Government of **Western Australia**
School Curriculum and Standards Authority

ENGINEERING STUDIES

GENERAL COURSE

Year 12 syllabus

Acknowledgement of Country

Kaya. The School Curriculum and Standards Authority (the Authority) acknowledges that our offices are on Whadjuk Noongar boodjar and that we deliver our services on the country of many traditional custodians and language groups throughout Western Australia. The Authority acknowledges the traditional custodians throughout Western Australia and their continuing connection to land, waters and community. We offer our respect to Elders past and present.

Important information

This syllabus is effective from 1 January 2024.

Users of this syllabus are responsible for checking its currency.

Syllabuses are formally reviewed by the School Curriculum and Standards Authority (the Authority) on a cyclical basis, typically every five years.

Content

Rationale

Engineers are involved in the design, manufacture and maintenance of a diverse range of products and infrastructure integral to the functioning of society, business and industry. They rely strongly on their creativity and problem solving to turn ideas into reality by applying lateral thinking and mathematical and scientific principles, to develop solutions to problems, needs and opportunities. An engineer also needs to be socially aware and involved in broader community issues; impacts on the environment, sustainable energy, health and safety, and consultation processes to understand social attitudes and opinion.

The Engineering Studies General course provides opportunities for students to investigate, research and present information, design and make products and undertake project development. These opportunities allow students to apply engineering processes, understand underpinning scientific and mathematical principles, develop engineering technology skills and explore the interrelationships between engineering and society.

The Engineering Studies General course is essentially a practical course focusing on real-life contexts. It aims to prepare students for a future in an increasingly technological world, by providing the foundation for life-long learning about engineering. It is particularly suited to those students who are interested in engineering and technical industries as future careers.

Course outcomes

The Engineering Studies General course is designed to facilitate achievement of the following outcomes.

Outcome 1 – Engineering process

Students apply and communicate a process to design, make, and evaluate engineered products.

In achieving this outcome, students:

- investigate needs and opportunities
- generate engineering production proposals to provide solutions
- manage engineering production processes to produce solutions
- evaluate intentions, plans and actions.

Outcome 2 – Engineering understandings

Students demonstrate understanding of materials, components, and scientific and mathematical concepts used in the engineering context.

In achieving this outcome, students:

- understand and explain properties and behaviours of materials and components
- understand and apply scientific and mathematical concepts used in the engineering context.

Outcome 3 – Engineering technology skills

Students use materials, skills and technologies when undertaking an engineering challenge.

In achieving this outcome, students:

- apply initiative and organisational skills
- apply materials, techniques and technologies to achieve solutions to engineering challenges
- operate equipment and resources safely
- apply skills of calculation and computation.

Outcome 4 – Engineering in society

Students investigate, analyse and understand the interrelationships between engineering projects and society.

In achieving this outcome, students:

- identify forms, sources and uses of energy
- describe advantages and disadvantages for society, business and the environment of forms of obsolescence.

Organisation

This course is organised into a Year 11 syllabus and a Year 12 syllabus. The cognitive complexity of the syllabus content increases from Year 11 to Year 12.

Structure of the syllabus

The Year 12 syllabus is divided into two units which are delivered as a pair. The notional time for the pair of units is 110 class contact hours.

Unit 3

In the development of an engineering project, students study core engineering theory and theory in their chosen specialist area. They develop an understanding of the different forms of energy, uses of these different forms and sources of renewable and non-renewable energy. In this unit, students also develop a greater understanding of the engineering design process and learn and apply more complex theory and understanding to a student developed design brief. Given guidelines and a context, students develop and respond to the design brief, through a process that requires them to investigate existing products, construction materials and components. Design ideas are developed through annotated sketches and concept drawings. Students select and analyse the most suitable concept for production as a prototype or working model.

Students finalise their chosen design by documenting its specifications in the form of appropriate orthographic drawings and lists of materials and components. They calculate the cost of the prototype or model. They then follow a given timeline to undertake the tasks required to produce, test and evaluate the product.

Unit 4

In this unit, students develop their understanding of core and specialist area theory to better understand the scientific, mathematical and technical concepts that explain how engineered products function. They study the impact of the different forms of obsolescence in engineering products on society, business and the environment.

Students refine their understanding of the engineering design process. Students develop a design brief and respond to the brief through a process that requires them to engage in a range of activities, and investigate construction constraints, materials and components. Design ideas are developed through annotated sketches and concept drawings. Students select and analyse the most suitable concept for production as a prototype or working model.

Each unit includes:

- a unit description – a short description of the purpose of the unit
- unit content – the content to be taught and learned.

Organisation of content

The course content is the focus of the learning program.

The course content is sequential and hierarchical in nature, and increases in complexity as further units are studied.

