Government of Western Australia
School Curriculum and Standards Authority

Engineering Studies

ATAR course

Year 11 syllabus

IMPORTANT INFORMATION

This syllabus is effective from 1 January 2015.

Users of this syllabus are responsible for checking its currency.

Syllabuses are formally reviewed by the School Curriculum and Standards 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 ATAR 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 ATAR 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 ATAR 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 the different 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 11 syllabus is divided into two units, each of one semester duration, which are typically delivered as a pair. The notional time for each unit is 55 class contact hours.

Unit 1

In the development of an engineering project, students study core engineering theory and their chosen specialist area theory. They develop an understanding of different forms of energy, uses of these different forms, and sources of renewable and non-renewable energy.

Given guidelines and a context, students apply their knowledge of the engineering design process and theory to develop and respond to a design brief. This requires them to investigate existing products, construction materials and components. Design ideas are developed through annotated sketches and concept drawings. Students then 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, specialist diagrams 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 2

This unit develops students' 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 continue to refine their understanding and skills of the engineering design process, undertaking tasks to produce, test and evaluate the product. 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.

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 sequential and hierarchical in nature, and increases in complexity as further units are studied.

Course content contains core content material and two specialist fields. The core content utilises an engineering design process to enable students to learn about engineering in a practical project-focused 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 allows 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 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 and by following a timeline.

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 the final 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 ATAR 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. Two major concepts are studied. These are: forms, sources and uses of energy; and the nature of obsolescence and its different forms.

Specialist engineering fields

Mechanical

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

- Materials
- Statics (Unit 1 only)
- Dynamics (Unit 2 only)
- 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 students who are undertaking the study of mechatronics. It is divided into three content areas:

- Electrical/electronics
  - components
  - laws and principles
  - production
  - quantities and unit prefixes
- Systems and control
  - nature of control systems
  - logic gates (Unit 1 only)
  - interfacing with a microcontroller (Unit 2 only)
- Mechanics
  - types of motion
  - mechanical drive systems
  - calculations
  - quantities.

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

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 ATAR 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 ATAR 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 for 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 (ICT) capability 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 ATAR 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 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 ATAR 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, 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 Engineering Studies. 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 Asia 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 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 1

Unit description

In the development of an engineering project, students study core engineering theory and their chosen specialist area theory. They develop an understanding of different forms of energy, uses of these different forms, and sources of renewable and non-renewable energy.

Given guidelines and a context, students apply their knowledge of the engineering design process and theory to develop and respond to a design brief. This requires them to investigate existing products, construction materials and components. Design ideas are developed through annotated sketches and concept drawings. Students then 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, specialist diagram 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

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

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

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

- produce annotated pictorial drawings of design ideas
- produce annotated orthographic drawings of design ideas
- analyse 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 centerlines
    - 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
- construct solutions by selecting and using appropriate tools and machines, following safe work practices
- test the solution for correct function and document using checklists and test data

Evaluating

- evaluate 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

- 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
  - $p = \pi d$

Surface area

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

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

- identify non-renewable sources
  - fossil fuels: coal, gas and oil
  - nuclear
- identify renewable sources
  - solar: thermal, biomass, photovoltaic and wind and waves
  - gravity: tidal and hydroelectric
  - geothermal
- list uses with advantages and disadvantages of non-renewable and renewable sources

Specialist engineering fields

Mechanical

Materials

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

  $\sigma = \frac{F}{A}$ Stress = Force/Area
- define 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)
- define Young's Modulus (elastic modulus) and use the formulae to determine one unknown value

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

  $P = \frac{F}{A}$ Pressure = Force/Area
- convert between the following pressure and stress units
  - kN mm^{-2}
  - Pa
  - kPa
  - Mpa
  - GPa

Statics

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

Mechanisms

- list and draw the following 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

  $$MA = \frac{F(load)}{F(effort)}$$

  Use only 100% efficiency (η) therefore $\frac{MA}{VR} = 1$
- identify and label the distances moved by the effort and the load for each simple machine
- calculate the resulting velocity ratios using the formula

  $$VR = \frac{d_{effort}}{d_{load}}$$

  velocity ratio = distance (effort)/distance (load)

Mechatronics

Electrical/electronics

Components

- recognise 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

- describe general characteristics of components listed above

- read and sketch simple circuit diagrams that contain the components listed above

- apply 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 circuit

Laws and principles

- Ohm's Law
  - $V = IR$

- Kirchhoff's Laws
  - $\sum I = 0$ Kirchhoff's Current Law
  - $\sum \Delta V = 0$ Kirchhoff's Voltage Law

- power
  - $P = VI = \frac{V^2}{R} = I^2R$
  - $R = \frac{P}{I^2} = \frac{V^2}{P}$
  - $V = \frac{P}{I} = \sqrt{PR}$
  - $I = \frac{P}{V} = \sqrt{\frac{P}{R}}$

