Next Generation Higher National Unit Specification

Sustainable Design Engineering and Innovation Entrepreneurship (SCQF level 8)

Unit code: J7C4 48

SCQF level: 8 (24 SCQF credit points)

Valid from: session 2024 to 25

Prototype unit specification for use in pilot delivery only (version 2.0) November 2024

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: December 2024 (version 2.0)

Unit purpose

This unit enables learners to develop knowledge and skills in innovation and entrepreneurship; the engineering design process; design research; concept design engineering; detailed design engineering; and prototyping and testing.

The target learner group for the unit is learners who want to develop their core design engineering, sustainable design, and innovation and entrepreneurship skills to support a career in engineering design in a wide range of industries.

Entry to the unit is at your centre's discretion. However, we recommend that learners have one or more of the following:

- a fundamental knowledge and understanding of engineering disciplines, and mathematical concepts and principles, for example an SCQF level 7 qualification in Electrical Engineering, Electronics, Mechanical Engineering or Engineering Systems
- relevant equivalent workplace experience

The unit provides learners with suitable knowledge and skills to progress to further study or employment in a wide range of engineering industries.

Unit outcomes

Learners who complete this unit can:

1 evaluate opportunities for innovation and entrepreneurship
2 evaluate ways to create engineering products
3 elaborate new product design specifications
4 create the best alternative new product concept
5 generate engineering requirements for new product concepts
6 evaluate new product prototype performance

Evidence requirements

You should assess the unit holistically, using a portfolio of evidence generated by learners. They must produce a reflective report for each outcome, evaluating the knowledge and skills they have gained.

Learners must achieve each outcome before they begin the next. Any reassessment must be done before proceeding to the next outcome. Evidence should principally consist of written or oral recorded evidence from reviews of each outcome. Learners generate evidence under controlled or supervised, open-book conditions, and it must be authenticated as being all their own work. The evidence must contain a mix of knowledge and skills items to match the evidence requirements of the unit, and include various forms of evidence, such as:

- assignments
- case studies
- reports
- essays
- simulations
- structured controlled tests
- practical evidence
- other relevant sources of evidence

To successfully achieve the unit, learners must provide evidence for the following outcomes.

Outcome 1

- Identify types of innovation and entrepreneurship.
- Evaluate types of innovation and entrepreneurship.
- Select appropriate types of innovation and entrepreneurship for a new engineering design project.

Outcome 2

- Identify ways of creating engineering products.
- Evaluate ways of creating engineering products.

- Select appropriate ways for creating new products for a new engineering design project.

Outcome 3

- Identify customer needs and wants.
- Evaluate competing products.
- Elaborate new product design specifications.

Outcome 4

- Create new product concepts.
- Evaluate new product concepts.
- Select the best alternative solution or concept for a new product.

Outcome 5

- Generate engineering design solutions associated with the new product concept.

Outcome 6

- Generate new product prototypes to test and evaluate their performance.
- Communicate a new design to relevant interested parties.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Outcome 1 Learners should understand: ♦ value creation ♦ innovation and types of innovation ♦ disruptive thinking ♦ sustainable innovation ♦ products, services and systems ♦ drivers of engineering entrepreneurship ♦ sources of funding for engineering entrepreneurship ♦ business models for engineering entrepreneurship ♦ copyright, patents and other forms of intellectual property rights protection ♦ design engineering ethics	**Outcome 1** Learners can: ♦ list ways to create value ♦ evaluate engineering problems and situations in different ways ♦ generate an unusual idea, or invent a new solution, or make a one-of-a-kind solution ♦ list different ways to modify or improve products to make them more sustainable ♦ list new situations in which products, services and systems can be used ♦ identify different kinds of engineering entrepreneurship drivers ♦ identify different kinds of sources of engineering entrepreneurship funding ♦ focus on many kinds of business models for engineering entrepreneurship ♦ identify many and different kinds of situations in which copyright and patent regulations apply ♦ list different ways to produce ethically sound designs

Knowledge	Skills
Outcome 2 Learners should understand: ♦ design engineering factors ♦ human-centred design ♦ the engineering design process ♦ 'design for X', for example design for: — sustainability — circular economy — net zero — cost — value and growth — manufacture — assembly — reliability — safety — test and maintenance — material and process selection — equality, diversity and inclusion — ethics — aesthetics — ergonomics	**Outcome 2** Learners can: ♦ identify, evaluate and improve different kinds of design factors that describe a product or an engineering system ♦ suggest changes or improvements to existing products using human-centred design principles ♦ design new products using a systematic design engineering process ♦ list different ways to create, modify or improve engineering products by using 'design for X'
Outcome 3 Learners should understand: ♦ customer needs and wants ♦ benchmarking or competition analysis ♦ technology push, market pull ♦ product design specifications	**Outcome 3** Learners can: ♦ identify customer needs and wants ♦ evaluate existing competing products and suggest ways to improve engineering products ♦ suggest changes or improvements to existing products by evaluating innovative technology and/or identifying relevant market needs ♦ build on extensive design research to elaborate comprehensive product design specifications