Course content contains core content material and two specialist fields offered in all four units. The core content utilises an engineering design process to enable students to learn about engineering in a practical, project focussed approach. The study of core content develops student knowledge, understandings and skills of general engineering concepts and processes. The content of the two specialist fields allow for students to develop a more specific, practical understanding of major engineering and industrial technologies.

Core content

- Engineering design process
- Materials
- Fundamental engineering calculations
- Engineering in society

Specialist engineering fields

- Mechanical

  OR

- Mechatronics

Core content

Engineering design process

Investigating

Creating, interpreting, and responding to a design brief is the starting point for the engineering design process. Existing engineered products, materials, components and sources of energy are researched to develop a greater understanding of what a solution might include.

Devising

Annotated sketches and drawings of design ideas are used to generate concepts that are analysed and compared to the requirements of the design brief. The preferred concept is identified and used for the production phase.

Producing

The production phase commences with the specifications of the chosen design being confirmed and documented. Pictorial and orthographic drawings are produced that contain sufficient information for manufacture of the product to be undertaken. Depending on the specialist area being studied, there may also be other forms of drawing or graphics necessary to explain the final solution. Materials and parts lists are derived from the drawings and production techniques identified. The construction and testing of the product – a prototype or working model – is undertaken by following safe and appropriate work practices.

Evaluating

Evaluation occurs throughout the engineering design process to assess the viability, appropriateness and performance of existing solutions, materials, components, energy systems, design ideas, construction methods and prototype or working model.

Materials

Identifying and understanding the characteristics of common materials used in engineering is a necessary requirement for the selection and use of materials in making functional models and prototypes.

Fundamental engineering calculations

Applying mathematical concepts is a fundamental requirement for the Engineering Studies General course. This entails extracting data from drawings, charts, diagrams and tables; determining perimeters, surface area, volume, density and mass of engineered products; simple energy and efficiency calculations; and using unfamiliar formulae to solve problems.

Engineering in society

The impact of engineering on society is a vital consideration. Forms, source and uses of energy are studied. At particular stages, automation and technical innovation, obsolescence, and product life cycle analysis are studied.

Specialist engineering fields

Mechanical

The content in this section is specialised knowledge that applies to mechanical engineering. It is divided into three content organisers:

- materials
- statics/dynamics
- mechanisms

An understanding of the scientific and mathematical nature and properties of materials underpins fundamental decisions concerning their selection and use in the design of engineering projects.

Materials used in engineering and solid state structures are classified on the basis of their structure and properties. Plastics, wood, and most importantly, metals (ferrous, non-ferrous, pure and alloy) are materials commonly used in engineering because of their structure and properties; both static and dynamic.

Young's modulus and stress-strain graphs are fundamental to all materials, structures and mechanical principles used throughout engineering.

There are testing regimes for stress, strain, tension, compression and torsion. The analysis of results from such regimes, together with information on existing data and specifications tables, forms the basis for selecting materials for engineering technologies.

Structures are defined as a body of materials selected and used because they can resist applied forces. Equilibrium, forces, structures, bending moments, shear force, torsion and Newton's Three Laws of Motion are important when analysing static loads and the application of forces to structures.

Newton’s Three Laws of Motion in conjunction with equilibrium principles are the basis for analysing engineering mechanisms and motion conversion systems.

Mechatronics

The content in this section is specialised knowledge that applies to candidates who are undertaking the study of mechatronics. It is divided into three content organisers:

- electrical/electronics
  - components
  - laws and principles
  - production
  - quantities and unit prefixes
- systems and control
  - nature of control systems
  - interfacing with a microcontroller
- mechanics (Unit 4 only)
  - types of motion
  - mechanical drive systems
  - calculations
  - quantities

An understanding of scientific, mathematical and technical concepts contained in the three strands, coupled with the engineering design process, provides students with the opportunity to design, make, analyse, test and evaluate mechatronics devices.

These devices are an integration of electrical/electronic circuits, process control delivered using microcontrollers and mechanical actuators. Moreover, some form of structure or chassis is often required to complete the design.

Representation of the general capabilities

The general capabilities encompass the knowledge, skills, behaviours and dispositions that will assist students to live and work successfully in the twenty-first century. Teachers may find opportunities to incorporate the capabilities into the teaching and learning program for the Engineering Studies General course. The general capabilities are not assessed unless they are identified within the specified unit content.

Literacy

Literacy is of fundamental importance in the study of the Engineering Studies General course. Students access engineering and technological content through a variety of print, oral, visual, spatial and electronic forms, including data books, texts, computer software, images, and written technical materials. They learn to investigate, interpret and apply engineering principles from a variety of sources to design solutions for engineering tasks. They analyse and evaluate information for authority, reliability, relevance and accuracy. They learn to monitor their own language use for accuracy in the use of design principles and technological terms for clarity of ideas, processes and explanations of engineering activities, and development and evaluation of functioning prototypes.

