Government of Western Australia
School Curriculum and Standards Authority

Engineering Studies

ATAR 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 2025.

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 opinions.

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 focuses on real-life contexts through a blend of theoretical and practical applied learning. 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.

Aims

The Engineering Studies ATAR course is designed to enable students to:

- identify and compare forms, sources and uses of energy
- apply and communicate a process to design, make, and evaluate engineered products through
  - investigating needs and opportunities
  - generating engineering production proposals to provide solutions
  - managing engineering production processes to produce solutions
  - evaluating intentions, plans and actions
- understand and explain properties and behaviours of materials and components
- understand and apply scientific and mathematical concepts used in the engineering context
- use materials, skills and technologies when undertaking an engineering challenge by
  - applying initiative and organisational skills
  - applying skills of calculation and computation
  - utilising materials, techniques and technologies to achieve solutions to engineering challenges
  - operating equipment and resources safely
- investigate, analyse and understand the interrelationships between engineering projects and society, the environment and industry.

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 this unit, students undertake a major project as an engineering design process. This begins with the development of a comprehensive design brief that has a problem, need or opportunity as its focus. The students must synthesise a response to the brief by engaging in a range of activities that include detailed research of similar existing engineered products, construction materials and components; sketching, drawing and notating concepts; and analysing and justifying the choice of the most promising of these for production as a prototype or working model. Students then undertake the production of their product, including formative testing and evaluation. This requires them to carefully manage time and resources to meet deadlines for completion of tasks.

Through the study of core and specialist area theory, students develop their understanding of the scientific, mathematical and technical concepts that explain how engineered products function.

They also study the effects on society, the environment and business of obtaining and using different forms of renewable and non-renewable energy.

Unit 4

Students refine their use of the engineering design process to acquire knowledge, understandings and skills necessary to complete the production of their major project and to test and evaluate the resulting product.

Core and specialist area theory continues to be studied to further develop their understanding of the scientific, mathematical and technical concepts necessary to predict and explain the behaviour of engineered products.

Students also consider and analyse the stages within the life cycle of engineering products. They develop and demonstrate an understanding of the effects on society, the environment and business that occur during the life cycle of engineered products.

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 uses 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 optional two specialist fields allows for students to develop a greater specific practical understanding of major engineering and industrial technologies.

Core content

- Engineering design process
- Materials
- Fundamental engineering calculations
- Mechanisms
- Effects on society, the environment and industry

Specialist engineering fields

- Mechanical

  OR

- Mechatronics

Core content

Engineering design process

Investigating

The starting point for the engineering design process is creating, interpreting, and responding to a design brief. 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 that is developed and/or maintained by the student.

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; calculating variables for mechanisms, energy, work, power and efficiency; and using unfamiliar formulae to solve problems.

Mechanisms

Identifying and understanding the characteristics of common machines and mechanisms, including the mechanics of motion, drive systems, formulas and calculations, and quantities used to measure variables associated with inputs and outputs of mechanical systems.

Effects on society, the environment and industry

The effects of engineering on society, the environment and industry are vital considerations in engineering. Two major concepts are studied. These are: forms, sources and uses of energy; and life cycle analysis (LCA) of engineered products.

Specialist engineering fields

Mechanical

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

- Materials
- Statics
  - deflection of beams
  - method of sections
- Dynamics.

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.

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.

The graphed results of a tensile test conducted on a material can accurately depict the relationship between stress, strain, yield point, UTS, ductility, toughness, resilience and Young's Modulus of the test sample, and are fundamental to understanding the mechanical properties of materials in order to determine their suitability for purpose and are used throughout engineering.

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 is divided into two content areas:

- Electrical and electronics
  - components and equipment
  - laws and principles
  - quantities and unit prefixes
- Systems and control
  - systems and control diagrams
  - flowcharts
  - interfacing with a microcontroller.

Mechatronics is a multidisciplinary field that refers to the skill sets needed in contemporary, advanced automated technology industries. At the intersection of mechanics, electronics, and computing, mechatronics specialists create simpler, smarter systems. Mechatronics is an essential foundation for the growing trends in robotics and automation in many fields such as manufacturing, minerals processing, mining, pollution control, renewable power generation and waste processing.

The subject content is based around the characteristics and use of microcontrollers and how they are interfaced into 'real world' applications.

An understanding of scientific, mathematical and technical concepts contained in the two content areas coupled with the engineering core content and 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 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 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 ATAR 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. 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 may 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 3

Unit description

In this unit, students undertake a major project for which they use an engineering design process. This begins with the development of a comprehensive design brief that has a problem, need or opportunity as its focus. The students must synthesise a response to the brief by engaging in a range of activities that include detailed research of similar existing engineered products, construction materials and components; sketching, drawing and notating concepts; and analysing and justifying the choice of the most promising of these for production as a prototype or working model. Students then undertake the production of their product including formative testing and evaluation. This requires them to carefully manage time and resources to meet deadlines for completion of tasks.

Through the study of core and specialist area theory, students develop their understanding of the scientific, mathematical and technical concepts that explain how engineered products function.

They also study the effects on society, the environment and business of obtaining and using different forms of renewable and non-renewable energy.

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.