- cells and batteries
  - series
    - $V_T = V_{B1} + V_{B2} + \ldots\ldots..$
  - parallel
    - $V_T = V_{B1} = V_{B2} = \ldots\ldots..$

- resistor networks
  - series
    - $R_T = R_1 + R_2 + R_3 +$
  - parallel (maximum of 2 resistors)
    - $R_T = \dfrac{R_1\,R_2}{R_1 + R_2}$ for a pair
    - $\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$
  - combinational networks of up to 4 resistors
    - Ohm's law
    - Kirchhoff's laws
    - Power

- capacitor
  - series (maximum of 2)
    - $C_T = \dfrac{C_1\,C_2}{C_1 + C_2}$
    - $\dfrac{1}{C_T} = \dfrac{1}{C_1} + \dfrac{1}{C_2}$
  - parallel
    - $C_T = C_1 + C_2 + C_3 + \ldots\ldots$

Production

- safety
  - electrical
  - drilling
  - soldering

- design printed circuit boards
  - single sided through hole – interfacing circuits

- 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
  - complex open loop
    - input(s)
    - process
      - subsystem(s) inside process block
      - subsystem(s) outside process block
      - output(s)

    - simple closed loop
        - input
        - process
        - control
            - feedback loop
            - error detection – negative only
        - output

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

- interpret flowcharts and explain how these function

- draw flowcharts given specifications

Logic gates

- NOT, AND, NAND, OR, NOR and XOR logic
    - symbols – all are two (2) input gates with the exception of NOT which has only one (1) input
    - recognise and complete truth tables for individual gates
    - recognise Boolean expressions for individual logic gates

$\overline{A}$ $A.B$ $\overline{A.B}$ $A+B$ $\overline{A+B}$ $A \oplus B$

- develop, describe and draw combinational logic diagrams that can be used to control a specified system – maximum of three (3) inputs
    - complete truth tables
    - derive Boolean logic expressions

Unit 2

Unit description

This unit develops students' 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 continue to refine their understanding and skills of the engineering design process, undertaking tasks to produce, test and evaluate the product. 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.

Unit content

This unit builds on the content covered in Unit 1.

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 appropriate forms of energy supplies

Devising

- produce annotated pictorial drawings of design ideas
- produce annotated orthographic drawings of design ideas
- analyse features of the chosen option to be developed 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
    - 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
- construct solution by selecting and using appropriate tools and machines, following safe work practices
- test the solution for correct function and document using checklists and test data

Evaluating

- evaluate 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

- define physical properties of materials
  - density
  - elasticity
  - plasticity
  - strength – tensile and compressive
  - stiffness
  - toughness
  - ductility
  - malleability
  - conductivity – electrical and thermal
  - corrosion resistance
- fitness for purpose
  - identify and describe the required properties of a material for a specified application

Fundamental engineering calculations

Volume

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

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 = $\frac{\text{output}}{\text{input}} \times 100$

Unfamiliar formula

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

Engineering in society

Obsolescence

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

Specialist engineering fields

Mechanical

Materials

- draw, label and interpret 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

- apply 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)
  - $v^2 = u^2 + 2as$
- define potential energy as energy of position or state
- define kinetic energy as energy of motion
- solve problems involving energy and energy conversion using
  - $E_p = mgh$
  - $E_k = \frac{1}{2}mv^2$
  - $\Delta E_p = \Delta E_k$

Mechanisms

- calculate the following for 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
- apply the 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

  $$v = \frac{(rpm)(2\pi r)}{60}$$
- determine velocity, distance or time variables using the relationship

  $v = \frac{s}{t}$ where $s = 2\pi r$ for winch drums
- define torque and apply the formula to determine one unknown
  Note – determining the applied force does not require vector resolution

  $\tau = rF$ torque = radius x Force

Mechatronics

Electrical/electronics

Laws and principles

- digital input
  - switch with resistor
    - 'pull up' (normally high signal)
    - 'tie down' (normally low signal)
    - Ohm's law
    - Kirchhoff's laws
- analogue inputs
  - voltage dividers
    - LDR with resistor or variable resistor
    - NTC thermistor with resistor or variable resistor
    - potentiometer

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

- NPN transistor
  - transistor model
    - cut-off
    - saturation
  - buffer/driver for a microcontroller
    - driving relays, DC motor (unidirectional), bulb/lamp, high current LED
      - transistor model
      - Ohm's law
      - Kirchhoff's laws
      - power

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

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

- data extraction
  - extract and use data from charts, tables and diagrams

Systems and control

Interfacing with microcontroller

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

- power supply
  - batteries
    - voltage to be specified or found on data sheet
  - voltage regulator
    - fixed positive voltage to be specified or found on data sheet

