Government of Western Australia
School Curriculum and Standards Authority

Sample Course Outline

Engineering Studies – Mechanical

ATAR Year 12

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.

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Sample course outline
Engineering Studies ATAR Year 12 (Mechanical)
Unit 3 and Unit 4

Semester 1

<table>
<tr><th>Week</th><th>Key teaching points</th></tr>
<tr><td>1–3</td><td>Overview of unit and course outline
Introduction to Engineering design process, and development of a design folio

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

Fundamental engineering calculations (Core)
All Unit 3 and Unit 4 content related to:

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
▪ circles
Surface area
• determine surface area of
▪ square and rectangular plane figures
▪ cubes and rectangular right-prisms
▪ right-triangular plane figures
▪ triangular right-prisms
▪ circles
▪ open-ended cylinders
▪ spheres

Volume
• determine volume of
▪ cubes, rectangular right-prisms and triangular right-prisms
▪ cylinders
▪ spheres
Density
• $density = \rho = \frac{m}{V}$
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</td></tr>
</table>

<table>
<tr><th>Week</th><th>Key teaching points</th></tr>
<tr><td></td><td>Efficiency
• calculate efficiency as a percentage
  ▪ $\eta = \frac{output}{input}$ x 100%

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

Task 1 Part A: Design Project 1 – Focus: dynamic vehicles, mechanisms and/or energy harvesting devices</td></tr>
<tr><td>4–8</td><td>Materials (Core)
All Unit 3 and Unit 4 content related to:
Types and classification
• define and compare
  ▪ metals (pure)
  ▪ alloys
  ▪ polymers
  ▪ composite
• classify
  ▪ metals (pure)
  ▪ alloys
  ▪ polymers
  ▪ composite
Properties
• define and compare
  ▪ density
  ▪ elasticity
  ▪ plasticity
  ▪ ductility
  ▪ malleability
  ▪ strength
  ▪ stiffness
  ▪ toughness
  ▪ resilience
  ▪ conductivity
  ▪ corrosion resistance
  ▪ hardness
• fitness for purpose
  ▪ identify and justify properties required of a material for a specified purpose
• 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

Materials (Mechanical specialist)
All Unit 3 and Unit 4 content related to material tensile testing, including:</td></tr>
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Week	Key teaching points

	Materials
	• define the terms stress, pressure, strain and Young's modulus (modulus of elasticity)
	• select and use the formulae associated with
	  ▪ stress and pressure
	  ▪ strain
	  ▪ elasticity (Young's modulus)
	• 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)
	Properties
	• properties of materials represented in a stress-strain graph
	  ▪ toughness
	  ▪ resilience
	Processes
	• processes applied to steel alloys
	  ▪ rolled – both hot and cold
	  ▪ cold drawn
	  ▪ cast
	  ▪ forged
	  ▪ pressed
	Factor of safety
	• $FS = \frac{\sigma_{UTS}}{\sigma_{safeworking}}$
	Miscellaneous
	• 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
	
	Task 1 Part B: Devising – sketches

9–10	**Engineering design process**
	Producing
	• present specifications for the selected solution
	• create dimensioned pictorial and orthographic drawings
	• create orthographic drawings and sketches that are third-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
	• select materials with justification of choices
	• present a parts lists
	• present costing of the project, i.e. the prototype or working model
	
	Task 2 Part A: Produce specifications for the selected solution for Project 1

Week	Key teaching points

11–14	**Engineering design process**
	
	Producing
	• present specifications for the selected solution
	• create annotated pictorial drawings
	• create orthographic drawings and sketches that are third-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
	• present a parts lists
	• present costing of the project, i.e. a prototype or working model
	• display project management skills for timely development 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 those aspects of the prototype or working model that have been completed for correct function and document using checklists and test data
	
	Effects on society, the environment and industry
	
	Energy
	• energy, work and power
	  ▪ definitions
	  ▪ examples
	• conservation of energy
	  ▪ definition
	  ▪ examples
	• forms of energy
	  ▪ kinetic
	  ▪ potential
	• non-renewable sources of energy
	  ▪ fossil fuels
	  ▪ nuclear
	• renewable sources of energy
	  ▪ solar
	  ▪ wind
	  ▪ hydroelectric
	  ▪ geothermal
	  ▪ ocean
	  ▪ hydrogen
	• advantages and disadvantages for society, industry and the environment of obtaining and using non-renewable and renewable sources of energy
	