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

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 comprehensive design brief in response to a problem, need or opportunity (student and/or teacher directed)
- conduct research to identify and assess existing solutions or similar products
- research and critique materials and components relevant to the design brief
- consider different ways to supply energy for efficient and effective functioning of the design

Devising

- produce annotated pictorial sketches and/or drawings of design ideas
- produce annotated 3rd angle orthographic sketches of design ideas
- compare and analyse alternative designs and justify the choice of options to be used as the solution

Producing

- present specifications for the selected solution

    - annotated pictorial drawings
    - orthographic drawings and sketches are 3rd angle projections that comply with the accepted standards for
        - lines – outlines, hidden detail, and centrelines
        - dimensioning - linear, radii, circles, spheres and part spheres, through holes and partial depth with flat base
    - select materials with justification of choices
    - parts lists
    - costing of the project, i.e. a prototype or working model
- project management skills for timely development and testing of project
- construct a prototype or working model by selecting and using appropriate tools and machines and by following safe work practices
- test those aspects of the prototype or working model that have been completed for correct function and document using checklists and test data

Evaluating

- evaluate the development of the project
    - meeting the requirements of the design brief
    - safety, function, fit and finish
    - modifications and changes to the design during production

Materials

Types and classification

- define and compare
    - metals (pure)
    - alloys
        - ferrous
        - non-ferrous
    - polymers
        - thermoplastic
        - thermoset
        - elastomer
    - composite
- classify
    - metals (pure)
        - aluminium
        - copper
        - zinc
        - iron
    - alloys
        - ferrous (includes major constituents)

    - steel (iron and carbon)
    - stainless steel (iron, carbon, nickel and chromium)
    - cast iron (iron and carbon)
  - non-ferrous (includes major constituents)
    - brass (copper and zinc)
    - bronze (copper and tin)
- polymers
  - thermoplastic (abbreviations only where applicable)
    - acrylic
    - polycarbonate
    - ABS (acrylonitrile butadiene styrene)
    - PLA (polylactic acid)
    - PVC (polyvinyl chloride)
  - thermoset
    - epoxy and polyester resin
  - elastomer
    - natural and synthetic rubber
- composite
  - concrete
    - normal
    - reinforced
  - fibre-reinforced plastic (FRP)

Fundamental engineering calculations

Dimensional

- examine dimensioned drawings to determine
  - overall length, width, and height
  - direct and indirect dimensions

Perimeter

- determine perimeter of
  - square and rectangular plane figures
  - right-triangular plane figures
    - hypotenuse^2 = opposite^2 + adjacent^2
    - $\cos\theta = \frac{a}{h}$, $\sin\theta = \frac{o}{h}$ and $\tan\theta = \frac{o}{a}$
  - circle
    - $C = \pi d$

Surface area

- determine surface area of
  - square and rectangular plane figures

  - cubes and rectangular right prisms
  - right-triangular plane figures
  - triangular right prisms
  - circles
    - $A = \pi r^2$
  - open-ended cylinder
    - $A = \pi dh$
  - spheres
    - $A = 4\pi r^2$

Volume

- determine volume of:
  - cubes, rectangular right-prisms, and triangular right-prisms
  - cylinders
    - $V = \pi r^2 h$
  - spheres
    - $V = {}^4/_3\, \pi r^3$

Units

Quantity	Unit name	Unit
Length *(L)*	metre	m
Area *(A)*	square metre	m^2
Volume *(V)*	cubic metre	m^3

Prefixes

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

Mechanisms

Simple machines and mechanisms

- mechanical advantage (*MA*)
  - definition and examples
    - inclined plane (including screw threads)

        - three classes of levers
- velocity ratio (*VR*)
    - definition and examples
- explain and give examples of the following types of motion
    - linear
    - reciprocating
    - rotary
    - oscillating
    - transformation of motion
        - rotary into linear and vice-versa
        - rotary into reciprocating and vice-versa
        - rotary into oscillating and vice-versa
- recognise and describe general characteristics and applications for
    - pulley belt
    - chain and sprocket
    - simple gear drive
        - idler gear
    - compound gear drive
    - worm and worm wheel (single start)
    - rack and pinion
    - lead screw (single and multiple start)

Effects on society, the environment and industry

Energy

- energy, work, and power
    - definitions
    - examples
- conservation of energy
    - definition
    - examples
- forms of energy
    - kinetic
        - definition
        - examples
    - potential
        - definition
        - examples
- non-renewable sources of energy
    - fossil fuels
        - coal
        - gas

- oil
- nuclear
- renewable sources of energy
  - solar
    - thermal
    - photovoltaic
  - wind
  - hydroelectric
  - geothermal
  - ocean
    - tidal
    - waves
  - hydrogen
    - assuming production uses renewable sources, i.e. ‘green’ hydrogen
- advantages and disadvantages for society, industry and the environment of obtaining and using non-renewable and renewable sources of energy

Specialist engineering fields

Mechanical

Materials

- define the terms stress, pressure, strain and Young’s Modulus (modulus of elasticity)
- select and use the following formula
  - stress and pressure
    - $\sigma = \frac{F}{A}$ and $P = \frac{F}{A}$
  - strain
    - $\varepsilon = \frac{\Delta L}{L}$
  - elasticity (Young’s Modulus)
    - $E = \frac{\sigma}{\varepsilon}$
    - $E = \frac{FL}{A\Delta L}$
- stress-strain graphs
  - recognise and analyse stress strain graphs for
    - ABS
    - copper
    - mild steel
    - stainless steel
  - derive values from graphs and tables for
    - Young’s Modulus
    - elastic limit

- yield stress
- yield strain
- ultimate tensile strength (UTS)

