Engineering Single and Double at Samuel Whitbread Academy
Curriculum Sequencing

Single & Double units

Unit 1

Unit 1		
A Algebraic and trigonometric mathematical methods	A1 Algebraic methods	• Solve, transpose and simplify equations.
		• Indices and logarithms:
		• Application to problems involving exponential growth and decay.
		• Linear equations and straight line graphs:
		• Factorisation and quadratics:
	A2 Trigonometric methods	• Circular measure:
		• Triangular measurement:
		• Mensuration:
B Static engineering systems	B1 Static engineering systems	• Non-concurrent coplanar forces:
		• Simply supported beams:
		• Reactions:

	B2 Loaded components	• direct stress and strain
		• shear stress and strain
		• tensile and shear strength
		• elastic constants
C Dynamic engineering systems	C1 Dynamic engineering systems	• kinetic parameters and principles:
		• dynamic parameters and principles:
		• angular parameters:
		• lifting machines, including inclined planes, scissor jacks, pulleys:
D Fluid engineering systems	D1 Fluid systems	• submerged surfaces in fluid systems:
		• immersed bodies:
		• fluid flow in a gradually tapering pipe:
E Static and direct current electricity and circuits	E1 Static and direct current electricity	• conductance
		• conventional current flow
		• charge/electron flow
		• voltage
		• Coulomb’s law
		• factors affecting resistance, including conductor length, cross sectional area, resistivity, and temperature coefficient of resistance

		• resistors, including function, fixed, variable, values
		• electric field strength, including uniform electric fields
		factors affecting capacitance, including plate spacing, plate area, permittivity
		• capacitors – typical capacitance values and construction, including plates, dielectric materials and strength, flux density, permittivity.
	E2 Direct current circuit theory	• Ohm's law
		• Power
		• Efficiency
		• Kirchhoff voltage and current laws
		• Charge, voltage, capacitance and energy stored in capacitors
		• RC transients (capacitor/resistor), charge and discharge, including exponential growth and decay of voltage and current, and time constant
		• Diodes, including forward and reverse bias characteristics
	E3 Direct current networks	• DC power sources, including cells, batteries, stabilised power supply, photovoltaic cell/array and internal resistance
		• at least five resistors in series and parallel combinations
		• DC circuits containing resistors and two power sources
		DC power source with at least two capacitors connected (series, parallel, combination).
F Magnetism and electromagnetic induction	F1 Magnetism	• magnetic field:

		• electromagnetic induction and applications:
G Single-phase alternating current	G1 Single-phase alternating current theory	• waveform characteristics
		• AC principles

Unit 2

Unit 2		
Learning aim A: Examine common engineering processes to create products or deliver services safely and effectively as a team	A1 Common engineering processes	• Transforming ideas and materials into products or services
		• A product and a service are closely aligned concept
		• Common processes used to create engineered products
		• Common processes used in engineering services
	A2 Health and safety requirements	• Current Health and Safety at Work legislation
		• Current Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)
		• Current Personal Protective Equipment (PPE) at Work Regulations
		• Current Control of Substances Hazardous to Health Regulations (COSHH) –
		• Current Manual Handling Operations Regulations (MHOR)

	A3 Human factors affecting the performance of engineering processes	• Understanding that human factors affect the productivity of processes
		Understanding that human factors affect the performance of individuals and teams
Learning aim B: Develop two-dimensional computer-aided drawings that can be used in engineering processes	B1 Principles of engineering drawing	• Attributes of orthographic projections
		• Drawing conventions or other relevant international equivalents
	B2 2D computer-aided drawing	• coordinates – absolute, relative, polar
		• drawing template – border, title block with all necessary information
		• layers – names, line types, colours, visibility
		• commands
		• cross-hatching
Learning aim C: Carry out engineering processes safely to manufacture a product or to deliver a service effectively as a team	C1 Principles of effective teams	• Good communication
		• Planning
		• Motivation
		• Working with others
		• Working environment
	C2 Team set-up and organisation	• A team is defined as containing three or more individual members who have a shared common objective to complete.
		• Strengths and limitations of team members

