
<td>15</td>
<td>Key knowledge: system performance electrical components, concepts and principles</td>
</tr>
<tr>
<td>16</td>
<td>Key knowledge: system performance electrical components, concepts and principles</td>
</tr>
<tr>
<td>17</td>
<td>Key knowledge: electrical components, concepts and principles diagnosis and repair (using partially developed project where possible)</td>
</tr>
<tr>
<td>18</td>
<td>Key knowledge: diagnosis and repair/testing</td>
</tr>
<tr>
<td>19</td>
<td>Key knowledge: diagnosis and repair/testing</td>
</tr>
<tr>
<td>20</td>
<td>Key knowledge: review Systems Engineering Process</td>
</tr>
<tr>
<td></td>
<td><strong>Double periods</strong></td>
</tr>
<tr>
<td>11</td>
<td>Plan, build and fabricate the system</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and change</td>
</tr>
<tr>
<td>12</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>13</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>14</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>15</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>16</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>17</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>18</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>19</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
<tr>
<td>20</td>
<td>Plan, build and fabricate</td>
</tr>
<tr>
<td></td>
<td>Re-evaluate, modify and document progress and changes</td>
</tr>
</tbody>
</table>

**Holidays**

*continued*
<table>
<thead>
<tr>
<th>Week no.</th>
<th>Work to be done/outcomes due</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Single period</strong></td>
</tr>
<tr>
<td>21</td>
<td>Unit 4 Area of Study 2</td>
</tr>
<tr>
<td></td>
<td>Commence research for Area of Study 2</td>
</tr>
<tr>
<td>22</td>
<td>Learning activities for Area of Study 2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Continue research and class activities for Area of Study 2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Learning activities for Area of Study 2</td>
</tr>
<tr>
<td></td>
<td>Revision for Outcome 2</td>
</tr>
<tr>
<td></td>
<td>Outcome 2 assessment task</td>
</tr>
<tr>
<td>25</td>
<td>Testing. Allow time for students to formally present appropriate testing. Teacher led discussion/instruction for documentation of test procedures and results</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Testing/begin finalising evaluation</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Evaluation</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Preparation of final folio presentation</td>
</tr>
<tr>
<td>29</td>
<td>Preparation of final folio presentation</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Holidays</strong></td>
</tr>
<tr>
<td>30</td>
<td>Exam preparation</td>
</tr>
<tr>
<td>31</td>
<td>Exam preparation</td>
</tr>
<tr>
<td>32</td>
<td>Exam preparation</td>
</tr>
<tr>
<td>33</td>
<td>Exams begin</td>
</tr>
</tbody>
</table>
SCHOOL-ASSESSED COURSEWORK

In Units 3 and 4 teachers must select appropriate tasks from the assessment table provided for each unit. Advice on the assessment tasks and performance descriptors to assist teachers in designing and marking assessment tasks will be published online by the Victorian Curriculum and Assessment Authority in an assessment handbook. The following is an example of a teacher’s assessment program using a selection of the tasks from the Units 3 and 4 assessment tables.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Marks allocated</th>
<th>Assessment tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 3</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome 2</td>
<td>50</td>
<td>A test that requires students to describe current and developing technological systems designed to minimise the harmful effects of energy use while maintaining energy supply to existing and developing technological systems.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>And</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>A multimedia or written report focusing on methods of generating electricity or other forms of energy that reduce fossil fuel dependence and carbon emissions.</td>
</tr>
<tr>
<td><strong>Total marks for Unit 3</strong></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td><strong>Unit 4</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome 2</td>
<td>50</td>
<td>A written report that requires students to give details of developments in systems engineering products and components, how they work and their applications. Reference should be given to developments in systems engineering processes that improve sustainability, efficiency and risk management. Reasons should be given for the development of the new and emerging technologies, including new discoveries, new materials, technology convergence and manufacturing methods and processes. Students should list positive and negative impacts and potential of new and emerging technologies.</td>
</tr>
<tr>
<td><strong>Total marks for Unit 4</strong></td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>
SCHOOL-ASSESSED TASK

In Units 3 and 4 teachers must provide students with the opportunities to complete the School-assessed Task. The following is an example of a teacher’s assessment program based on the tasks from the Units 3 and 4 assessment tables.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Assessment tasks</th>
</tr>
</thead>
</table>
| **Unit 3**  
Outcome 1  
Investigate, analyse and use advanced mechanical-electrotechnology integrated and control systems concepts, principles and components, and using selected relevant aspects of the Systems Engineering Process, design, plan and commence construction of an integrated and controlled system. | A design folio that includes reference to the Systems Engineering Process and factors that influence the design, planning, production and use of a system. Identification of a need/opportunity/situation and ideas to address these. Evaluation criteria, records of research and feasibility studies to determine appropriate processes, components, subsystems and costs. Working drawings, annotated sketches, CAD drawings, flow diagrams, PCB artwork, wiring diagrams, schematic diagrams, and calculations carried out to determine and justify selection of components and materials for the planned integrated controlled system. Production planning including components and materials lists complete with costing, expected timeline/sequence of operations/Gantt chart. Students commence work on the fabrication of their system and document progress. |
| **Unit 4**  
Outcome 1  
Produce, test, and diagnose an advanced mechanical-electrotechnology integrated and controlled system using selected relevant aspects of the Systems Engineering Process, and manage, document and evaluate the system and processes. | Production work demonstrating safe use of materials, tools and processes, accompanied by a logbook/record of progress including photographs and documentation of testing, quality checks/measures and modifications as a result of constant re-evaluation. Use of ICT where appropriate. Completed operational integrated controlled system is presented. A test journal showing records of completed tests and all relevant data complete with comments explaining test results. An evaluation report using evaluation criteria and examining the student's ability to effectively utilise the Systems Engineering Process and the factors that may influence the design, planning, production and use of the system. The evaluation report should draw reasonable conclusions and make recommendations for improvement. |