Next Generation Higher National Unit Specification

Manufacturing Engineering: Simulation and Modelling (SCQF level 7)

Unit code: J6D1 47

SCQF level: 7 (24 SCQF credit points)

Valid from: session 2023–24

Prototype unit specification for use in pilot delivery only (version 1.0) August 2023

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: August 2023 (version 1.0)

Unit purpose

This unit provides learners with specific knowledge and skills that are fundamental to manufacturing engineering. There is a particular focus on modelling and simulation elements that provide the foundation for working with digital twins.

It is aimed at those studying towards qualifications that develop core engineering design and analysis skills to support an industrial career in an engineering field such as manufacturing engineering. It is also for learners who want to develop the practical, personal and professional skills required for a successful career as an engineering technician.

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

- a broad knowledge and understanding of manufacturing and mechanical concepts and theorems, for example an SCQF level 6 qualification in subjects related to manufacturing and mechanical principles
- an appreciation of engineering principles, for example an SCQF level 6 qualification in subjects related to engineering systems
- relevant, equivalent workplace experience or SCQF level 6 qualifications, for example Higher Physics or a National Certificate in Engineering Systems

This unit is for learners who want to become engineering technicians or progress to further study.

Unit outcomes

Learners who complete this unit can:

1 produce 3D engineering models and create 2D model-driven drawings
2 demonstrate simulation and modelling techniques used in manufacturing engineering
3 demonstrate an understanding of statistical process control and lean manufacturing principles

Evidence requirements

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

Evidence should principally consist of written or oral recorded evidence from reviews of case study reports and mini projects. Learners can generate evidence under unsupervised, open-book conditions. They should use at least three sources of materials, and at least one of these should be a current British Standards Institution (BSI) standard.

The standard of evidence should be consistent with the SCQF level of this unit.

You can find further information below, in the ‘Additional guidance’ section.

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

Outcome 1

- Generate 3D engineering models.
- Interpret engineering drawings and modifications.
- Create 2D engineering drawings to manufacture and/or assemble from.
- Prepare a parts list and add instructions for manufacture and/or assembly.

Learners must produce a number of technical drawings to the current BSI standards. They must include full dimensioning and tolerancing, as well as multiple different views in both 2D and 3D. They must also produce a manufacturing work instruction using images from a 3D model, clearly outlining the steps and the bill of materials required for the task.

Outcome 2

- Describe and compare advanced manufacturing systems.
- Create a simulated model of a manufacturing system.
- Apply validation and verification techniques to a case study (digital twin).
- Solve a problem for a practical application using a simulation tool or tools.

Learners should demonstrate their ability to answer questions on a variety of advanced manufacturing systems. They create their own simulation of a manufacturing system, and validate this by assessing it against a real-world scenario to prove the simulation’s accuracy.

They should interrogate it further by scenario testing an improvement to the system, to create another simulation with superior performance.

Outcome 3

- Explain lean manufacturing philosophy and associated concepts and practices.
- Plan the transition of a manufacturing process to lean operations.
- Explain the principles of Six Sigma.
- Apply statistical process control techniques to a manufacturing process.

Where learners are supported by an employer, evidence from project work within the employer's business is eligible to contribute towards the overall portfolio of evidence.

Knowledge and skills

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

Knowledge	Skills
Outcome 1 Learners should understand how to: ♦ interpret technical engineering drawings and associated symbols ♦ apply geometric dimensioning and tolerancing; first, third, isometric and sectioned views; assembly sequence views; and a bill of materials ♦ develop manufacturing work instructions	**Outcome 1** Learners can: ♦ read and create engineering drawings of components of various complexities ♦ add appropriate dimensioning with tolerances from a suitable datum ♦ create various views to ensure all information is present to allow manufacture or assembly ♦ define all components necessary for manufacture ♦ create step-by-step instructions to aid manufacture
Outcome 2 Learners should understand how to: ♦ describe various manufacturing systems and their applications, simulation software and how to simulate manufacturing systems ♦ validate and verify the simulation against a physical system and the effects ‘as built’ has against simulated nominals or assumptions ♦ understand the fundamentals of a digital twin and its use for interrogation and scenario testing, using the simulation or digital twin to test system changes or problem resolution virtually	**Outcome 2** Learners can: ♦ carry out analysis of manufacturing process and application of lean methodologies ♦ scientifically structure an improvement project using define, measure, analyse, improve and control (DMAIC) ♦ carry out statistical analysis of data, converting data into a process control, and applying lean tools in practice