		• Allocation of responsibilities
		• Timescales – planning the activities
		• Objectives – team targets.
	C3 Health and safety risk assessment	• identification of hazards
		• assessing risk by determining how hazards can cause injury
		• choosing and using appropriate control measures and precautions to reduce risk
		• recording all findings
		• reviewing the risk assessment after new equipment/work activities have been undertaken, at regular intervals.
	C4 Preparation activities for batch manufacture or batch service delivery	• A batch is defined as a quantity of three or more of a product or service delivered together
		• Understanding the requirements of production plans
	C5 Delivery of manufacturing or service engineering processes	• For engineered products or engineering services
		• Examples of engineered products
		• Selecting, setting up and using engineering equipment to manufacture engineered products
		• Examples of engineering services
		• Selecting, setting up and using engineering equipment to deliver engineering services

Unit 3

Unit 3		
A Design triggers, challenges, constraints and opportunities, and materials and processes	A1 Design triggers	• market pull/technology push (product and process)
		• demand
		• profitability
		• innovation
		• market research
		• product/process performance issues
		• sustainability (carbon footprint)
		• designing out risk.
	A2 Design challenges	• reduction of energy wasted during design of an engineered product
		• reduction of energy wasted during operation of an engineered product
		• reduction of physical dimensions
		• reduction of product mass

		• increase in component efficiency
		• energy recovery features
		• reduced product life cycle costs
		• integration of different power sources for vehicles
		• reduced use of resources in high-value manufacturing
		• sustainability issues throughout the product lifecycle (raw materials, manufacture, packaging and distribution, use and reuse, end of life)
		• designing out risk (for individual employees and customers).
	A3 Equipment level and system level constraints and opportunities	• reasons for selecting different solutions for equipment interfaces (mechanical, electrical, hydraulic, software)
		• systems integration compromises (cooling, location for optimum equipment performance, bonding, centre of gravity, electrical and electronic compatibility)
		• equipment product design specification (PDS) (shortcomings absorbed at system level, electromagnetic compatibility (EMC), mass, cooling)
		• cost effective manufacture (capital outlay, use of tooling, set up cost)
	A4 Material properties	• mechanical properties

		• physical properties
		• thermal properties
		• electrical and magnetic properties
		• behaviour of advanced materials (bio materials, smart alloys, nanoengineered materials)
		• modes of failure
		• surface treatments and coating
		• lubrication (purposes, regimes).
	A5 Mechanical power transmission	• linkages (types, mechanical advantage, examples from nature)
		• mechanical motion (linear, rotary, reciprocating, oscillating)
		• power sources (mechanical, electrical, energy from nature)
		• control of power transmission (sensors, actuators, servo motors).
	A6 Manufacturing processes	• processes for metals (additive, moulding, machining, forming, casting, powder metallurgy, joining, assembly)
		• processes for polymers (additive, casting, moulding, extrusion, thermoforming)

		• processes for ceramics (additive, casting, forming)
		• processes for composites (layup, moulding, automated tow placement)
		• effects of processing (recrystallisation, grain structure, alloying elements, material combinations, process parameters)
		• scales of manufacture (one-off, small batch, large batch, mass, continuous).
B Interpreting a brief into operational requirements and analysing existing products	B1 Design for a customer	• types of customer (internal, external)
		• product and service requirements
		• product design specification/criteria
		• commercial protection (patents, registration, copyright, trademarks).
	B2 Regulatory constraints and opportunities	• legislation, standards, codes of practice, national and international certification requirements
		• environmental constraints (sustainability, carbon footprint, product life cycle)
		• health and safety, security (product and process).
	B3 Market analysis	• unique selling point (USP)
		• benefits of the design