	Energy, work and power
	• energy
	  ▪ $E = Pt$
	  ▪ $E_P = mg\Delta h$
	  ▪ $E_K = \frac{1}{2}mv^2$
	• work done
	  ▪ $W = \Delta E$
	• work (linear)
	  ▪ $W = Fs = F\Delta x = F(x_f - x_i)$
	• work (rotational)
	  ▪ $W = \tau\theta$

<table>
<tr><th>Week</th><th>Key teaching points</th></tr>
<tr><td></td><td>

power
$P = \frac{\Delta E}{\Delta t} = \frac{W}{\Delta t}$
power (linear)
$P = \frac{Fs}{\Delta t} = \frac{F\Delta x}{\Delta t} = \frac{F(x_f - x_i)}{\Delta t} = Fv$
power (rotational)
$P = \frac{\tau\theta}{t} = \tau\omega = \tau\frac{(rpm)(2\pi)}{60}$
power (electrical)
$P = VI$

Dynamics
Constant acceleration in straight line motion

$F = ma$
$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$
$v_f = v_i + a\Delta t$
${v_f}^2 = {v_i}^2 + 2as$
$s = v_i\Delta t + \frac{1}{2}a\Delta t^2$
not quadratic equation
mathematical resolution of vectors for displacement, velocity and acceleration

Engineering design process
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

Task 1 Part C: Evaluation Project 1

Task 2 Part B: Production of Project 1

Task 3: Test – Materials; Effects on society, the environment and industry; Energy, work and power; Dynamics (Unit 3 [50%] and Unit 4 [50%])
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<tr><td>15</td><td>Task 4: Semester 1 examination based on Unit 3 content</td></tr>
</table>

Engineering Studies ATAR Year 12 (Mechanical)

Unit 3 and Unit 4

Semester 2

Week	Key teaching points

1–4	**Mechanisms**
	Simple machines and mechanisms
	• mechanical advantage (MA)
	  ▪ definition and examples
	• velocity ratio (VR)
	  ▪ definition and examples
	• explain and give examples of the following types of motion
	  ▪ linear
	  ▪ reciprocating
	  ▪ rotary
	  ▪ oscillating
	  ▪ transformation of motion
	    o rotary into linear and vice versa
	    o rotary into reciprocating and vice versa
	    o rotary into oscillating and vice versa
	• recognise and describe general characteristics and applications for
	  ▪ pulley belt
	  ▪ chain and sprocket
	  ▪ simple gear drive
	    o idler gear
	  ▪ compound gear drive
	  ▪ worm and worm wheel (single start)
	  ▪ rack and pinion
	  ▪ lead screw (single and multiple start)
	• ideal machine (100% efficiency)
	• speed/velocity (v)
	• torque
	
	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
	• describe 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
	
	Task 5 Part A: Project 2 – Investigation and design sketches (Focus: static structures or analysis of results from prototype/Project 1)

Week	Key teaching points
	Note: Project 2 may be completely separate from project one or it may be an extension of the theme used for Project 1. **Task 6 Part A: Produce specifications for the selected solution for Project 2 (or development of Project 1)**

Week	Key teaching points

5–10	**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
	  ▪ 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)
	• 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 vertical point loads and UDLs
	  ▪ 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)
	  ▪ rectangular hollow section (base is horizontal)
	  ▪ round solid section
	  ▪ circular tube section
	• data extraction
	  ▪ extract and use data from charts, graphs, tables and diagrams
	Deflection of beams
	• calculate one unknown variable using one of the four beam deflection formulae
	  ▪ cantilevered beam with single load at unsupported end
	  ▪ cantilevered beam with UDL along whole length of the beam; can be or include self-weight of beam
	  ▪ centrally loaded beam simply supported at both ends
	  ▪ 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
	• 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
	
	Trusses
	Method of sections
	• simply supported pin-jointed, parallel chord trusses
	  ▪ calculate reaction forces at supports
	  ▪ calculate forces in members
	
	Engineering design process

Week	Key teaching points
	• display 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 **Task 6 Part B: Production of Project 2 (or development of Project 1)** **Task 7: Test – Mechanisms; Effects on society, the environment and industry; Statics; Trusses (Unit 3 [50%] and Unit 4 [50%])**

11–13	**Engineering design process**
	• display 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
	
	Task 5 Part B: Evaluation Project Two

14	Examination revision
15	**Task 8: Semester 2 examination based on Unit 3 (33%) and Unit 4 (67%) content**