Numeracy

Numeracy is fundamental in calculating and evaluating engineering processes. Students develop their understanding and skills of numeracy while undertaking tasks to produce, test and evaluate engineered products. Core and specialist area theory continues to be studied to forge greater understanding of the scientific, mathematical and technical concepts that explain how engineered products function.

Information and communication technology capability

Information and communication technology capability (ICT) is important in all stages of the design process. Students use digital tools and strategies to locate, access, process and analyse information. They use ICT skills and understandings to investigate and devise design ideas. Students access information from websites and software programs to develop design solutions. Students use computer-aided drawing software and computer control software to produce engineered products.

Critical and creative thinking

Critical and creative thinking is integral to the design process. Design thinking methodologies are fundamental to the Engineering Studies General course. Students develop understandings and skills in critical and creative thinking during periods of evaluation at various stages of the design process. They devise plausible solutions to problems and then, through interrogation, critically assess the performance of the most efficient solution. Students identify possible weaknesses in their design solutions and then analyse, evaluate, and modify the developing solution to construct a functioning prototype.

Personal and social capability

Personal and social capability skills are developed and practiced in the Engineering Studies General course by students enhancing their communication skills and participating in teamwork. Students have opportunities to work collaboratively during stages of investigation and when producing engineering products. Students develop increasing social awareness through the study of the impact of engineering in society and on the environment.

Ethical understanding

Students have opportunities to explore and understand the diverse perspectives and circumstances that shaped engineering technology and the actions and possible motivations of people in the past compared with those of today. Students have opportunities both independently and collaboratively to explore the values, beliefs and principles that have influenced past engineering achievements and global engineering activities of today.

Intercultural understanding

Students have opportunities to explore the different beliefs and values of a range of cultural groups, and develop an appreciation of cultural diversity. Students have opportunities to develop an understanding of different contemporary perspectives with regard to building materials, styles of structures, energy supply and use, and engineering and technological influences on different groups within society, and how they contribute to individual and group actions in the contemporary world.

Representation of the cross-curriculum priorities

The cross-curriculum priorities address the contemporary issues which students face in a globalised world. Teachers may find opportunities to incorporate the priorities into the teaching and learning program for the Engineering Studies General course. The cross-curriculum priorities are not assessed unless they are identified within the specified unit content.

Aboriginal and Torres Strait Islander histories and cultures

Students have opportunities to explore Aboriginal and Torres Strait Islander development and use of engineering and technology, and the interconnectedness between technologies and identity, People, Culture and Country/Place. Students understand that many engineering activities occur on land that is part of traditional Country.

Asia and Australia's engagement with Asia

Students have opportunities to explore traditional, contemporary, and emerging technological achievements in the countries of the Asian region. Students explore Australia's rich and ongoing engagement with the peoples and countries of Asia to create appropriate products and services to meet personal, community, national, regional and global needs.

Sustainability

Students take action to create more sustainable patterns of living. Students can develop knowledge, understanding and skills necessary to design for effective sustainability.

Students focus on the knowledge, understanding and skills necessary to choose technologies and systems with regard to costs and benefits. They evaluate the extent to which the process and designed solutions embrace sustainability. Students reflect on past and current practices, and assess new and emerging technologies from a sustainability perspective.

Unit 3

Unit description

In the development of an engineering project, students study core engineering theory and theory in their chosen specialist area. They develop an understanding of the different forms of energy, uses of these different forms and sources of renewable and non-renewable energy. In this unit, students also develop a greater understanding of the engineering design process and learn and apply more complex theory and understanding to a student developed design brief. Given guidelines and a context, students develop and respond to the design brief through a process that requires them to investigate existing products, construction materials and components. Design ideas are developed through annotated sketches and concept drawings. Students select and analyse the most suitable concept for production as a prototype or working model.

Students finalise their chosen design by documenting its specifications in the form of appropriate orthographic drawings and lists of materials and components. They calculate the cost of the prototype or model. They follow a given timeline to undertake tasks required to produce, test and evaluate the product.

Unit content

An understanding of the Year 11 content is assumed knowledge for students in Year 12. It is recommended that students studying Unit 3 and Unit 4 have completed Unit 1 and Unit 2.

It is divided into core content and specialist engineering fields. Students must study all of the core content material and at least one of the specialist engineering fields.

This unit includes the knowledge, understandings and skills described below.