		• obsolescence.
	B4 Performance analysis	• product form
		• product functionality
		• technical considerations
		• choice of materials and components
		• environmental sustainability (impact, carbon footprint)
		• interactions with other areas/components
		• likelihood of failure or wear.
	B5 Manufacturing analysis	• processes for manufacturing/assembly
		• manufacturing requirements
		• quality indicators
		• environmental sustainability (impact, carbon footprint)
		• design for manufacture.
C Using an iterative process to design ideas and develop a	C1 Design proposals	• technical design criteria

modified product proposal		• idea generation (context, creativity, range)
		• initial design ideas (fitness for purpose, refinements, recognition of constraints)
		• developed design idea
		• use of information sources.
	C2 Communicating designs	• freehand sketching and diagrams (2D and 3D, illustrations, technical)
		• graphical techniques (charts, keys, shading, animation, symbols, conventions)
		• written skills (annotation, technical language, interpreting results)
		• documentation (detail and assembly orthographic projections, specifications, parts list, materials list, production plan, circuit/block diagrams, flowchart, design log).
	C3 Iterative development process	• refining a task or process (analysing, adapting, enhancing)
		• cyclic process (logical non-linear approach, focus on product design specification/criteria).
D Technical justification and validation of the design solution	D1 Statistical methods	• statistical measurement (discrete/continuous, mean, median, mode, variance)
		• data handling
	D2 Validating designs	• objective referencing against product design specification/criteria
		• objective referencing against weighted matrix

		• indirect benefits and opportunities
		• balancing benefits and opportunities with constraints
		• design for manufacturing
		• further modifications

Unit 10

Unit 10		
Learning aim A: Develop a three-dimensional computer-aided model of an engineered product that can be used as part of other engineering processes	A1 3D parametric modelling	• Configure the parametric modeller, including origin, units, snap and grid, correct format, project files, selection of file types and planes, e.g. XY, XZ and YZ
		• Sketching commands, including line, arc, centre line, construction line, circle, fillet, and dimension

		• Display commands, including pan, zoom, and orbit.
		• Editing commands, including erase, extend, trim, and rotate.
		• Construction commands
	A2 Develop 3D components	• Creation of 2D sketches, including basic shape, dimensioning, modifications, and geometric constraints
		• 2D sketch to a 3D model, including rotate about an axis, revolve, extrude, and Boolean manipulation
		• 3D features
		• Combination of solid objects, including Boolean operations.

		• 2D sketching on 3D faces.
		• Modification of the 3D model, including addition of features to existing geometry
		• Application of materials
	A3 Develop a 3D model	• Placement of 3D components, including degrees of freedom, XYZ translational freedom and XYZ rotational freedom
		• Assembly constraints and the relationships between components
		• Modification to 3D components due to assembly constraints
		• Consideration of assembly, including storyboarding, component relationship.

	A4 Output of drawings from a model	• 2D paper space, including drawing template, scale, size, title block, editing
		• creation of component drawings, including an orthogonal base view and projected views, 3D solid model/surface model, appropriate scale, detail views, dimensioning, and centre lines
		• creation of an assembly drawing, including parts list or bill of materials (BOM).
Learning aim B: Develop two-dimensional detailed computer-aided drawings of an engineered product that can be used as part of other engineering processes	B1 2D drawing commands	• Configuration of a 2D CAD system
		• Use of drawing commands
		• Use of display commands, including pan, zoom
		• Use of modify commands, including erase, trim, mirror, move, array, copy, undo and stretch
	B2 Development of 2D engineering drawings	• Drawing commands, including line types, centre line, dashed, text, offset, hatching and editing of hatching.
		• Use of layers, including manipulation, creation, switching on/off, frozen and locked.
		• Use of blocks/symbols, including creation of blocks/symbols, symbols library, insertion of blocks
		• Use of modify commands, including mirror, pan, scale, chamfer, and fillet.
		• Use of dimensioning, including dimension styles,