Units

Quantity	Unit name	Unit
Length (L)	metre	m
Area (A)	square metre	m^2
Stress (σ) or Pressure (P)	newtons per square metre or pascal	Nm^{-2} Pa
	kilo newtons per square metre or kilo pascal	kNm^{-2} kPa
	newtons per square millimetre or mega pascal	Nmm^{-2} MPa
	kilo newtons per square millimetre or giga pascal	$kNmm^{-2}$ GPa
Strain (ε)	no units (ratio of length over length)	
Young's Modulus (E)	newtons per square metre	Nm^{-2}

Statics

Beams

- determine one unknown where the applied force may need to be resolved into its component forces, to contain no more than two vector resolutions
- define a moment as
  - $M = Fd$
- three conditions for equilibrium
  - $\Sigma M = 0$
    - $\Sigma \text{CWM} = \Sigma \text{ACWM}$
  - $\Sigma F_x = 0$
    - $\Sigma F_{\text{left}} = \Sigma F_{\text{right}}$
  - $\Sigma F_y = 0$
    - $\Sigma F_{\text{up}} = \Sigma F_{\text{down}}$

  Note: for this course the conventions are CWM are positive, F_{right} are positive and F_{up} are positive

- calculate applied forces as vertical and horizontal with no more than one angular force requiring trigonometry to resolve for its horizontal and vertical components
- use 'conditions of equilibrium' formulae to solve for one unknown external force or distance variable
- use moments formula to determine the reaction forces at a beam's supports (two supports only)
  - $\Sigma M = 0$
    - $\Sigma CWM = \Sigma ACWM$
  - $\Sigma F_y = 0$
    - $\Sigma F_{up} = \Sigma F_{down}$

  Note: for this course the conventions are CWM are positive and F_{up} are positive

- construct shear force and bending moment diagrams for simply supported beams
  - horizontal and supported at both ends
  - horizontal and supported at one end, i.e. simple cantilever
  - vertical point loads
  - full or partial uniformly distributed loads (UDLs)
  - or a combination of the two
  - calculate shear force (SF) values finding the SF to the left and right of specified points
  - calculate bending moment (BM) values at specified points, including the magnitude and position of the maximum bending moment
  - where the maximum bending moment occurs along a UDL, calculate the position of the maximum bending moment using
    - $x = \frac{y}{m}$
      - y = SF at start of UDL
      - m = the gradient of SF under the UDL = uniformly distributed load per unit length (ω)
- second moment of area for material cross-sections
  - rectangular solid section (base is horizontal)
    - $I_{xx} = \frac{bh^3}{12}$
  - rectangular hollow section (base is horizontal)
  - $I_{xx} = \frac{b_o\ h_o^3}{12} - \frac{b_i\ h_i^3}{12}$
  - round solid section
    - $I_{xx} = \frac{\pi D^4}{64}$
  - circular tube section
    - $I_{xx} = \frac{\pi(D_o^4 - D_i^4)}{64}$
- data extraction
  - extract and use data from charts, graphs, tables and diagrams

Units

Quantity	Unit name	Unit
moments (M)	newton metre	Nm
force (F)	newton	N
distance (d)	metre	m
uniformly distributed load per unit length (ω)	newtons per metre	N m^{-1}
second moment of area (I_{xx})	millimetres to the fourth power	mm^4
breadth of beam (b)	millimetre	mm
height of beam (h)	millimetre	mm
diameter of beam (D)	millimetre	mm

Quantity	Unit
second moment of area (I_{xx})	mm^4

Trusses

Method of sections

- simply supported pin-jointed, parallel chord trusses
  - calculate reaction forces at supports
    - all external forces are vertical
    - truss is horizontal
    - $\Sigma M = 0$
    - $\Sigma CWM = \Sigma ACWM$
    - $\Sigma F_y = 0$
    - $\Sigma F_{up} = \Sigma F_{down}$

    Note: for this course the conventions are *CWM* are positive, and F_{up} are positive
  - calculate forces in members
    - sectioning line cuts three (3) members maximum
    - use $\sum M$ calculations to determine unknown force in *at* least 2 of the sectioned members
    - all external forces are vertical
    - use $\sum M$ calculations to determine unknown force in at least 2 of the sectioned members
    - $\Sigma M = 0$
    - $\Sigma CWM = \Sigma ACWM$

      Note: for this course the convention is *CWM* are positive
    - the unknown force in the third sectioned member can be determined using ΣF_x or ΣF_y
    - $\Sigma F_x = 0$

- $\Sigma F_{left} = \Sigma F_{right}$
- $\Sigma F_y = 0$
- $\Sigma F_{up} = \Sigma F_{down}$

  Note: for this course the conventions are F_{right} are positive and F_{up} are positive

Units

Quantity	Unit name	Unit
Moment *(M)*	newton-metre	N m
force (F)	newton	N

Mechatronics

Electrical and electronics

Components and equipment

- circuit symbol, general appearance and characteristics of
  - cells and batteries
  - power supply (DC)
  - fuse
  - voltage regulator
    - 3-pin fixed voltage positive (7805 or similar)
  - switches
    - SPST, SPDT and DPDT
    - push to make (N/O) and push to break (N/C)
    - N/O magnetic reed
  - fixed value resistors
  - potentiometer
    - including its use as a variable resistor
  - light dependent resistor (LDR)
  - thermistor (NTC)
  - capacitor
    - polarised (electrolytic and tantalum)
    - non-polarised (assume not electrolytic or tantalum)
  - diodes
    - silicon rectifier
    - LED
  - DC motor
  - piezo sounder
  - electromagnet, including solenoid
  - servo 0 - 180^0 and 360^0 (continuous)
  - stepper motor