Knowledge	Skills
Outcome 4 Learners should understand: ♦ the function of existing products ♦ technology-readiness levels ♦ patents as sources of ideas ♦ new product concepts ♦ Pugh's concept selection method ♦ concept evaluation and selection	**Outcome 4** Learners can: ♦ identify, evaluate and suggest improvements to the performance of existing products ♦ evaluate technology-readiness levels ♦ list ways to improve existing product concepts by analysing patents ♦ generate original ideas or concepts for new product designs ♦ evaluate generated ideas or concepts using Pugh's concept selection method ♦ evaluate the best alternative solution or concept, and reflect on the concept evaluation and selection process

Knowledge	Skills
Outcome 5 Learners should understand: ♦ forms generation ♦ tolerance design ♦ materials and process selection ♦ product function analysis ♦ fault analysis and management ♦ safety analysis and management ♦ robust design ♦ optimisation engineering	**Outcome 5** Learners can: ♦ generate new parts forms and assemblies using appropriate computer-aided drafting software ♦ list, evaluate and select specifications for individual parts using formal tolerance analysis ♦ evaluate alternative materials and processes and select the best alternative options ♦ create alternative new product function diagrams using the function analysis system technique and evaluate these diagrams ♦ identify faults and evaluate them using formal reliability engineering techniques ♦ identify, evaluate and reduce safety and health risks through formal design for safety techniques ♦ generate and evaluate different ways to modify or improve the performance of engineering products using formal robust design methods, such as the Taguchi method ♦ generate and evaluate alternative options for modifying or improving product performance using formal engineering principles

Knowledge	Skills
Outcome 6 Learners should understand: ♦ rapid prototyping ♦ product performance evaluation ♦ engineering change ♦ design documentation and communication ♦ patent applications	**Outcome 6** Learners can: ♦ create or construct, and test or simulate, new product prototypes ♦ evaluate and reflect on the performance of new product prototypes ♦ identify any change in the process, materials, components, technology or any other items listed in the product design specifications ♦ build on the whole design engineering process activity, and document and communicate the new design ♦ build on the novelty of the new product design, elaborate it and apply for a patent

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the engineering sector.

Self-management

Learners develop the meta-skills of integrity (self-awareness, ethics and self-control) and adapting (critical reflection and self-learning) when producing their portfolio or project assignments. They also develop initiative (decision-making, self-motivation and responsibility) during learning activities and when they elaborate reports.

Social intelligence

Learners develop communication skills (receiving information, listening and giving information) by accessing unit material through a virtual learning environment (VLE), keeping an e-portfolio and completing technical reports. They also develop their collaborative skills (team working and collaboration) when engaging with lecturers and other learners throughout the unit.

Innovation

Learners develop the meta-skills of curiosity (observation, questioning, information sourcing and problem recognition); creativity (imagination, idea generation, visualising and maker mentality); sense making (pattern recognition, holistic thinking, synthesis, opportunity recognition and analysis); and critical thinking (deconstruction, logical thinking, judgement and computational thinking) during learning activities and projects, working either individually or in groups.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop numeracy skills by performing engineering calculations related to their engineering design project.

Communication

Learners develop communication skills by studying the course material and engaging with lecturers, other learners and other interested parties.

Digital

Learners develop digital skills and computer literacy by using appropriate engineering software packages and accessing the course material through a VLE.

Delivery of unit

This unit is part of the Higher National Diploma (HND) in Engineering. The framework includes mandatory and optional units, and you can tailor the selected combination of units to specific engineering pathway needs.

While the exact time allocated to the unit is at your centre's discretion, the notional design length is 120 hours.

The amount of time you allocate to each outcome is also at your discretion, however we suggest spending approximately 20 hours on each outcome, including assessment.

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

This unit gives learners fundamental knowledge and skills in sustainable design, design engineering, and innovation and entrepreneurship that are needed to support a career in engineering in a wide range of industries.

