



National Unit Specification: general information

UNIT Engineering Design (SCQF level 6)

CODE F5K5 12

SUMMARY

This Unit may form part of a National Qualification Group Award or may be offered on a free standing basis.

This Unit is designed to provide candidates with the knowledge, understanding and skills to undertake simple engineering design. During Unit delivery, candidates will learn about the relationship between engineering design and product design and the factors relevant to each. They will also learn about the factors and processes involved in systematic design. They will also develop their knowledge, understanding and skills to produce a simple engineering design. This will involve candidates in finalising a design specification, developing a number of potential solutions to a given design brief and specification, undertaking analysis associated with the solutions, selecting and justifying the best solution and presenting this solution in an appropriate format.

This Unit is suitable for candidates training to be manufacturing, mechanical or multi-disciplinary engineering technicians.

OUTCOMES

- 1 Explain the processes and factors in systematic engineering design.
- 2 Develop an engineering design from a given brief and outline specification.

Administrative Information

Superclass: VF

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RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- ◆ Standard Grade Mathematics at credit level
- ◆ Standard Grade Physics at credit level
- ◆ Standard Grade Technological Studies at credit level
- ◆ Standard Grade Graphical Communication at credit level

CREDIT VALUE

1 credit at SCQF level 6 (6 SCQF credit points at SCQF level 6*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

CORE SKILLS

There is no automatic certification of Core Skills in this Unit.

The Unit provides opportunities for candidates to develop aspects of the following Core Skills:

- ◆ Communication (SCQF level 5)
- ◆ Numeracy (SCQF level 5)
- ◆ Using Information Technology (SCQF level 5)
- ◆ Problem Solving (SCQF level 5)
- ◆ Working with Others (SCQF level 5)

These opportunities are highlighted in the Support Notes of this Unit Specification.

National Unit Specification: statement of standards

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Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Explain the processes and factors in systematic engineering design.

Performance Criteria

- (a) Explain correctly the relationship between engineering design and product design.
- (b) State correctly the factors relevant to engineering design and product design.
- (c) Explain correctly the engineering design process from customer need to production.
- (d) Describe correctly the factors relevant to systematic design.

OUTCOME 2

Develop an engineering design from a given brief and outline specification.

Performance Criteria

- (a) Complete accurately a specification for an engineering design.
- (b) Develop a number of potential design solutions from a given design brief and specification.
- (c) Undertake correctly analysis appropriate to the design solutions.
- (d) Select and justify optimum design solution to meet customer requirements.
- (e) Present clearly optimum design solution in appropriate format.
- (f) Report correctly on the key factors that influenced the choice of the optimum design solution.

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate that candidates have achieved all Outcomes and Performance Criteria.

Outcome 1

Written and/or recorded oral evidence should be produced to demonstrate that a candidate has achieved all Outcomes and Performance Criteria. Outcome 1 must be assessed by a single assessment which should not exceed 45 minutes. Assessment must be conducted under supervised, closed-book conditions in which candidates are not allowed to bring their own notes, handouts, textbooks or other materials into the assessment.

With regard to Outcome 1:

- ◆ candidates must state four factors relevant to engineering design and four factors relevant to product design
- ◆ factors relevant to systematic design must include a minimum of three of the following: technical analysis, ergonomics, safety, manufacturability, reliability, serviceability, sustainability, cost and marketing

National Unit Specification: statement of standards (cont)

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Outcome 2

Written and/or recorded oral, product and performance evidence supplemented with an assessor observation checklist should be produced to demonstrate that a candidate has achieved the Outcome and Performance Criteria. Outcome 2 must be assessed by a single assessment covering the Outcome and Performance Criteria. This assessment should be designed such that candidates are able to complete it in approximately 30 hours. Assessment should be carried out at appropriate points throughout the delivery of the Unit. Given the nature of the engineering design process it will not be possible to assess all aspects of candidate assessment activities under supervised conditions. However, centres should conduct enough assessment activity under supervised conditions to check that candidates are producing sufficient evidence on their own to satisfy the Outcome and Performance Criteria requirements.