        - bipolar (full stepping)
    - SPDT and DPDT relays
    - transistor
        - NPN
    - integrated circuits
        - voltage regulator (7805 or similar)
        - microcontroller
        - L293D or similar H-bridge IC
        - UNL2803 Darlington driver or similar
- read and understand markings:
    - fixed value resistors - 4 band E12 values
    - capacitors: E12 values, µF (polarised) and 3-digit labelling (non-polarised)
    - serial numbers
        - refer to data sheets or diagrams to identify component and determine pin outs for
            - voltage regulator
            - NPN transistors
            - integrated circuits (including microcontroller)
- read and sketch circuit diagrams that contain listed components
- multimeter
    - correct setup and use to measure
        - voltage
        - resistance
        - current

Electrical and electronics

Laws and principles

- charge
    - $Q = It$
- Ohm's law
    - $V = IR$
- power
    - $P = VI = I^2R = \frac{V^2}{R}$
- voltage
    - $V = \frac{P}{I} = \sqrt{P \ x \ R}$
- current
    - $I = \frac{V}{R} = \frac{P}{V} = \sqrt{\frac{P}{R}}$
- resistance
    - $R = \frac{V}{I} = \frac{P}{I^2} = \frac{V^2}{P}$

- Kirchhoff's laws
  - Kirchhoff's voltage law (KVL)
    - $\sum \Delta V = 0$
  - Kirchhoff's current law (KCL)
    - $\sum I = 0$
- cells and batteries
  - series
    - $V_T = V_1 + V_2 +$
    - $I_T = I_1 = I_2 =$
  - parallel
    - $V_T = V_1 = V_2 =$
  - current capacity
    - $\text{Ah} = \frac{Wh}{V}$
- resistor networks
  - series
    - $R_T = R_1 + R_2 + \ldots$
  - parallel
    - $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
  - combinational
    - apply following formulae
      - series resistors
      - parallel resistors
      - Ohm's law
      - power
      - KVL
      - KCL
- capacitor networks
  - charge
    - $Q = CV$
  - series
    - $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots..$
    - $Q_T = Q_1 = Q_2 = \ldots.$
  - parallel
    - $C_T = C_1 + C_2 + \ldots.$
    - $Q_T = Q_1 + Q_2 + \ldots.$
  - combinational
    - maximum of three capacitors
    - apply KVL and appropriate formulas to determine values for:
      - capacitance, charge, and voltage

- voltage dividers
  - $V_1 = V_{CC} \times \frac{R_1 \times R_2}{R_1 + R_2}$
  - $V_2 = V_O = V_{CC} \times \frac{R_1 \times R_2}{R_1 + R_2}$
  - $V_{CC} = V_1 + V_2$
- diodes
  - silicon rectifier diode
    - forward and reverse bias
    - 0.6 V forward voltage
    - back e.m.f. protection
    - reverse voltage protection
  - light emitting diode (LED)
    - forward and reverse bias
    - forward voltage from data sheet
    - current limiting resistor
      - $R = \frac{V_{cc} - V_{LED}}{I_{LED}}$
      - KVL
      - KCL

Units

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

Systems and Control

Systems and control diagrams

- universal block diagram
  - input
  - process
  - output
- subsystem diagram
  - systems boundary
  - external input/s

        - external output/s
        - subsystems within boundary
            - microcontroller
            - programming
            - interfacing circuits
                - sensors
                - driver circuits
            - actuators (motors)
                - electromagnet including solenoid
                - DC motor
                - servo 0^{O} – 180^{O} and 360^{O} (continuous)
                - bipolar stepper motor
            - mechanisms
- open-loop
    - input
    - processes
    - output
    - no feedback from output to input
- closed-loop
    - input
        - set point
    - controller
    - system (plant)
    - output
    - output sensor
    - error detector
        - negative feedback only

Unit 4

Unit description

Students refine their use of the engineering design process to acquire knowledge, understandings, and skills necessary to complete the production of their major project and to test and evaluate the resulting product.

Core and specialist area theory continues to be studied to further develop their understanding of the scientific, mathematical and technical concepts necessary to predict and explain the behaviour of engineered products.

Students also consider and analyse the stages within the life cycle of engineering products. They develop and demonstrate an understanding of the effects on society, the environment and business that occur during the life cycle of engineered products.

Unit content

This unit builds on the content covered in Unit 3.

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

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

Producing

- present specifications for the selected solution
  - dimensioned pictorial and orthographic drawings
  - orthographic drawings and sketches are 3rd angle projections that comply with the accepted standards for
    - lines – outlines, hidden detail, and centrelines
    - dimensioning – linear, radii, circles, spheres and part spheres, through holes or partial depth holes with flat base
  - selected materials with justification of choices
  - parts lists
  - costing of prototype or working model
- project management skills for timely completion and testing of project
- construct the prototype or working model by selecting and using appropriate tools and machines and by following safe work practices
- test the prototype or working model for correct function and documents using checklists and test data

Evaluating

- evaluate the resulting prototype or working model
  - meeting the requirements of the design
  - safety, function, fit and finish
  - modifications and changes to the design during production
  - refinements and changes for future development