- digital input
  - 'high' and 'low' signals (also 0 and 1, 'on' and 'off')
  - sensors
  - switch with resistor
- analogue input
  - signal values that can vary on a defined scale
  - sensors
    - voltage dividers
- analogue to digital conversion (ADC)
  - 8 bit 0 – 255
  - 10 bit 0 – 1023
- 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 concept – mechanical switch models using
      - four (4) SPST switches
      - single DPDT switch
      - DPDT relay
    - H-bridge integrated circuit – motor controlled by two (2) outputs from microcontroller
      - includes L293D motor controller

Mechanics

Types of motion

- recognise linear, rotary, oscillating and reciprocating

Mechanical drive systems

- recognise and describe general characteristics and applications for:
  - pulley belt
  - chain and sprocket
  - spur gear drive
  - compound gear drive
  - worm and worm wheel
  - rack and pinion

Calculations

- velocity ratio = $\dfrac{\text{distance moved by effort}}{\text{distance moved by load}}$
- mechanical advantage = $\dfrac{\text{load}}{\text{effort}}$
- pulley belt ratio = $\dfrac{\text{Ø follower pulley}}{\text{Ø driver pulley}}$ = input revolutions: 1 output revolution

- chain and sprocket ratio = $\dfrac{\text{n}^{\text{o}}\text{ teeth follower gear}}{\text{n}^{\text{o}}\text{ teeth driver gear}}$ = input revolutions:1 output revolution

- gear ratio = $\dfrac{\text{n}^{\text{o}}\text{ teeth follower gear}}{\text{n}^{\text{o}}\text{ teeth driver gear}}$ = input revolutions:1 output revolution
  - pinion gear
  - idler gear

- worm and worm wheel ratio = $\dfrac{\text{n}^{\text{o}}\text{ teeth follower gear}}{1}$ = input revolutions:1 output revolution

- rack and pinion
  - distance moved = $\dfrac{\text{n}^{\text{o}}\text{ teeth pinion} \times \text{n}^{\text{o}}\text{ revolutions}}{\text{n}^{\text{o}}\text{ teeth per metre of rack}}$

- speed/velocity
  - velocity (v) = $\dfrac{\text{distance}}{\text{time}} = \dfrac{(\text{rpm})(2\pi\text{r})}{60}$
  - output speed (rpm) = $\dfrac{\text{input speed (rpm)}}{\text{gear or pulley ratio}}$

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 ATAR Year 11 syllabus and the weighting for each assessment type.

Assessment table – Year 11

Type of assessment	Weighting
Design Students investigate needs, opportunities and problems that are 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 devise 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 can also include a research assignment. Students apply their knowledge and skills in responding to a series of stimuli or prompts. Types of evidence can include tests, worksheets, a journal or observation checklists.	30%
Production Students finalise and document the specifications for their solution. They plan the making process by identifying and using appropriate tools and techniques. They 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 evaluated by the student. Teachers assess the students' understanding and competence when undertaking the making and evaluation of their engineered product. Types of evidence required include the engineered product and project folio (hard copy or electronic or combination). Other evidence can include a journal and observation checklists.	40%
Examination Typically conducted at the end of each semester and/or unit. In preparation for Unit 3 and Unit 4, the examination should reflect the examination design brief included in the ATAR Year 12 syllabus for this course.	30%

Teachers are required to use the assessment table to develop an assessment outline for the pair of units (or for a single unit where only one is being studied).

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 twice. In the assessment outline where a single unit is being studied, each assessment type must be included at least once.

The set of assessment tasks must provide a representative sampling of the content for Unit 1 and Unit 2.

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

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 (or for a unit where only one unit is being studied). 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 Engineering Studies ATAR Year 11 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 11

A	**Design** Independently investigates needs, opportunities and problems that are comprehensively documented and defined in a design brief. Investigates, evaluates and documents alternative solutions, with attention to detail that demonstrates insightful analytical skills. These may include existing products, systems, components and parts as well as the student's ideas. Presents a final design, thoroughly tested and evaluated against criteria that are defined in the design brief. Includes a variety of drawings, diagrams, tables, charts and text in the design folio, as required, and these are complete, accurate and clearly communicate information that is central to understanding the development, testing and evaluation of the design. Where other types of design related tasks are undertaken, for example, tests, worksheets, a journal or observation checklists, completes these with very few errors and with careful attention to detail.
	Production Presents in the design folio, clearly explained and documented final specifications for the solution and includes relevant detailed drawings, diagrams, tables, charts and text as required. These are accurate, complete and neatly presented. Provides final specifications that are an appropriate and sophisticated response to the design brief. Uses a timeline for producing and testing the resulting model or prototype; this is referred to, maintained and modified as required. Meets all deadlines on time. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the engineered product which is crafted to a very high standard with great care and attention to detail. Delivers a product that functions correctly, reliably and safely.
	Examination Attempts all calculations, which are accurately completed and correct units applied. Produces accurate, comprehensive and fully annotated diagrams to communicate solutions to given problems. Comprehensively explains key concepts using appropriate justifications where required. Correctly interprets data to develop comprehensive and realistic solutions to given problems.

