Unit 3: Engineering Product Design and Manufacture

Level: **3**

Unit type: **External**

Guided learning hours: **120**

Unit in brief

Learners will explore engineering product design and manufacturing processes and will complete activities that consider function, sustainability, materials, form and other factors.

Unit introduction

Engineering products are part of our daily lives, from aircraft to the smallest electronic circuits found in medical devices. Engineering products are designed as a result of the identification of a need or opportunity, and then engineers using creative skills and technical knowledge to devise and deliver a new design or improvements to an existing design. For example, advances in the development of fuels led to the first internal combustion engine, and engineers have been improving its design ever since.

In this unit, you will examine what triggers changes in the design of engineering products and the typical challenges that engineers face, such as designing out safety risks. You will learn how material properties and manufacturing processes impact on the design of an engineering product. Finally, you will use an iterative process to develop a design for an engineering product by interpreting a brief, producing initial ideas and then communicating and justifying your suggested solution. You will draw on and apply knowledge and understanding from *Unit 1: Engineering Principles* and *Unit 2: Delivery of Engineering Processes Safely as a Team*, for example by using calculations to demonstrate a reduction in mass, by sketching using orthographic projection drawing methods or by justifying an engineering process as its use reduces the carbon footprint of a product. In this unit you will draw on your learning from across your programme to complete assessment tasks.

It is important that engineers use creative and technical knowledge, understanding and skills to transform ideas into viable products, and that they understand the critical importance of this activity in ensuring that products are both safe and effective. This unit will help prepare you for an engineering apprenticeship, engineering courses in higher education or for technician-level roles in a variety of engineering sectors.

Summary of assessment

This unit is assessed by a set task of 60 marks provided by Pearson and completed under supervised conditions. Learners will be given a case study two weeks before a supervised assessment period, to carry out three hours of independent preparatory research.

The supervised assessment period is ten hours and can be arranged over a number of sessions within a three-week assessment period timetabled by Pearson. During the supervised assessment period, learners will complete a task that will require them to follow a standard development process of interpreting a brief, scoping initial design ideas, preparing a design proposal and evaluating their proposal.

The assessment availability is May/June each year. The first assessment availability is May/June 2017.

Sample assessment materials will be available to help centres prepare learners for assessment.

Assessment outcomes

AO1 Demonstrate knowledge and understanding of engineering products and design

AO2 Apply knowledge and understanding of engineering methodologies, processes, features and procedures to iterative design

AO3 Analyse data and information and make connections between engineering concepts, processes, features, procedures, materials, standards and regulatory requirements

AO4 Evaluate engineering product design ideas, manufacturing processes and other design choices

AO5 Be able to develop and communicate reasoned design solutions with appropriate justification

Essential content

The essential content is set out under content areas. Learners must cover all specified content before the assessment.

A Design triggers, challenges, constraints and opportunities, and materials and processes

A1 Design triggers

The triggers that stimulate engineering design activity, including:

- 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

Commercial-, regulatory- or public policy-based trends that challenge current technology or design, including:

- 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

Factors that place limitations and offer opportunities at equipment level on the design of engineering products, including:

- 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

Properties, modes of failure, protection and lubrication of engineering materials and components that impact upon their selection when designing an engineering product, including:

- 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

Characteristics of an engineering system that makes use of forces and movement that impacts on mechanical power transmission component selection when designing an engineering product, including:

- 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, servomotors).

A6 Manufacturing processes

Characteristics and effects of manufacturing processes that impact on the selection of engineering materials and components when designing an engineering product, including:

- 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

Meeting customer needs during engineering design activity, including:

- types of customer (internal, external)
- product and service requirements (performance specifications, compliance to operating standards, manufacturing quantities, reliability/product support, product life cycle, usability, anthropometrics)
- product design specification/criteria (cost, quantity, maintenance, finish, materials, weight, aesthetics, product life cycle, sustainability, carbon footprint, reliability, safety, testing, ergonomics, usability, competition, market, manufacturing facility, manufacturing constraints, manufacturing processes)
- commercial protection (patents, registration, copyright, trademarks).

B2 Regulatory constraints and opportunities

Regulatory factors that place limitations and opportunities on the design of engineering products, including:

- 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

Engineering goals in terms of marketing when designing an engineering product, including:

- unique selling point (USP)
- benefits of the design
- obsolescence.

B4 Performance analysis

Engineering goals in terms of performance when designing an engineering product, including:

- 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

Engineering goals in terms of manufacturing when designing an engineering product, including:

- 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 modified product proposal

C1 Design proposals

Initial and developed propositions to improve an engineering product, including:

- technical design criteria
- idea generation (context, creativity, range)
- initial design ideas (fitness for purpose, refinements, recognition of constraints)
- developed design idea (aesthetics, ergonomics, sizes, mechanical and electronic principles, material requirements, manufacturing processes, assembly arrangements, cost estimations, factor of safety, selection procedures for bought out components)
- use of information sources.