Materials

Properties

- define and compare
  - density
  - elasticity
  - plasticity
  - ductility
  - malleability
  - strength
    - tensile
    - compressive
    - torsional
    - shear
  - stiffness
  - toughness
  - resilience
  - conductivity
    - thermal
    - electrical
  - corrosion resistance
  - hardness
- fitness for purpose
  - identify and justify properties required of a material for a specified purpose

Fundamental engineering calculations

Density

- Density = $\rho = \frac{m}{V}$ = kg m^{-3}

Quantity estimates

- determine the following for combinations of previously specified geometric shapes and forms (the latter may be solid or hollow)
  - surface area
  - volume
  - mass

- density

Efficiency

- calculate efficiency as a percentage
  - $\eta = \frac{Output}{Input} \times 100\%$

Unfamiliar formula

- determine unknown factor in unfamiliar formula associated with geometric shapes and forms given sufficient data to complete the calculation

Units

Quantity	Unit name	Unit
Length *(L)*	metre	m
Area *(A)*	square metre	m^2
Volume *(V)*	cubic metre	m^3
Mass *(m)*	kilogram	kg
Density (ρ)	kilograms per cubic metre	kg m^{-3}

Fundamental engineering calculations

Mechanisms

- mechanical advantage (MA)
  - $MA = \frac{F_{(load)}}{F_{(effort)}}$
- velocity ratio (VR)
  - $VR = \frac{d_{(effort)}}{d_{(load)}}$
  - pulley belt
    - $VR = \frac{Ø_{(follower)}}{Ø_{(driver)}}$
  - chain and sprocket
    - $VR = \frac{n^o\ teeth_{(follower)}}{n^o\ teeth_{(driver)}}$
  - gear drive
    - $VR = \frac{n^o\ teeth_{(follower)}}{n^o\ teeth_{(driver)}}$
    - idler gear
  - worm and worm wheel (single start)
    - $VR = \frac{n^o\ teeth_{(worm\ wheel)}}{1}$
  - compound gear drive
    - $VR = \frac{F_1 F_2 F_3}{D_1 D_2 D_3} \ldots$
      - F = n° teeth follower
      - D = n° teeth driver
    - compound pulleys

- rack and pinion
  - distance moved = $\frac{n^o \text{ teeth pinion} \times n^o \text{ revolutions}}{n^o \text{ teeth per metre rack}}$
- lead screw
  - single start
    - distance moved = pitch x revs
  - multiple start
    - Lead (distance moved) = n° starts × pitch × revs
- ideal machine (100% efficiency)
  - MA = VR
- speed/velocity (v)
  - $v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i} = \frac{distance}{time} = \frac{(rpm)(2\pi r)}{60}$
  - output speed = $\frac{Input\ speed\ (rpm)}{VR}$
- torque
  - $\tau = rF$
    - no vector resolution required for calculations of torque

Unfamiliar formula

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

Units

Quantity	Unit name	Unit
speed/velocity (v)	metres per second	$m\ s^{-1}$
distance (s)	metre	m
time (t)	second	s
torque (τ)	newton-metre	N m
force (F)	newton	N

Fundamental Engineering calculations

Energy, work and power

- energy
  - E = Pt
  - $E_P = mg\Delta h$
  - $E_K = {}^1/_2 mv^2$
  - $\Delta E_P = \Delta E_K$ (assuming 100% efficiency)
- work (linear)
  - $W = Fs = F\Delta x = F(x_f - x_i)$

- work (rotational)
  - $W = \tau\Theta$
    - 1 revolution (360°) = 2π rad
- power (linear)
  - $P = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t} = \frac{Fs}{\Delta t} = \frac{F\Delta x}{\Delta t} = \frac{F(x_f - x_i)}{\Delta t} = Fv$
- power (rotational)
  - $P = \frac{\tau\Theta}{t} = \tau\omega = \tau\frac{(rpm)(2\pi)}{60}$
- power (electrical)
  - $P = V \times I$

Unfamiliar formula

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

Units

Quantity	Unit name	Unit
energy (E)	joule	J
	kilowatt hour	kW h
	megawatt hour	MW h
power (P)	watt	W
time (t)	second	s
mass (m)	mass	kg
gravity (g)	metres per second squared	m s^{-2}
height (h)	metre	m
velocity (v)	metres per second	m s^{-1}
work (W)	joule	J
force (F)	newton	N
distance (s)	metre	m
torque (τ)	newton-metre	N m
angular displacement (Θ)	radian	rad
angular velocity per second (ω)	radians per second	rad s^{-1}
voltage (V)	volt	V
current (I)	amp	A

Effects on society, the environment and industry

Life cycle analysis of engineered products

- define the term 'life cycle analysis'
  - material inputs and outputs
  - energy inputs and outputs
  - disruption to environment
- stages of the life cycle
  - materials acquisition
  - processing materials
  - manufacture
  - packaging
  - transport
  - maintenance/operation
  - reuse/recycle/disposal
- describe effects on society, the environment and industry that occur during the life cycle of engineered products.