Evaluate opportunities for innovation and entrepreneurship (outcome 1)

This outcome introduces learners to innovation and entrepreneurship that relates to real-life business environments. This provides learners with the main principles of value creation; innovation and types of innovation; disruptive thinking; sustainable innovation; and products, services and systems. The study of entrepreneurship should include drivers of engineering entrepreneurship, sources of funding and business models. Learners also learn about intellectual property rights and design ethics.

Evaluate ways to create engineering products (outcome 2)

This outcome introduces learners to the design engineering process. This provides learners with relevant principles that relate to engineering design in industrial situations. The study of the design engineering process should include the fundamentals of design engineering factors, human-centred design and an overview of the design engineering process. Learners also learn about a wide range of ‘design for X’ factors, such as:

- sustainability
- circular economy
- net zero
- cost
- value and growth
- manufacture
- assembly
- reliability
- safety
- test and maintenance
- material and process selection
- equality, diversity and inclusion
- ethics
- aesthetics
- ergonomics

Elaborate new product design specifications (outcome 3)

This outcome introduces learners to design engineering research. It provides learners with the basic knowledge and skills that relate to design research in a wide range of business situations. The study of design engineering research should include techniques and methods on how to gather and develop a thorough understanding of customer needs, and how to benchmark competing products in a marketplace. Learners should also learn the fundamentals of technology push and market pull, and new product design specifications.

Create the best alternative new product concept (outcome 4)

This outcome introduces learners to concept design of new products. This provides learners with the basics of creative and critical thinking as they relate to creating new product concepts in highly competitive companies. The study of concept design engineering should include the function of products, technology-readiness levels, patents, generation of ideas, and techniques for evaluating and selecting ideas or concepts that meet customer needs and wants.

Generate engineering requirements for new product concepts (outcome 5)

This outcome introduces learners to detailed design engineering, providing learners with the basics of engineering principles that relate to a wide range of professional engineering design practices. The study of detailed design engineering should include generating forms using appropriate engineering software, tolerance design, and material and process selection. Learners also learn more advanced principles and techniques such as function analysis system technique, fault analysis and management, safety analysis and management, robust design, and optimisation engineering principles and techniques.

Evaluate new product prototype performance (outcome 6)

This outcome introduces new product performance evaluation that relates to real-life prototyping and testing practice. The study of product performance evaluation should include the basics of rapid prototyping and engineering change. Learners also learn how to document and communicate new designs and patent applications.

Required resources

There are no specific resources required for this unit other than appropriate engineering software, such as computer-aided drafting (CAD) software, and information and communication technology (ICT). However, you can greatly enhance learners' understanding of the subject material by providing a range of technology and equipment, for example 3D printing for prototyping.

Approaches to delivery

We recommend that learners complete outcomes 1 and 2 first, then complete outcomes 3 to 6 in order. Outcomes 3 to 6 build on knowledge and skills developed in outcomes 1 and 2.

You should deliver the unit in a learning space or through a VLE. You should teach primarily using problem-based-learning (PBL) and project-based-learning techniques, supported by other methods such as creative and critical thinking, gradual release of responsibility,

scaffolding, working and long-term memory, and schema-building techniques. Learners should have opportunities to work independently and as part of a team.

Approaches to assessment

We recommend that you assess this unit holistically by reviewing case study reports and projects. Learners should generate written and/or oral evidence under controlled or supervised, open-book conditions, and collate all evidence in their individual portfolios.

Learners should demonstrate evidence of all knowledge and skills in the context of one or more overarching design engineering and innovation entrepreneurship scenarios.

You could assess outcomes 1 to 6 using a single engineering design project. You should give learners instructions and a completion date for the assessment, making sure they have enough time to understand the requirements and complete the project. Throughout outcomes 1 and 2 learners must produce evidence of the engineering design project initial ideas and planning. You should provide appropriate guidance and assistance to learners from the outset of the project assignment. For outcomes 3 to 6, learners should generate evidence over time and for each outcome. Each outcome must be achieved before the next outcome is started. This means that any reassessment of any of these outcomes must be done before proceeding to the next outcome. To achieve outcome 3, learners should produce evidence regarding customer needs and wants, benchmarking, and comprehensive product design specifications. To achieve outcome 4, learners should produce evidence about the generation, evaluation and selection of the new product design concept. To achieve outcome 5, learners should produce evidence in relation to the detailed engineering design of the new product. Learners should produce evidence regarding prototyping and testing the new product.

As part of this design project assignment, each learner could give a presentation based on their final design to an audience. The presentation could be followed by a short question and answer session.