		dimensions, and editing of dimensions.
	B3 Output of 2D drawings	• set up of output parameters, including paper size, units, plot area, scale, orientation, paper space, model space, model and layout drawing, and template
		• creation of component drawings, including orthogonal views, appropriate scale, sectional view, dimensioning, and centre lines
		• creation of an assembly drawing, including general arrangement, parts list or bill of materials (BOM)
Learning aim C: Develop a three-dimensional computer-aided model for a thin walled product and a fabricated product that can be used as part of other engineering processes	C1 3D modelling commands	• Configuration of the parametric modeller, including origin, units, snap and grid, correct format, project files, selection of file types, and planes, e.g. XY, XZ and YZ
		• Creation of 2D sketches, including basic shape, dimensioning, modifications, and geometric constraints
		• 2D sketch to a 3D model, including rotate about an axis, revolve, extrude, and Boolean manipulation
		• Sheet metal parameters, including folding rule, bending rule, corner reliefs.

		• Use of sketching commands, including line, arc, centre line, construction line, circle, fillet, and dimension
		• Use of construction sheet metal commands, including face, material thickness, bends, flange, holes, slots, 3D modify, e.g. hole, move, face, chamfer
		• Use of construction thin walled commands, including 3D creation, imprint/shell, Boolean manipulation, sweep, loft, shell, work planes, emboss, 3D modify, e.g. hole, move, face, chamfer.
		• Use of display commands, including pan, zoom, and orbit.
		• Use of editing commands, including erase, extend, trim, and rotate.
	C2 Develop 3D components	• Create 2D sketches, including basic shape, dimensioning, modifications, and geometric constraints.
		• 2D sketch to a 3D component and sheet metal fabrication, including folding, bending, slots, revolve, extrude, and Boolean manipulation.

		• 3D features of the components
		• 3D features of the thin walled components
	C3 Development of a 3D model	• Placing 3D components, including degrees of freedom, XYZ translational freedom and XYZ rotational freedom.
		• Assembly constraints and the relationships between components
		• Modification to 3D components due to assembly constraints
		• Consideration of assembly, including storyboarding, component relationship.
		• Use of rendering, including render, shadows, reflections, lights, materials, textures, ray tracing.

	C4 Output of product drawings	• 2D paper space
		• creation of component drawings

Double Only Units

Unit 4

Unit 4		
Learning aim A: Examine business functions and trade considerations that help engineering organisations thrive	A1 Business functions and key activities	• manufacturing of products and delivering services, e.g. forming, fabrication, removal of material, addition of material, assembly processes, quality control
		• supply chain management, e.g. outsourcing decisions, supplier appraisal
		• marketing and sales, e.g. brand awareness, market research, sales, customer feedback

		• customer relations, e.g. meeting expectations, being proactive
		• resource management, e.g. sources of funding, resource allocation, stock control
		• staff recruitment, e.g. internal and external recruitment, apprenticeships
		• staff management, e.g. appraisals, support and training (continuing professional development)
		• financial, e.g. financial statements (profit and loss, break-even).
	A2 Trade considerations	• terms, both expressed and implied, e.g. breach of contract, force majeure

		• warranties and conditions, e.g. indemnities, guarantees, insurance
		• consequences of non-performance, e.g. rejection of goods/services, financial penalty clauses
		• documentation, e.g. drawings, estimates, quotations, specifications.
	A3 Competitive advantage	• by innovating
		• using new technology
		• protecting intellectual property

		• managing costs.
Learning aim B: Explore activity-based costing as a method to control costs and to determine if an engineering product or service is profitable	B1 Reasons for cost control and types of costs	• Reasons for cost control
		• Types of costs
	B2 Activity-based costing method	• identifying activities, including the processes and activities required to produce an output
		• assigning resource costs to activities, including direct costs, indirect costs and general/administration costs
		• identifying outputs, including products, services or customers
		• assigning activity costs to outputs, including using activity drivers to assign costs to outputs (cost objects)
		• activity cost pools, including material handling, set-up costs, and procurement
		• application of activity-based costing to determine profitability.
Learning aim C: Explore how engineering organisations use quality systems and value management to create value	C1 Quality systems	• Quality standards and accreditation include international quality standards that can be applied for voluntarily by engineering organisations
		• Quality assurance
		• Purposes of implementing a quality system