Specialist engineering fields

Mechanical

Materials

- properties of materials represented in a stress-strain graph
  - toughness
    - the energy absorbed by a material without fracturing and measured by the area under the stress-strain graph up to the point of failure—no calculations are required
  - resilience
    - the energy absorbed by a material within its linearly elastic range and measured by the area under the stress-strain graph up to the yield point – no calculations are required
- processes applied to steel alloys
  - rolled – both hot and cold
  - cold drawn
  - casting
  - forging
  - pressing
- Factor of safety
  - $FS = \frac{\sigma_{UTS}}{\sigma_{safeworking}}$
- unfamiliar formula
  - determine unknown factor in unfamiliar formula given sufficient data, with descriptions, to complete the calculation
- data extraction
  - extract and use data from charts, graphs, tables and diagrams

Statics

Deflection of beams

- calculate one unknown variable using one of the four beam deflection formulae
  - cantilevered beam with single load at unsupported end
    - $y = \frac{FL^3}{3EI_{xx}}$
  - cantilevered beam with UDL along whole length of the beam and can be, or include self-weight of beam
    - $y = \frac{F_{UDL}L^3}{8EI_{xx}}$
  - centrally loaded beam simply supported at both ends
    - $y = \frac{FL^3}{48EI_{xx}}$
  - universally loaded beam simply supported at both ends. The UDL is spread along the whole length of the beam and can be, or include self-weight of the beam.
    - $y = \frac{5F_{UDL}L^3}{384EI_{xx}}$
- deflection scenarios, when solving for '*y*', are to be calculated in isolation and a maximum of two load scenarios in total may be combined to give the final deflection sum

Note: second moment of area (Ixx) values for differing beam cross-sections beyond the four specified under the 'Second moment of area' heading can be directly provided for use in deflection calculations.

Units

Quantity	Quantity	Unit
maximum deflection (y)	millimetre	mm
force of uniformly distributed load (F_{UDL})	newton	N
length of beam (L)	millimetre	mm
Young's Modulus (E)	newtons per square millimetre	N mm^{-2} or MPa
second moment of area (I_{xx})	millimetres to the power of four	mm^4

Dynamics

Constant acceleration in straight line motion

- $F = ma$
  - $a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$
    - $v_f = v_i + a\Delta t$
  - $v_f^2 = v_i^2 + 2as$
  - $s = v_i\Delta t + {}^1/_2 a\Delta t^2$
    - not quadratic equation

- mathematical resolution of vectors for displacement, velocity and acceleration

Units

Quantity	Unit name	Unit
Force (F)	newton	N
Mass (m)	kilogram	kg
Acceleration (a)	metres per second squared	ms^{-2}
Initial velocity (u)	metres per second	ms^{-1}
final velocity (v)	metres per second	ms^{-1}
distance (s)	metre	m
time (t)	seconds	s

Mechatronics

Electrical and electronics

Systems and control

Interfacing with microcontroller

- microcontroller
  - external connections
    - power
      - 5 V voltage regulator
      - 7805 or similar
      - input voltage as per data sheet
      - 5 V output
      - smoothing capacitors
    - digital pins (I/0)
      - input
        virtually no current draw
      - output

Note: current draw per pin and total as per data sheet

- analogue pins
  - detects voltage on a scale 0 – 5 V

Note: see ADC under Analogue inputs

- virtually no current draw

- serial
  - serial input (RX) UART
  - serial output (TX) UART

Note: no need to code the above serial connections

- digital inputs
  - switch with pull-up resistor

- switch with tie-down resistor
- calculate digital states as voltages

- analogue inputs
  - voltage dividers
    - potentiometer
    - LDR in series with fixed value resistor or variable resistor
    - NTC in series with fixed value resistor or variable resistor
    - calculate values for voltage, resistance, current and power
  - analogue to digital conversion (ADC)
    - convert voltage into 8-bit and 10-bit values and vice versa
      - 8-bit
      - Range 0 – 255
      - Values $2^8 = 256$
      - 8-bit value = $\frac{V_O}{5\ V} \times 255$
- digital outputs
  - light emitting diode (LED)
    - sink configuration
    - source configuration
    - forward bias (correct polarity)
    - forward voltage
    - current limiting resistor
    - calculate values for voltage, resistance, current and power
  - piezo sounder
    - source configuration
    - controlled by potential difference
  - NPN transistor
    - common emitter configuration
    - base resistor
    - back e.m.f. diode (inductive loads)
    - calculate values for voltage, current, resistance, power and gain (β)
    - output transducers
      - high power LED
      - SPST and DPDT relay
      - DC motor
      - electromagnet (including solenoid)
  - Darlington pair
    - ULN2803 or similar
    - pinout sourced from data sheet

- controlling output actuators:
  - LED
  - piezo sounder
  - relay
  - DC motor
  - electromagnet (including solenoid)
- H-bridge
  - DPDT switch
  - DPDT relay
  - L293D or similar
  - pinout sourced from data sheet
    - single DC motor
    - independent pair DC motors
    - PWM speed control
      - frequency $f = \frac{1}{t}$
      - duty cycle i.e. % t is high
    - bipolar stepper motor
      - 4-steps (full stepping)
- servo motor
  - 0 -180 and 360 (continuous)
  - external connections
    - ground
    - supply (separate)
      - 4.8 V – 7.2 V (6 V preferred)
    - signal
      - PWM output from microcontroller
      - f = 50 Hz
      - duty cycle
        - 1 ms high = 5% = 0°
        - 1.5 ms high = 7.5% = 90°
        - 2 ms high = 10% = 180°
- bipolar stepper motor
  - full stepping (given chart showing coil sequences)