B	**Design** Investigates, given some direction, the needs, opportunities and problems that are well documented and defined in a design brief. Investigates, evaluates and documents several alternative solutions with attention to coverage of all significant and obvious criteria identified in the design brief. Alternative solutions may include existing products, systems, components and parts as well as the student's ideas. Presents a final design that is thoroughly tested and evaluated against the criteria defined in the design brief. Includes drawings, diagrams, tables, charts and text in the design folio, as required. There are some obvious omissions but most of what is presented accurately and clearly communicates information that is central to understanding the development, testing and evaluation of the design. Where other types of design related tasks are undertaken, for example, tests, worksheets, a journal or observation checklists, completes these with very few errors and with attention to detail.

	Production Clearly explains and documents in the design folio final specifications for the solution, and includes drawings, diagrams, tables, charts and text as required. There are some minor omissions and/or errors but most of the specifications are accurate, complete and neatly presented. Presents final specifications as an appropriate response to the design brief with some degree of innovation and/or clever insight. Uses a timeline for producing and testing the resulting model or prototype, and is referred to and used to meet all or most deadlines on time. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the engineered product which is crafted to a high standard with care and attention to detail. Delivers a product that functions correctly, reliably and safely.
	Examination Completes most calculations accurately and applies correct units. Communicates solutions to given problems with accurate, annotated diagrams. Explains key concepts accurately and uses appropriate justifications where required. Correctly interprets data to develop realistic solutions to given problems.

	Design Investigates, given direction and prompting, the needs, opportunities and problems that are documented and defined in a design brief. Investigates, evaluates and documents several alternative solutions with reference to most of the significant and obvious criteria identified in the design brief. Alternative solutions may include existing products, systems, components and parts as well as the student's ideas. Provides the final design that has been thoroughly tested and evaluated against most of the criteria that are defined in the design brief. Includes in the design folio relevant drawings, diagrams, tables, charts and text as required. There are some obvious omissions but most of what is presented accurately and clearly communicates information that is central to understanding most key elements of the development, testing and evaluation of the design. Where other types of design related tasks are undertaken, for example, tests, worksheets, a journal or observation checklists, completes these to a satisfactory standard and with some attention to detail.
C	**Production** Clearly explains and documents in the design folio the final specifications for the solution and includes drawings, diagrams, tables, charts and text as required. There are some noticeable omissions and/or errors but most of the specifications are accurate, complete and neatly presented. Provides the final specifications that are an appropriate response to the design brief. Follows a timeline for producing and testing the resulting model or prototype, and meets most deadlines on time. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the engineered product which is crafted to a good standard with care and attention to most details. Delivers a resulting product that functions correctly, reliably and safely most of the time.
	Examination Correctly completes simple calculations. Attempts complex calculations but is prone to making errors. Produces simple, partially annotated diagrams to communicate solutions to given problems. Explanations of key concepts are mostly correct with simple or superficial justifications where required. Selects correct data to develop partial or simple solutions to given problems.

D	**Design** Given considerable direction and prompting, interprets a teacher directed design brief that results in a simplistic understanding of the need, opportunity or problem. Investigates, evaluates and documents one or two alternative solutions. These are referenced to some of the criteria identified in the design brief. Tests and evaluates the final design in a superficial manner against some of the criteria that are defined in the design brief. Provides few drawings, diagrams, tables, charts and text in the design folio. These are mostly incomplete, and only provide the reader with a little understanding the development, testing and evaluation of the design. If other types of design related tasks are undertaken, for example, tests, worksheets, a journal or observation checklists, then completes these with a significant number of careless errors and/or omissions.
	Production Presents simplistic documentation of final specifications in the design folio. A significant number of required drawings, diagrams, tables, charts and text are incomplete and/or missing. The final specifications are an appropriate, albeit simplistic, response to the design brief. Generally does not adhere to a timeline for producing and testing the resulting model or prototype, and most deadlines are not met on time. Uses tools and techniques on most occasions in a safe and appropriate manner to manufacture and/or assemble the engineered product which is crafted to a limited standard with some obvious inaccuracies and/or incomplete sections. Delivers a resulting product that occasionally functions reasonably well but is prone to being unreliable.
	Examination Achieves limited accuracy with simple calculations. Produces vague or confusing diagrams when attempting to communicate solutions to given problems. Explains key concepts in a simplistic or only partially completed manner. Often interprets data incorrectly resulting in vague and/or unfeasible solutions to given problems.

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