Core content

Engineering design process

Investigating

- develop a design brief
- use research skills to identify existing solutions/products
- describe and analyse existing solutions/products
- research and describe materials and components relevant to the design brief
- consider forms of energy supplies

Devising

- annotated pictorial drawings of design ideas
- annotated orthographic drawings of design ideas
- the chosen option to be used as the solution

Producing

- present specifications for the selected solution
  - dimensioned pictorial and orthographic drawings
  - orthographic drawings and sketches are 3rd angle projections and include
    - lines – outlines, hidden detail and centrelines
    - dimensioning – linear, radii, circles, holes through or partial depth with flat base
  - materials selected
  - parts lists
  - costing of prototype or working model
- develop and use a timeline to construct and test the solution
- solution construction by selecting and using appropriate tools and machines, and following safe work practices
- solution testing for correct function and document using checklists and test data

Evaluating

- final solution in terms of:
  - meeting the requirements of the design brief
  - function and finish of the product
  - variations and changes to the design

Materials

Classify types of materials

- metals (pure)
  - aluminium
  - copper
  - zinc
  - iron
- alloys (ferrous)
  - steel
  - stainless steel
- alloys (non-ferrous)
  - brass
  - solder (lead/tin)
- polymers
  - polypropylene
  - polycarbonate
  - acrylic
  - ABS
  - nylon
- composites
  - concrete
  - reinforced concrete

Fundamental engineering calculations

Dimensional

- examine dimensioned drawings to determine:
  - overall length, height and width
  - direct and indirect dimensions: linear measurements, radii and diameters

Perimeter

- square and rectangular plane figures
- right triangular plane figures
  - $\text{hypotenuse}^2 = \text{opposite}^2 + \text{adjacent}^2$
- circles
  - $p = \Xi d$

Surface area

- square and rectangular plane figures
- cubes and rectangular right prisms
- right triangular plane figures
- triangular right prisms
- circles
  - $A = \Xi r^2$
- open ended cylinders
  - $A = \Xi d h$

Quantity estimates

- determine lengths and surface area of:
  - geometric shapes and forms
  - individual shapes
  - simple combinations of shapes and forms

Engineering in society

Energy

- define and describe relationships between:
  - energy
  - power
  - work
- define and compare forms of energy
  - kinetic
  - potential
  - thermal
  - chemical
  - electrical
  - electro-chemical

  - electromagnetic (light)
  - sound
  - nuclear
- identification of non-renewable sources
  - fossil fuels: coal, gas and oil
  - nuclear
- identification of renewable sources
  - solar: thermal, biomass, photovoltaic and wind
  - solar/gravity: waves
  - gravity: tidal and hydroelectric
  - geothermal
- advantages and disadvantages of non-renewable and renewable sources

Specialist engineering fields

Mechanical

Materials

- engineering processes with respect to steel
  - hardening
  - tempering
  - normalising
  - case hardening
  - annealing
- the effect of carbon content (C%) in steel
- steel's ability to be worked and hardened and its properties after processing
- stress and use of the formula to determine one unknown value

  $\sigma = \frac{F}{A}$ Stress = Force/Area
- strain and use the formula to determine one unknown value

  $\varepsilon = \frac{\Delta L}{L}$ Strain = change in length/original length

  (Strain is a ratio and therefore is without units and can be expressed as a percentage)
- Young's Modulus (elastic modulus) and the formulae to determine one unknown value

  $E = \frac{\sigma}{\varepsilon}$ and its extension $E = \frac{FL}{A\Delta L}$
- pressure and use of the formula to solve for one unknown value using:

  $P = \frac{F}{A}$ Pressure = Force/Area

- conversion between the following pressure and stress units
  - kN mm^{-2}
  - Pa
  - kPa
  - Mpa
  - GPa

Statics

- the three conditions for equilibrium as per:
  - $\sum M = 0$ or $\Sigma CWM = \Sigma ACWM$
  - $\sum F_H = 0$ or $\Sigma F(left) = \Sigma F(right)$
  - $\sum F_y = 0$ or $\Sigma F(up) = \Sigma F(down)$
- the moments formula to determine one unknown variable where the applied force does not require vector resolution
  - M = F d
  - $\Sigma CWM = \Sigma ACWM$ and $\sum F_V = 0$ to determine the reaction forces at a horizontal structure's supports (only two supports and only vertical forces applied)
  - $\Sigma CWM = \Sigma ACWM$ to solve for one unknown force or distance variable

Mechanisms

- list and draw these simple machines
  - lever
  - inclined plane
  - wheel and axle
  - pulley with pulley block
  - the screw jack
- label the load and effort associated with these simple machines
- calculate the mechanical advantage (MA) of each machine using the equation
  - $MA = \dfrac{F(load)}{F(effort)}$
  - use only 100% efficiency (η), therefore $\dfrac{MA}{VR} = 1$
- identify and label the distances moved by the effort and the load for each simple machine
- calculate the resulting velocity ratios using the formula
  - $VR = \dfrac{d_{effort}}{d_{load}}$
  - velocity ratio = distance (effort)/distance (load)