Electrical and electronics

Laws and principles

- NPN transistor model
  - cut-off
    - $I_B = I_C = 0$ A
  - forward-active

  - $\beta = \frac{I_C}{I_B}$
  - $I_B > 0$ A
  - $V_{BE} = 0.7$ V
  - $V_{CE} > 0$ V
- saturation
  - $\frac{I_C}{I_B} < \beta$
  - $I_B > 0$ A
  - $V_{BE} = 0.7$ V
  - $V_{CE} = 0$ V
- determine circuit values using
  - NPN transistor model
  - KVL
  - KCL
  - Ohm's law
  - Power

- Darlington pair
  - gain (β) approximation
    - $\beta_{Total} = \beta_1 \times \beta_2$
  - base-emitter voltage
    - $V_{BE,Total} = V_{BE1} + V_{BE2} = 0.7 + 0.7 = 1.4$ V
- data extraction
  - extract and use data from charts, graphs, tables and diagrams

Systems and control

Flow charts

- standard symbols
  - start/subroutine/stop
    - symbol: rectangle with semicircular ends
  - decision
    - symbol: diamond
    - yes no
      - switch condition
      - analogue value
      - variable value
  - process
    - symbol: rectangle
    - delay

    - mathematical operations (variables)
      - set variable(s)
      - add
      - subtract
      - multiply
      - divide
      - comparison
        - $= \neq < \leq > \geq$
      - mapping
        - 10-bit input to 8-bit output
          - potentiometer value (0 – 1023) mapped to PWM speed control (0 – 255) of DC motor
          - the above is a division operation using variables
        - 10-bit input to angle output
          - potentiometer value (0 – 1023) mapped to angle position (0° – 180°) of servo motor
          - the above is a division operation using variables
  - output
    - symbol: parallelogram
  - subroutine – call up
    - symbol: rectangle with vertical stripes inset at each end
  - flow of computation
    - arrowed line
- interpret flow charts
  - explain functions
- draw flow charts
  - these relate to listed interfacing circuits and mechatronic applications

Assessment

Assessment is an integral part of teaching and learning that at the senior secondary years:

- provides evidence of student achievement
- identifies opportunities for further learning
- connects to the standards described for the course
- contributes to the recognition of student achievement.

Assessment for learning (formative) and assessment of learning (summative) enable teachers to gather evidence to support students and make judgements about student achievement. These are not necessarily discrete approaches and may be used individually or together, and formally or informally.

Formative assessment involves a range of informal and formal assessment procedures used by teachers during the learning process in order to improve student achievement and to guide teaching and learning activities. It often involves qualitative feedback (rather than scores) for both students and teachers, which focuses on the details of specific knowledge and skills that are being learnt.

Summative assessment involves assessment procedures that aim to determine students' learning at a particular time, for example when reporting against the standards, after completion of a unit/s. These assessments should be limited in number and made clear to students through the assessment outline.

Appropriate assessment of student work in this course is underpinned by reference to the set of pre-determined course standards. These standards describe the level of achievement required to achieve each grade, from A to E. Teachers use these standards to determine how well a student has demonstrated their learning.

Where relevant, higher order cognitive skills (e.g. application, analysis, evaluation and synthesis) and the general capabilities should be included in the assessment of student achievement in this course. All assessment should be consistent with the requirements identified in the course assessment table.

Assessment should not generate workload and/or stress that, under fair and reasonable circumstances, would unduly diminish the performance of students.

School-based assessment

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

School-based assessment involves teachers gathering, describing and quantifying information about student achievement.

Teachers design school-based assessment tasks to meet the needs of students. As outlined in the *WACE Manual*, school-based assessment of student achievement in this course must be based on the Principles of Assessment:

- Assessment is an integral part of teaching and learning

- Assessment should be educative
- Assessment should be fair
- Assessment should be designed to meet its specific purpose/s
- Assessment should lead to informative reporting
- Assessment should lead to school-wide evaluation processes
- Assessment should provide significant data for improvement of teaching practices.

The table below provides details of the assessment types and their weighting for the Engineering Studies ATAR Year 12 syllabus.

Summative assessments in this course must:

- be limited in number to no more than eight tasks
- allow for the assessment of each assessment type at least once over the year/pair of units
- have a minimum value of 5 per cent of the total school assessment mark
- provide a representative sampling of the syllabus content.

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

Assessment table – Year 12

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, service conditions, 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 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' finaliseand 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.	30%
Examination Typically conducted at the end of each semester and/or unit and reflecting the examination design brief for this syllabus.	40%

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 twice.

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.

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 Engineering Studies ATAR Year 12 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.

ATAR course examination

All students enrolled in the Engineering Studies ATAR Year 12 course are required to sit the ATAR course examination. The examination is based on a representative sampling of the content for Unit 3 and Unit 4. Details of the ATAR course examination are prescribed in the examination design brief on the following page.

Refer to the *WACE Manual* for further information.