C2 Communicating designs

Communication of an initial and a developed proposition to improve an engineering product, including:

- 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

Using an iterative process to improve an engineering product, including:

- 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 techniques as applied to engineering problems, including:

- statistical measurement (discrete/continuous, mean, median, mode, variance)
- data handling:
  - graphical representation (bar chart, pie chart, frequency table, histogram, cumulative frequency diagram or graph)
  - frequency distributions (normal, skewed, standard deviation).

D2 Validating designs

Rationalise choices made when generating a developed proposition to improve an engineering product, including:

- objective referencing against product design specification/criteria
- objective referencing against weighted matrix
- indirect benefits and opportunities
- balancing benefits and opportunities with constraints (cost-benefit analysis, environmental benefits, health and safety risks, product life cycle considerations)
- design for manufacturing
- further modifications (technology-led adaptations).

Grade descriptors

To achieve a grade a learner is expected to demonstrate these attributes across the essential content of the unit. The principle of best fit will apply in awarding grades.

Level 3 Pass

Learners demonstrate knowledge and understanding of iterative design methodologies, processes, features and procedures and their application to engineering products. They can interpret a design brief to generate ideas, and will deploy skills and selected techniques to develop modified products in context. Learners demonstrate research and analytical skills in order to create a product design specification to meet the requirements of a brief. They make recommendations and proposals relevant to familiar and unfamiliar situations, with consideration of design sustainability and safety issues. Learners will make evaluative judgements in relation to their design proposal and be able to provide technical justifications in the validation of their design solution.

Level 3 Distinction

Learners demonstrate thorough knowledge and understanding of iterative design methodologies, processes, features and procedures and can apply this understanding to engineering products in context. They can interpret a design brief to generate complex design ideas, and will deploy a range of skills and selected techniques to develop modified products in context and with justification. They demonstrate comprehensive research and analysis skills in order to generate a product design specification that fully and effectively meets the requirements of the brief. They present justified recommendations and proposals relevant to familiar and unfamiliar situations, with consideration of design sustainability and safety issues. Learners are able to select appropriate techniques and processes to design ideas and will justify applications in arriving at creative, feasible and optimised solutions. Learners will make robust, evaluative judgements in relation to their design proposal and be able to provide detailed technical justifications in the validation of their design solution.

Key terms typically used in assessment

The following table shows the key terms that will be used consistently by Pearson in our assessments to ensure students are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Command or term	Definition
Client brief	Outlines the client's expectations and requirements for the product.
Design	A drawing and/or specification to communicate the form, function and/or operational workings of a product prior to it being made or maintained.
Manufacture	To make a product for commercial gain.
Project log	A document to record the progress made, key activities and decisions taken during the development of a project.

Links to other units

This mandatory unit is linked to most other units in the qualification, including:

- Unit 10: Computer Aided Design in Engineering
- Unit 12: Pneumatic and Hydraulic Systems
- Unit 13: Welding Technology
- Unit 16: Three Phase Electrical Systems
- Unit 17: Power and Energy Electronics
- Unit 19: Electronic Devices and Circuits
- Unit 20: Analogue Electronic Circuits
- Unit 22: Electronic Printed Circuit Board Design and Manufacture
- Unit 23: Digital and Analogue Electronic Systems
- Unit 25: Mechanical Behaviour of Metallic Materials
- Unit 26: Mechanical Behaviour of Non-metallic Materials
- Unit 27: Static Mechanical Principles in Practice
- Unit 28: Dynamic Mechanical Principles in Practice
- Unit 29: Principles and Applications of Fluid Mechanics
- Unit 30: Mechanical Measurement and Inspection Technology
- Unit 31: Thermodynamic Principles and Practice
- Unit 32: Computer System Principles and Practice
- Unit 33: Computer Systems Security
- Unit 35: Computer Programming
- Unit 36: Programmable Logic Controllers
- Unit 37: Computer Networks
- Unit 38: Website Production to Control Devices
- Unit 39: Modern Manufacturing Systems
- Unit 40: Computer Aided Manufacturing and Planning
- Unit 41: Manufacturing Secondary Machining Processes
- Unit 42: Manufacturing Primary Forming Processes
- Unit 43: Manufacturing Computer Numerical Control Machining Processes
- Unit 44: Fabrication Manufacturing Processes
- Unit 45: Additive Manufacturing Processes
- Unit 46: Manufacturing Joining, Finishing and Assembly Processes
- Unit 47: Composites Manufacture and Repair Processes
- Unit 48: Aircraft Flight Principles and Practice
- Unit 50: Aircraft Gas Turbine Engines
- Unit 52: Airframe Construction and Repair
- Unit 53: Airframe Mechanical Systems
- Unit 54: Aircraft Electrical and Instrument Systems.

Employer involvement

Centres may involve employers in the delivery of this unit if there are local opportunities. There is no specific guidance related to this unit.