Mechatronics

Electrical/electronic

Components

- general characteristics of components and the circuit symbols for:
  - cells and batteries
  - power supply (DC)
  - fuse
  - voltage regulator – 3 pin fixed voltage positive
  - switches
    - SPST, SPDT and DPDT
    - push to make and push to break
  - fixed value resistors
  - potentiometer, including its use as a variable resistor
  - light dependent resistor (LDR)
  - thermistor (NTC)
  - capacitor – polarised and non-polarised
  - diodes – rectifier and LED
  - bulbs/lamps
  - DC motor
  - SPDT and DPDT relays
  - transistor (NPN)
  - integrated circuit (generic)
  - measuring instruments – voltmeter, ohmmeter and ammeter
- read and sketch simple circuit diagrams that contain the components listed above
- identify markings
  - fixed value resistors – 4 band E12 series
  - capacitors: pF, nF and µF
  - serial numbers – refer to data sheets
    - pin outs: voltage regulator, transistor and integrated circuits

Laws and principles and types of circuits

- application of:
  - Ohm's Law
    - $V = IR$
  - Kirchhoff's Laws
    - $\sum I = 0$ Kirchhoff's Current Law
    - $\sum \Delta V = 0$ Kirchhoff's Voltage Law
  - power
    - $P = V I = I^2R$
- cells and batteries
  - series
    - $V_T = V_{B1} + V_{B2} + \ldots\ldots$
    - $I_T = I_{B1} = I_{B2} = \ldots\ldots$

- parallel
  - $V_T = V_{B1} = V_{B2} = ...$
  - $I_T = I_{B1} + I_{B2} + ...$

- resistor networks
  - series
    - $R_T = R_1 + R_2 + R_3 + ...$
  - parallel (maximum of 2 resistors)
    - $R_T = \frac{R_1 R_2}{R_1 + R_2}$ for a pair
    - $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
  - combinational networks of up to 3 resistors
    - Ohm's law
    - Power

- capacitor
  - series (maximum of 2)
    - $C_T = \frac{C_1 C_2}{C_1 + C_2}$ for a pair
    - $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$
  - parallel
    - $C_T = C_1 + C_2 + C_3 + ...$

- AC to DC rectification
  - half wave
  - half wave with smoothing capacitors
  - full wave (bridge rectifier)
  - full wave (bridge rectifier) with smoothing capacitors
  - waveforms for each of the above

Production

- safety
  - electrical
  - drilling
  - soldering

- populate a through hole printed circuit board

- soldering technique using correct equipment
  - identify and correct soldering faults

- measure resistance, voltage and current using a digital multimeter

Quantities

Quantity	Unit name	Symbol
electric potential difference/e.m.f.	volt	V
current (I)	ampere	A
resistance	ohm	Ω
power	watt	W
capacitance (C)	farad	F

Unit prefixes

Prefix	Symbol	Factor
pico	p	10^{-12}
nano	n	10^{-9}
micro	µ	10^{-6}
milli	m	10^{-3}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

Systems and control

Nature of control systems

- systems/control diagrams
  - simple open loop (universal block diagram)
    - input
    - process
    - output
  - simple closed loop
    - input
    - process
    - control
      - feedback loop
    - output

- flowcharts
    - standard symbols
        - start/end
        - input/output
        - decision
        - process
        - subroutine/procedure
        - flow of computation

Interfacing with microcontroller

- nature of microcontroller
    - internal subsystems
        - ALU, ROM, RAM, ADC, I/O and bus Memory, I/O

- power supply
    - batteries
        - voltage to be specified
    - voltage regulator
        - fixed positive voltage to be specified

- digital input
    - 'high' and 'low' signals (also 0 and 1, 'on' and 'off')
    - sensors
        - switch with resistor (pull up and tie down)

- analogue input
    - signal values that can vary on a defined scale
    - sensors
        - voltage dividers

- analogue to digital conversion (ADC)
    - range
        - 8 bit 0 – 255
        - 10 bit 0 – 1023
    - relationship to input voltage

Unit 4

Unit description

In this unit, students develop their understanding of core and specialist area theory to better understand the scientific, mathematical and technical concepts that explain how engineered products function. They study the impact of the different forms of obsolescence in engineering products, on society, business and the environment.

Students refine their understanding of the engineering design process. Students develop a design brief, and respond to the brief, through a process that requires them to engage in a range of activities, and investigate construction constraints, materials and components. Design ideas are developed through annotated sketches and concept drawings. Students select and analyse the most suitable concept for production as a prototype or working model.

Unit content

This unit builds on the content covered in Unit 3.

This unit includes the knowledge, understandings and skills described below.