Examination design brief – Year 12

Time allowed

Reading time before commencing work: ten minutes
Working time for paper: three hours

Permissible items

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to three calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination

Provided by the supervisor

A Data Book

Section	Supporting information
Section One **Core content** 50% of the total examination **Part A** 10% of the examination 5–8 short answer questions, without parts **Part B** 40% of the examination 4–6 questions each with parts Suggested working time: 90 minutes	The candidate is required to answer all Part A and Part B questions in this section. The questions may require the candidate to refer to stimulus materials, scenarios, concepts and/or engineering design problems. The Part A questions can require answers in the form of short responses, simple calculations and/or diagrams. The Part B questions can require answers comprising paragraphs, calculations and/or diagrams. The questions can have parts that typically will increase in complexity. Wherever appropriate, the candidate should use examples and fully labelled sketches and/or diagrams to illustrate and support their responses.
Section Two **Specialist engineering fields** 50% of the total examination Candidates choose from **one** of the following specialist engineering fields: • Mechanical • Mechatronics Each field contains: **Part A** 10% of the examination 5–8 short answer questions, without parts **Part B** 40% of the examination 4–6 questions, each with parts Suggested working time: 90 minutes	The candidate is required to answer all Part A and Part B questions in this section from their chosen specialist engineering field. The questions may require the candidate to refer to stimulus materials, scenarios, concepts and/or engineering design problems. The Part A questions can require answers in the form of short responses, simple calculations and/or diagrams. The Part B questions can require answers comprising paragraphs, calculations and/or diagrams. The questions can have parts that typically will increase in complexity. Wherever appropriate, the candidate should use examples and fully labelled sketches and/or diagrams to illustrate and support their responses.

Appendix 1 – Grade descriptions Year 12

A	**Design** Independently investigates needs, opportunities and problems that are comprehensively documented and defined in a design brief. Investigates, evaluates and documents, with attention to detail, alternative solutions that demonstrate insightful analytical skills; these may include existing products, systems, components and parts as well as the student's ideas. Thoroughly tests and evaluates the final design against criteria that are defined in the design brief. Develops a variety of annotated drawings, diagrams, tables, charts and text, as required; these are complete, accurate and clearly communicate information that is central to understanding the development and evaluation of the design proposal. Presents the final design proposal, clearly evaluated against the design brief criteria.
	Production Clearly explains and documents the final specifications for the solution using accurate, complete and neatly presented drawings, diagrams, tables, charts and text, as required. Presents appropriate, complete, sophisticated final specifications as a response to the design brief. Prepares, maintains and modifies, as required, a timeline for producing and testing the resulting model or prototype, meeting all deadlines. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the engineered product to a very high standard. Delivers a product that functions correctly, reliably and safely.
	Examination Interprets data correctly to develop comprehensive and realistic solutions to given problems. Applies correct formulas and units, and completes all calculations accurately. Presents accurate, comprehensive and fully annotated diagrams to communicate solutions to given problems. Explains key concepts comprehensively, using appropriate justifications where required.

B	**Design** Investigates needs, opportunities and problems that are well documented and defined in a design brief. Investigates and evaluates alternative solutions, such as existing products, systems, components and parts, including student ideas against the design brief criteria. Develops annotated project drawings, diagrams, tables, charts and text, as required. Presents, with few errors or omissions, accurate and clear information that is central to understanding the development and evaluation of the design proposal. Provides the final design proposal, evaluated against the design brief criteria.
	Production Clearly explains and documents the final specifications for the solution using complete and neatly presented drawings, diagrams, tables, charts and text, as required, with some minor omissions and/or errors. Presents the final specifications as an appropriate response to the design brief. Refers to and uses a timeline for producing and testing the resulting model or prototype to meet all or most deadlines. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the engineered product to a high standard. Delivers a product that functions correctly, reliably and safely.
	Examination Interprets data correctly to develop realistic solutions to given problems. Applies correct formulas and units, and completes most calculations accurately. Presents accurate, annotated diagrams to communicate solutions to given problems. Explains key concepts accurately, and uses appropriate justifications where required.

C	**Design** With assistance, investigates and documents needs, opportunities and problems that are defined in a design brief. Investigates and evaluates alternative solutions, such as existing products, systems, components and parts, including student ideas against the main points of the design brief. Provides drawings with some annotations, diagrams, tables and/or charts, as required. Presents information with occasional errors and/or omissions, showing the development and evaluation of the design. Presents the final design proposal evaluated against most of the design brief criteria.
	Production Clearly explains and documents the final specifications for the solution using neat drawings, diagrams, tables, charts and text, as required, but with some noticeable omissions and/or errors. Presents the final specifications as an appropriate response to the design brief. Refers to and uses a timeline for producing and testing the resulting model or prototype to meet most deadlines. Uses tools and techniques in a safe and appropriate manner to manufacture and/or assemble the engineered product to a satisfactory standard. Delivers a product that functions correctly, reliably and safely most of the time.
	Examination Uses data to develop partial or simple solutions to given problems. Applies correct formulas and units, and completes simple calculations. Attempts complex calculations but with errors. Produces simple, partially annotated diagrams to communicate solutions to given problems. Explains key concepts with simple or superficial justifications.

D	**Design** Presents a design brief showing limited consideration and documentation of needs, opportunities or problems. Develops project ideas with limited investigation or evaluation of alternative solutions. Presents few annotated drawings, diagrams, tables or charts. Provides little evidence of understanding the development or evaluation of the design proposal. Presents the final design proposal with minimal evaluation or reference to the design brief criteria.
	Production Provides specifications that are suitable, yet brief or simplistic, responses to the design brief. Presents the final specifications for the solution with obvious omissions and errors. Infrequently refers to a timeline for producing and testing the resulting model or prototype, and does not meet most deadlines. Uses tools and techniques in a safe manner to manufacture and/or assemble the engineered product. Delivers a product that does not function as designed.
	Examination Often interprets data incorrectly, resulting in vague and/or unfeasible solutions to given problems. Achieves limited accuracy with simple calculations. Produces vague or confusing diagrams when attempting to communicate solutions to given problems. Explains key concepts simplistically, or only partially.

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