		• Quality control
	C2 The principles and processes of value management	• Principles of value management
		• Phases in the process of carrying out a value analysis exercise on a product or service

Unit 5

Unit 5		
Learning aim A: Investigate an engineering project in a relevant specialist area	A1 Project life cycle	• initiation, to include identifying a problem, research and clarification of a problem, establishing key design features of possible solutions and constraints, idea generation and a feasibility stud
		• planning and design, to include resource and time planning for the chosen solution and creating a design based on the customer's requirements

		• implementation, to include undertaking project processes to develop the solution while controlling the project by monitoring it against the plans and managing risks and issues
		• evaluation, to include reviewing the outcome of the project, e.g. whether the customer requirements were met, whether the project was delivered on time and to budget, and how the project was delivered to the given theme or specification
	A2 Project idea generation and solution development	• researching a given project theme or initial idea and identifying problems to be solved using tools, e.g. the internet, journals, databases, libraries, publicly available company information
		• creativity tools to solve problems, e.g. rewording problems, challenging assumptions, thinking in reverse, mind mapping, drawing a diagram, group discussion, brainstorming and Edward De Bono's Six Thinking Hats®
		• a specification that scopes out alternative technical solutions, using outline information to define what possible, as yet undesigned, products, systems or processes are intended to contain and do.
	A3 Feasibility study of solutions	• Criteria to determine the feasibility of different solutions to a problem, including the potential

		• Selection of the proposed solution
Learning aim B: Develop project-management processes and a design solution for the specialist engineering project as undertaken in industry	B1 Planning and monitoring project-management processes	• resource plan, to include the internet, humans, peers, books and equipment
		• time plan, to include a Gantt chart and critical path analysis to set priorities for different activities
		• project contingency, e.g. an amount of time or additional budget that is included in the plan to manage unforeseen events
		• project constraints, including time, budget, scope, sustainability, ethics and legality
		• scheduled and frequent monitoring and management of the project
	B2 Risk and issue project-management processes	• The purpose of risk and issue management
		• A risk is an event that adversely impacts on the project processes or outcome, and an issue is a future event which could adversely or positively impact project processes or outcome
		• Risk and issue measures

		• The risk or issue severity = probability of the occurrence × expected impact on the project
		• The resultant risk and issue severity
		• Risks and issues should be assessed throughout the delivery of the project and medium, high and extreme severity risks and issues should be managed.
		• Management of risks and issues
		• Allowing contingency in the plans provides some flexibility in the event that risks and issues occur.
	B3 Technical specification	Technical specification for the chosen product, system or process being developed
	B4 Design information	• engineering drawings, computer-aided design (CAD), e.g. 3D, 2D and diagrams
		• simulations, e.g. pneumatic circuits, hydraulic circuits, electrical/electronic circuits and software models
		• physical modelling, e.g. 3D rapid prototyping (also known as 3D printing or additive manufacturing), mock-ups in wood, cardboard and modelling material
		• processes or computer program, e.g. detailed flow chart(s), planning, operation sheets

		• documents, e.g. tables, formulas, pseudocode, outline of key algorithms, description and record of ergonomic analysis
		• safety and sustainability considerations
Learning aim C: Undertake the solution for a specialist engineering project and present the solution as undertaken in industry	C1 Undertake and test the solution to the problem	• the use of project-management processes during the development of a solution, to include status reporting and management of risks and issues
		• the safe use of resources, e.g. machines, workshops, tools and consumables
		• troubleshooting methods to resolve problems
		• fitness for purpose
		• testing methods