Core content

Engineering design process

Investigating

- develop a design brief
- use research skills to identify existing solutions/products
- describe and analyse existing solutions/products
- describe materials and components relevant to the design brief
- appropriate forms of energy supplies

Devising

- annotated pictorial drawings of design ideas
- annotated orthographic drawings of design ideas
- analyse features of the chosen option to be developed as the solution

Producing

- specifications for the selected solution
  - dimensioned pictorial and orthographic drawings
  - orthographic drawings and sketches are 3^{rd} angle projections and include
    - lines – outlines, hidden detail and centrelines
    - dimensions – linear, radii, circles, holes through or partial depth with flat base
  - materials selected
  - parts lists
  - costing of prototype or working model

- develop and use a timeline to construct and test the solution
- solution construction by selecting and using appropriate tools and machines and following safe work practices
- test the solution for correct function, and document using checklists and test data

Evaluating

- the final solution in terms of:
  - meeting the requirements of the design brief
  - function and finish of the product
  - variations and changes to the design

Materials

Physical properties of materials

- define
  - density
  - elasticity
  - plasticity
  - strength – tensile and compressive
  - stiffness
  - toughness
  - ductility
  - malleability
  - conductivity – electrical and thermal
  - corrosion resistance

Fitness for purpose

- describe the required properties of a material for a specified application

Fundamental engineering calculations

Volume

- cube, rectangular right prism and triangular right prism
- cylinder
  - $V = \Xi r^2 h$

Density

- density = mass/volume = kg m^{-3}

Quantity estimates

- determine volume, mass, and density of geometric forms
  - individual or simple combinations
  - hollow or solid

Energy

- E = Pt
- 1 joule = 1 watt x 1 second
- 1 kW h = 1000 watts x 1 hour

Efficiency

- calculate efficiency as a percentage = (output/input) x 100

Unfamiliar formula

- determine unknown factor in an unfamiliar formula, given sufficient data to complete the calculation

Engineering in society

Obsolescence

- define and compare forms of obsolescence
  - technical
  - functional
  - postponement
  - planned
- advantages and disadvantages for society, business and the environment, of forms of obsolescence

Specialist engineering fields

Mechanical

Materials

- stress and strain graphs for common steel alloys
- define the following terms with reference to common steel alloys and their stress/strain graphs:
  - yield stress
  - yield strain
  - ultimate tensile stress (UTS)
  - elastic limit

  Note terms: elastic limit = proportional limit = yield point

Dynamics

- formulae to find one unknown variable in constant acceleration, straight line motion
  - $F = ma$
  - $a = \frac{v - u}{t}$
  - $s = ut + \frac{1}{2}at^2$ (no quadratic equation)
  - $v^2 = u^2 + 2as$
- potential energy as energy of position or state
- define kinetic energy as energy of motion

- problems involving energy and energy conversion using:
  - $E_p = mgh$
  - $E_k = \frac{1}{2}mv^2$
  - $\Delta E_p = \Delta E_k$

Mechanisms

- compound gear trains and associated linked mechanisms
  - drum circumference
  - pulley ratios and amounts
  - rotational to linear velocities
  - time factors to lift/travel distances
- calculate the velocity ratio for a compound gear train or pulley system containing up to 3 paired gear or 3 paired pulley combinations
  - VR = number of teeth on the follower gear divided by number teeth on the driver gear
  - VR = diameter of follower pulley divided by diameter of the driver pulley
- formula for compound drive trains
  - $VR = \frac{F_1}{D_1}\frac{F_2}{D_2}\frac{F_3}{D_3}$

  Note – the term 'follower' is used in preference to the term 'driven' to avoid confusion
- calculate the output or input rpm of a compound gear or pulley system using the formulae
  - output rpm = input rpm/VR
- calculate linear velocities using:
  - $v = \frac{(rpm)(2\pi r)}{60}$
- velocity, distance or time variables using the relationship
  - $v = \frac{s}{t}$ where $s = 2\pi r$ for winch drums
- torque and formula to determine one unknown
  - $\tau = rF$ torque = radius x Force

  Note: determining the applied force does not require vector resolution

Mechatronics

Electrical/electronic

Laws and principles

- analogue inputs
  - voltage dividers
    - LDR with resistor or variable resistor
    - thermistor with resistor or variable resistor
    - potentiometer

- $V_1 = V_{cc} \frac{R_1}{(R_1 + R_2)}$
- $V_2 = V_{cc} \frac{R_2}{(R_1 + R_2)}$
- $V_{CC} = V_1 + V_2$

- NPN transistor
  - buffer/driver for a microcontroller
    - driving relays, DC motor (unidirectional), bulb/lamp, high current LED

- diodes
  - power/rectifier diode (silicon)
    - forward bias voltage 0.6 V
    - back e.m.f. protection
  - light emitting diode (LED)
    - $R = \frac{(V_{CC} - V_{LED})}{I_{LED}}$
- voltage regulator
  - positive voltage 3 pin fixed value, including 78XX series
  - smoothing capacitors