Learners can keep a linear reflective account to assess their meta-skills, digital literacies, communication skills and wider employer-desired skills. They should record this in their personal portfolio. You should provide learners with support, guidance and feedback on areas of development, and signpost developmental opportunities.

As the assessment is open book, you must take care to ensure authenticity. You can do this by using variable values in the coursework, making use of oral questioning and using originality-checking software.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Information for learners

Sustainable Design Engineering and Innovation Entrepreneurship (SCQF level 8)

This information explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit provides you with knowledge and skills specific to design engineering, sustainable design, innovation and entrepreneurship. It is part of HND Engineering.

In the unit, you learn about topics such as entrepreneurship and innovation fundamentals; design engineering fundamentals; product design research; concept design engineering; detailed design engineering; and evaluation of new product performance.

Before starting the unit, we recommend that you have a fundamental knowledge and understanding of engineering disciplines, and mathematical concepts and principles. This could be an SCQF level 7 qualification in Electrical Engineering, Electronics, Mechanical Engineering or Engineering Systems. The unit provides you with suitable knowledge and skills to progress to further study or employment in a wide range of engineering industries.

On completion of the unit, you can:

1 evaluate opportunities for innovation and entrepreneurship
2 evaluate ways to create engineering products
3 elaborate new product design specifications
4 create the best alternative new product concept
5 generate engineering requirements for new product concepts
6 evaluate new product prototype performance

Outcome 1 introduces you to innovation and entrepreneurship. This provides you with the fundamentals that relate to how competitive companies innovate, and the basics associated with being an entrepreneur. This includes learning about value creation; types of innovation; disruptive thinking; sustainable innovation; products, services and systems; drivers of engineering entrepreneurship; sources of funding for engineering entrepreneurship; business models; copyright and patents; and design ethics.

Outcome 2 introduces you to ways to design engineering products or engineering systems. It provides you with the principles, techniques and methods that relate to creating new products in an industrial context. This includes learning about human-centred design, design

engineering factors, the engineering design process and ‘design for X’, which includes relevant factors currently used in industry, such as:

- sustainability
- circular economy
- net zero
- cost
- value and growth
- manufacture
- assembly
- reliability
- safety
- test and maintenance
- material and process selection
- equality, diversity and inclusion
- ethics
- aesthetics
- ergonomics

Outcome 3 introduces you to design engineering research. This provides you with the basic methods and techniques that relate to discovering new product needs and wants relating to current engineering business design research practice. This includes learning about how to discover and gather customer needs and wants, benchmarking, technology and market pull, and product design specifications.

Outcome 4 introduces you to concept design engineering. This provides you with the key principles, methods and techniques that relate to creating, evaluating and selecting the best alternative new product concept as practised in competitive companies. This includes learning about and applying function analysis of existing products, technology-readiness levels, patents as sources of ideas, new product concepts, and Pugh’s concept evaluation and selection method.

Outcome 5 introduces you to detailed design engineering. This provides you with a firm understanding of the fundamentals of engineering design principles, methods and techniques. This includes learning about and applying forms generation; tolerance design; materials and process selection; function analysis; fault analysis and management; safety analysis and management; robust design; and optimisation engineering.

Outcome 6 introduces you to new product performance evaluation as used in industry. This provides you with sound understanding of the basic techniques and methods for evaluating the performance of new products at the prototyping stage of modern engineering design activities. This includes learning about and applying rapid prototyping, product performance evaluation, engineering change, design documentation and communication, and patent applications.

You are assessed using a variety of ways, including review of case study reports and projects. There is a holistic approach to assessment, where you demonstrate evidence of all knowledge and skills in the context of one or more overarching design engineering scenarios. You produce evidence under controlled or supervised, open-book conditions. You should collate all evidence in your individual portfolio.

Meta-skills

Throughout the unit, you can develop meta-skills to enhance your employability in the engineering sector. Meta-skills include self-management, social intelligence and innovation.

Self-management

You develop the meta-skills of integrity, adapting and initiative as you study the unit learning material, and as you conduct learning activities such as case studies and projects.

Social intelligence

You develop your communication skills by accessing the unit material through a virtual learning environment (VLE), keeping an e-portfolio and completing technical reports. You also develop your collaboration skills when engaging with lecturers and other learners throughout the unit.

Innovation

You develop the meta-skills of curiosity, sense-making, creativity and critical thinking when carrying out your design engineering case studies and projects.

Administrative information

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Superclass: AB

History of changes

Version	Description of change	Date
2.0	♦ Evidence requirements updated to clarify conditions of assessment. ♦ Approaches to assessment and information to candidates updated to clarify conditions of assessment.	Dec 2024

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.