		• fitness for audience
	C2 Demonstration of relevant behaviours	• time planning and management to complete all the different activities within an appropriate timeframe and in an appropriate order
		• communication and literacy skills to follow and implement instructions appropriately, interpret documentation and communicate effectively with others in writing and verbally
		• commercial and customer awareness to ensure the product, process or system is fit for purpose and meets the brief
		• observable emotions linked to successes and issues during the project development, including personal successes and issues as well as attitudes and behaviour
		• individual support required to complete the project
	C3 Present a solution to the problem	• thematic title and/or initial idea

		• research and clarification of the problem
		• possible solutions and constraints
		• initial specification of alternative technical solutions
		• feasibility study
		• technical specification
		• project-management documents, including plans and a risk and issues log
		• logbook of events, e.g. diary, outline sketches, notes, records

		• design documents, e.g. sketches, engineering drawings, simulation and flow charts
		• artefacts for a product, service or process, e.g. prototype product, computer program, pneumatic or hydraulic circuit, electronic circuit, experiment process demonstration
		• test documentation, e.g. results, video, customer feedback and photographs
		• peer reviews and tutor monitoring
		• conclusions on the success of the solution against the project theme and initial idea.

Unit 58

Unit 58		
Learning aim A: Know about energy management	A1 Legislation and international agreements	• UK legislation (Climate Change Act).

	A2 Sectors	• International protocols and accords.
		• Business and public sector.
	A3 Terminology	• Energy intensive industries.
		• Small businesses.
		• Energy suppliers.
		• Key terminology, e.g. low carbon economy.
	A4 Energy conservation techniques	• Carbon footprint.
		• Global emissions.
		• Energy consumption.
		• Risk.
		• Saving energy, e.g. insulation, equipment, lighting, waste management
	A5 Energy technologies	• Saving energy, e.g. advanced photovoltaic cells, industrial energy efficiency accelerator, low carbon buildings accelerator
Learning aim B: Be able to plan for an energy management audit	B1 Energy source suppliers	• Fossil and non-fossil fuels.
		• Electricity.
		• Gas.
		• Costs.
	B2 Organisational policies	• Energy policy statements.
	B3 Practices and procedures	• Energy usage, daytime, night-time, weekends.

		• Transport notices.
		• Communication.
		• Rewards.
	B4 Employer/employees	• Attitudes.
		• Commitment.
		• Leadership.
		• Communication.
		• Organisational structure.
		• Accountability.
	B5 Buildings/equipment/materials/transport vehicles	• Insulation.
		• Usage.
		• Age.
		• Alternatives.
		• Life cycle replacement.
	B6 Actions	• Approval.
		• Aims.
		• Objectives.
		• Checklist.
	B7 Audit procedures	• Checklist.
		• Logs.

		• Metering and measurements.
		• Frequency.
Learning aim C: Be able to conduct an energy management audit	C1 Energy audit	• Tours with key staff.
		• Employer and employee discussions.
	C2 Energy usage checklist	• Energy suppliers.
		• Energy tariff.
		• Range of quantifiable procedures and practices.
		• Costing procedure.
		• Equipment age and maintenance.
		• Materials used.
		• Buildings, doors, windows, insulation, lighting.
		• Recycling.
		• Waste.
	C3 Information and data collection	• Qualitative and quantitative information.
		• Database.
		• Report.
		• Benchmarking.
		• Patterns.
		• Deviations.
		• Results analysis.

		• Strengths and areas for improvement.
		• Recommendations for energy savings.
Learning aim D: Understand how to monitor and target energy savings	D1 Targeting	• Performance indicators, benchmarking.
		• Patterns.
		• Deviations.
	D2 Monitoring	• Collection techniques.
		• Timelines.
		• Frequency.
		• Data analysis.
		• Patterns.
		• Accuracy.
	D3 Review	• Practices.
		• Policies.
		• Procedures.
		• Employer/employee commitment.
		• Targets versus actual energy savings.

		• Energy wastage.