With regard to Outcome 2

- ◆ candidates must be provided with an incomplete design specification and asked to complete it by adding a minimum of four further specifications.
- ◆ a minimum of three potential design solutions must be developed.
- ◆ the nature of the analysis undertaken by candidates will vary depending on the engineering subject area candidates are studying and the design being developed. The list shown below provides guidance on different fields of engineering where analysis may take place (the list is not intended to be exhaustive). The fields have been categorised to assist lecturers delivering different NQGs in Engineering, however the categorisations are not intended to be in anyway restrictive as some designs may require types of analysis that draw from more than one field:
 - electrical and electronics
 - fabrication and welding
 - manufacturing
 - mechanical
 - maintenance
 - product design
 - any other relevant engineering area

Each of these areas may involve the following factors (this list is not intended to be exhaustive):

- ◆ safety
- ◆ aesthetics
- ◆ alignment
- ◆ costs
- ◆ customer requirements
- ◆ ergonomics
- ◆ factors of safety
- ◆ life expectancy
- ◆ maintainability
- ◆ manufacturability
- ◆ manufacturing processes
- ◆ material properties
- ◆ reliability
- ◆ research

National Unit Specification: statement of standards (cont)

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- ◆ stress/strain analysis
- ◆ other types of mechanical analysis applicable to candidates at SCQF level 6
- ◆ sustainability (eg recycling, disposability, energy efficient etc)
- ◆ any other valid factors
- ◆ design solutions may be presented in a range of formats including one or more of the following:
 - engineering drawing
 - oral presentation supported by appropriate slides
 - written documentation
 - model(s)
 - computer simulation

Candidates should be encouraged where possible to work in groups during part or all of the design process. However, where group work takes place centres should check that candidates are generating sufficient evidence on their own to meet the Outcome and Performance Criteria.

The Assessment Support Pack for this Unit provides sample assessment material. Centres wishing to develop their own assessments should refer to the Assessment Support Pack to ensure a comparable standard.

National Unit Specification: support notes

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This part of the Unit Specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON THE CONTENT AND CONTEXT FOR THIS UNIT

This Unit forms part of the National Qualification Group Award (NQGA) in Mechanical Engineering at SCQF level 6, but may also be offered on a free standing basis.

This Unit is designed to provide candidates with the knowledge, understanding and skills to undertake simple engineering design. On successful completion of the Unit, candidates will be able to explain the relationship between engineering design and product design and list the factors relevant to each. Candidates will also be able to explain the factors and processes involved in systematic design. Candidates will also have the knowledge, understanding and skills to produce a simple engineering design. As such candidates will be able to finalise a design specification, develop a number of potential solutions for a given design brief and specification, undertake analysis associated with the solutions, select and justify the best solution and present this solution in an appropriate format.

Outcome 1 is intended to introduce candidates to the engineering design process and the factors which are relevant to systematic design. The purpose of engineering design should be explained, together with its relationship to product design. The factors associated with both engineering design and product design should be identified. The stages involved in the design process should be described from customer needs through to readiness for final production. There have been many models developed to explain the design process. Lecturers should select a model(s) that best suits candidate abilities and the main areas of engineering design candidates will be actively pursuing during delivery of the Unit. The use of a block diagram to explain a design process model can greatly enhance candidates' knowledge and understanding of the model. Factors involved in the design process should be discussed. These should relate to fitness for purpose and include technical analysis, ergonomics, safety, manufacturability, reliability and serviceability. A brief discussion of marketing factors and an introduction to the importance of costing should be included.

In Outcome 2 candidates should be allowed to develop design solutions for a given design brief and outline specification. However, before embarking on any design exercise candidates should be taught about a range of issues relevant to engineering design. These may include some of the following topics:

Design brief

- ◆ the purpose of a design brief
- ◆ the difference between open and closed design briefs
- ◆ design brief analysis

Design specifications

- ◆ the purpose of a design specification
- ◆ different types of design specifications (eg marketing, technical, performance etc)
- ◆ writing design specifications

National Unit Specification: support notes (cont)

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Analysis

- ◆ research and analysis of information (eg the role of market research, questionnaire design, how to record and use customer feedback etc)
- ◆ ideas generation (eg brainstorming, mind maps, morphological analysis, technology transfer etc)
- ◆ simple mechanical engineering analysis (eg stress/strain analysis, bending moment and shear force diagrams etc)