Systems and control

Interfacing with microcontroller

- outputs
  - LED (low power)
  - piezo sounder
  - NPN transistor driver/buffer
    - relays, DC motor (unidirectional), bulb/lamp, high current LED
  - DC motor (bi-directional)
    - H-bridge integrated circuit – motor controlled by two (2) outputs from microcontroller
      - includes L293D motor controller

Mechanics

Types of motion

- linear, rotary, oscillating and reciprocating

- transformation
  - examples and applications of:
    - rotary to linear
    - rotary to reciprocating
    - rotary to oscillating

Mechanical drive systems

- general characteristics and applications for pulley belt, chain and sprocket, spur gear drive, compound gear drive, and rack and pinion

Calculations

- pulley belt ratio = $\frac{\text{Ø follower pulley}}{\text{Ø driver pulley}}$ = input revolutions:1 output revolution
- chain and sprocket ratio = $\frac{\text{n}^{\text{o}}\text{ teeth follower gear}}{\text{n}^{\text{o}}\text{ teeth driver gear}}$ = input revolutions:1 output revolution
- gear ratio = $\frac{\text{n}^{\text{o}}\text{ teeth follower gear}}{\text{n}^{\text{o}}\text{ teeth driver gear}}$ = input revolutions:1 output revolution
  - pinion gear
  - idler gear
- rack and pinion
  - distance moved = $\frac{\text{n}^{\text{o}}\text{ teeth pinion} \times \text{no revolutions}}{\text{n}^{\text{o}}\text{ teeth per metre of rack}}$
- speed
  - output speed (rpm) = $\frac{\text{input speed (rpm)}}{\text{gear or pulley ratio}}$

Quantities

Quantity	Unit name	Symbol
speed/velocity (v)	metre per second	$m\ s^{-1}$
distance	metre	m
time (t)	second	s

School-based assessment

The *Western Australian Certificate of Education (WACE) Manual* contains essential information on principles, policies and procedures for school-based assessment that needs to be read in conjunction with this syllabus.

Teachers design school-based assessment tasks to meet the needs of students. The table below provides details of the assessment types for the Engineering Studies General Year 12 syllabus and the weighting for each assessment type.

Assessment table – Year 12

Type of assessment	Weighting
Design Students investigate needs, opportunities and problems defined in a design brief. They devise a solution that considers factors, such as function, environment, materials, components and parts. Teachers assess how well students conduct the investigation and the devising of a solution in response to the design brief, by referring to the student's documentation of the process. Types of evidence must include, a project folio (hard copy or electronic or combination) and may also include a research assignment.	25%
Production Students finalise and document the specifications for their solution. They plan the making process by identifying and using appropriate tools and techniques, and then manufacture and/or assemble their engineered product which they test for safe and correct function. Planning also includes working to deadlines. The product and process are also evaluated by the student. Teachers assess the students' understanding, confidence and competence when undertaking the making and evaluation of their engineered product. Types of evidence must include the engineered product and project folio (hard copy or electronic or combination). Other evidence may include a journal and observation checklists.	50%
Response Students apply their knowledge and skills in responding to a series of stimuli or prompts. Types of evidence include tests, worksheets and research assignments. Other evidence can include a journal and observation checklists.	10%
Externally set task A written task or item or set of items of 50 minutes duration developed by the School Curriculum and Standards Authority and administered by the school.	15%

Teachers are required to use the assessment table to develop an assessment outline for the pair of units.

The assessment outline must:

- include a set of assessment tasks
- include a general description of each task
- indicate the unit content to be assessed
- indicate a weighting for each task and each assessment type
- include the approximate timing of each task (for example, the week the task is conducted, or the issue and submission dates for an extended task).

In the assessment outline for the pair of units, each assessment type must be included at least once over the year/pair of units. The externally set task occurs in Term 2.

The set of assessment tasks must provide a representative sampling of the content for Unit 3 and Unit 4.

Assessment tasks not administered under test/controlled conditions require appropriate validation/authentication processes.

Externally set task

All students enrolled in the Engineering Studies General Year 12 course will complete the externally set task developed by the Authority. Schools are required to administer this task in Term 2 at a time prescribed by the Authority.

Externally set task design brief – Year 12

Time	50 minutes
Format	Written
	Conducted under invigilated conditions
	Typically between two and five questions
	Can require students to refer to source material
Content	The Authority informs schools during Term 3 of the previous year of the Unit 3 syllabus content on which the task will be based

Refer to the *WACE Manual* for further information.

Grading

Schools report student achievement in terms of the following grades:

Grade	Interpretation
A	Excellent achievement
B	High achievement
C	Satisfactory achievement
D	Limited achievement
E	Very low achievement

The teacher prepares a ranked list and assigns the student a grade for the pair of units. The grade is based on the student's overall performance as judged by reference to a set of pre-determined standards. These standards are defined by grade descriptions and annotated work samples. The grade descriptions for the Year 12 Engineering Studies General syllabus are provided in Appendix 1. They can also be accessed, together with annotated work samples, through the Guide to Grades link on the course page of the Authority website at www.scsa.wa.edu.au.

To be assigned a grade, a student must have had the opportunity to complete the education program, including the assessment program (unless the school accepts that there are exceptional and justifiable circumstances).

Refer to the *WACE Manual* for further information about the use of a ranked list in the process of assigning grades.

Appendix 1 – Grade descriptions Year 12

A	**Design** Independently interprets a design brief. Investigates, documents and evaluates in detail a range of alternative existing solutions. Generates and develops explicit design ideas and proposals which feature a range of graphical representations, views and appropriate technical terms. Presents in-depth content in all elements of the engineering design process. Clearly communicates complete, accurate information that is central to understanding the development, testing and evaluation of the design ideas and proposal. The final design solution is thoroughly evaluated against all design brief criteria.
	Production Clearly explains and documents final specifications for the solution, including drawings, diagrams, tables, charts and text as required. These are accurate, complete and neatly presented. Presents final specifications that are an appropriate response to the design brief. Organises and communicates production processes using engineering language, techniques and conventions. Applies and consistently refers to a timeline to produce and test the resulting model or prototype, which results in all deadlines being met. The resulting solution functions correctly, reliably and safely. Works independently and collaboratively, using available materials, techniques and equipment. Predicts and recognises hazards and works with regard for the safety of self and others.
	Response Accurately conducts all computations, and applies correct formula and units. Interprets and uses data correctly to develop solutions to given problems. Produces accurate, annotated diagrams to communicate detailed information and solutions to given problems. Explains key concepts, and includes appropriate justifications where required.

B	**Design** Interprets and documents a design brief. Investigates, documents and evaluates a range of different existing solutions. Uses graphical representations/models and common technical terms to generate distinct design ideas and proposals. Presents detailed content in the main elements of the engineering design process. Clearly communicates accurate information that is central to understanding the development, testing and evaluation of the design ideas and proposal. Evaluates the final design solution against all design brief criteria.
	Production Implements and communicates production processes, using given engineering techniques and controlling given variables to produce solutions. Presents relevant, complete and neat specifications for the proposed solution. Organises production processes using engineering language, techniques and conventions. Applies and manages a timeline to produce and test the resulting model or prototype, which results in deadlines being met. Works independently and collaboratively using available materials, techniques and equipment. Recognises hazards and works with regard for the safety of self and others.
	Response Conducts all computations, and applies correct formulae and units. Interprets data correctly to develop solutions to given problems. Produces detailed, annotated diagrams to communicate information and solutions to given problems. Explains key concepts, and includes relevant justifications where required.

C	**Design** Interprets a design brief and uses short or general statements to document a design summary. Investigates and documents several different and alternative existing solutions. Uses graphical representations/models and common technical terms to develop design ideas and proposals. Presents relevant content in each main element of the engineering design process. Communicates some specific information that is central to understanding the development, testing and evaluation of the design ideas and proposal. Uses brief statements to present an evaluation of the final design solution against most design brief criteria.
	Production Implements and communicates production processes, using given engineering techniques to produce solutions. Presents the main specifications for the proposed solution. Uses production processes, techniques, engineering language and conventions. Follows a timeline to produce and test the resulting model or prototype and satisfies deadlines. Works independently and collaboratively using available materials, techniques and equipment. Works with regard for the safety of self and others.
	Response With some guidance, applies correct formulae and units to complete most computations. With some guidance, interprets data correctly to develop solutions to given problems. Produces annotated diagrams to communicate information and solutions to given problems. Explains key concepts in general terms, and includes some justifications where required.

D	**Design** With guidance, interprets a design brief and presents a design summary in short, general statements. Investigates and documents a minimal number of different existing solutions. Uses graphical representations and general technical terms to develop design ideas. Presents a minimal amount of content in each main element of the engineering design process. Communicates some information that demonstrates development, testing and evaluation of the design ideas and proposal. Presents incomplete statements about the evaluation of the final design solution.
	Production Presents simple specifications for the proposed solution. With guidance, follows a production process characterised by minimal planning to produce solutions. Attempts to follow a timeline to produce a solution; however, infrequently meets deadlines. Performs limited testing of model or prototype. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the product, but with some obvious inaccuracies and/or incomplete sections. Produces a product that is unfinished, partially functions and is prone to being unreliable.
	Response With guidance, interprets data correctly, applies formulae and completes some computations. Produces annotated, but incomplete, diagrams to communicate information and solutions to given problems. Explains key concepts in general terms and includes some simple justifications where required.

E	Does not meet the requirements of a D grade and/or has completed insufficient assessment tasks to be assigned a higher grade.