Communicating design solutions

- ◆ drawing conventions
- ◆ sketching design solutions
- ◆ producing engineering drawings
- ◆ preparing an oral presentation including the preparation of slides
- ◆ modelling techniques
- ◆ the use of computer simulation in arriving at a design solution
- ◆ preparation of written documentation to support design solution

Costing

- ◆ price versus cost
- ◆ direct and indirect costs
 - staff
 - materials
 - manufacturing
 - distribution
 - training

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that the Unit is delivered in the same sequence the Outcomes are presented in the National Unit Specification: statement of standards section of the Unit. The Unit may be delivered by a combination of lectures, tutorial work, group discussions and industrial visits. Industrial visits may prove particularly helpful in providing an insight into design in practice and would greatly enhance the presentation of the Unit.

Existing artefacts should be used to demonstrate aspects of design practice and to illustrate the influence of factors such as ergonomics, safety, materials and cost. Candidates should be shown examples of good and bad design practice. Alternative design solutions to a common problem could also be shown.

Candidates should be given access to a wide range of relevant information including manufacturers' catalogues, standards and codes of practice, technical publications and standard components. Computer software and the Internet should be used where possible.

National Unit Specification: support notes (cont)

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Candidates should be encouraged to work as part of a group during part or all of the design process in Outcome 2. For example, to simulate industrial practice centres may encourage candidates to form into design teams while undertaking design exercises in Outcome 2. Candidates may wish to use appropriate group ideas generation methods to develop a range of solutions to design problems. Candidates may also give joint presentations of their optimum design solution. However, where group work takes place centres should check that candidates are generating sufficient evidence on their own to meet the Outcome and Performance Criteria.

Where facilities exist candidates may be encouraged to use Rapid Prototyping techniques to model their design solutions.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

The Reading Communication Core Skill component at SCQF level 5 may be developed in both Outcomes while candidates are reading paper based and/or electronic materials on aspects of engineering design processes and consulting manufacturers' catalogues, standards and codes of practice, textbooks and technical publications.

The Oral Communication Core Skill component at SCQF level 5 may be developed while candidates work as part of groups in the design process in Outcome 2 and while giving an oral presentation as part of the assessment to Outcome 2.

The Written Communication Core Skill component at SCQF level 5 may be developed while candidates are providing written answers to the formal assessment in Outcome 1 and while producing any written documentation to support their design solution in Outcome 2.

The Using Number Core Skill component at SCQF level 5 may be developed while candidates are undertaking calculations associated with the design solutions in Outcome 2.

The Using Graphical Information Core Skill component at SCQF level 5 may be developed in Outcome 2 while candidates present design solutions as sketches, engineering drawing and other graphical formats.

The *Information Technology* Core Skill at SCQF level 5 may be developed while candidates are investigating aspects of the design process on the Internet or using computer simulation software.

The Critical Thinking Core Skill component at SCQF level 5 may be developed in Outcome 2 while candidates are determining their optimum design solution for the assessment in Outcome 2.

The Planning and Organising Core Skill component at SCQF level 5 may be developed in Outcome 2 while candidates are planning and monitoring the steps required to complete the design exercise.

The Review and Evaluation Core Skill component at SCQF level 5 may be developed in Outcome 2 while candidates evaluate their various solutions to determine the optimum design solution for the design problem.

The *Working with Others* Core Skill at SCQF level 5 may be developed while candidates work in groups as part of the design process in Outcome 2.

National Unit Specification: support notes (cont)

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GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Centres are encouraged to use formative assessment extensively as it plays a particularly important role in allowing candidates to develop a sound knowledge and understanding of the engineering design process.

For Outcome 1 candidates may be presented with an assessment paper comprising of a series of restricted response and structured questions designed to cover all the Performance Criteria.

The assessment of Outcome 2 should be integrated into a single design project in which candidates are required to undertake the design of a product or a mechanical engineering component or system from customer need to final production. Candidate evidence may partially be presented in the form of a portfolio which should contain evidence relevant to the Performance Criteria in Outcome 2.

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003)*, *SQA Guidelines on e-assessment for Schools (BD2625, June 2005)*.

DISABLED CANDIDATES AND/OR THOSE WITH ADDITIONAL SUPPORT NEEDS

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website www.sqa.org.uk/assessmentarrangements