Knowledge	Skills
Outcome 3 Learners should understand how to: ♦ describe the fundamentals of lean manufacturing; the 8 wastes; and DMAIC ♦ describe the different levels of projects related to accreditations (yellow, green, black and master black belts) ♦ understand lean principles and Six Sigma	**Outcome 3** Learners can: ♦ carry out analysis of manufacturing process and application of lean methodologies ♦ scientifically structure an improvement project using DMAIC ♦ carry out statistical analysis of data, converting data into a process control, and applying lean tools in practice

Meta-skills

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

Self-management

Learners develop a range of skills through self-directed work, either from course handouts or a case study-type project. They develop their focusing skills when allocating time appropriately to tasks to ensure they complete activities in the timeframe of the unit.

They develop integrity through ethical decision-making in outcomes 2 and 3, as the early decisions they make have an impact on their results later in the unit. They also develop initiative in outcome 3, as applying lean and Six Sigma principles to a real-life scenario requires them to look at the process differently and be creative.

Social intelligence

Learners develop their communication skills throughout all learning outcomes, but particularly in outcome 1, as the engineering drawing and work instructions effectively communicate technical information.

They must review their work from the perspective of the manufacturer, to ensure they have included all the information required to manufacture a component in their drawing and instructions. They also develop their collaborating and teamwork skills in outcome 3, as one of the main principles of Six Sigma is to ensure there is a broad problem-solving team to stimulate more and better solutions and ideas.

Innovation

Learners develop sense-making skills as they:

- interpret 3D objects into 2D drawings
- create manufacturing or assembly sequence instructions
- create a simulation that can be verified and validated
- analyse a manufacturing process using lean principles

They have the opportunity to develop their creativity, as there is no fixed way to do things. It is up to learners to decide how best to create drawings and models, and where to apply the Six Sigma principles in the manufacturing process. Learners also develop critical thinking as much of the work is carried out virtually. This means they must be able to critique how their work could be used in the physical world, to ensure drawings and instructions are suitable.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy skills in several ways, but primarily in outcome 3, where there is significant emphasis on statistics. This involves them using process data and measurement data (mostly numerical variables, and possibly some string and attribute variables).

Learners analyse this data using various methods. For example, one of the most common is analysis of variance (ANOVA), which uses standard deviation functions to understand the variation in a manufacturing process.

Communication

Learners develop their communication skills when interacting with you and their fellow learners. They also complete written work and present their projects to others.

Digital

Learners develop digital literacy continuously, as they carry out much of the work virtually, using computer-aided systems. They complete the engineering drawings (outcome 1) on computer-aided design (CAD) software, the simulation elements (outcome 2) on computer-aided engineering (CAE) software, and the Six Sigma elements (outcome 3) using spreadsheet or statistical software.

Outcome 2 also focuses on digital twins and extends digital literacy beyond the IT domain. It introduces the Internet of Things and operational technology domains, where digital literacies are slightly different but very important.

Delivery of unit

This unit is part of the Higher National Certificate (HNC) 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 this unit is at your centre’s discretion, the notional design length is 120 hours.

The amount of time between the outcomes is at your discretion, however we suggest the following time distribution for each outcome, including assessment:

Outcome 1 — produce 3D engineering models and create 2D model-driven drawings
(30 hours)

Outcome 2 — demonstrate simulation and modelling techniques used in manufacturing engineering
(54 hours)

Outcome 3 — demonstrate an understanding of statistical process control and lean manufacturing principles
(36 hours)

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

Learners develop knowledge, understanding and skills related to manufacturing engineering principles, with a focus on computer-aided engineering, simulation and data.

Produce 3D engineering models and create 2D model-driven drawings (outcome 1)

Introduces learners to CAD through any CAD software available. They develop an aptitude for creating 2D drawings driven by 3D models, through practical use of the software. This outcome extends to creating assemblies from multiple models, and the associated work instructions and bill of materials. If appropriate, learners should use library parts and templates, such as for generating standard frames around drawings and for creating assemblies, and generic parts such as nuts and bolts.

Demonstrate simulation and modelling techniques used in manufacturing engineering (outcome 2)

Introduces learners to a range of manufacturing technologies covering discrete manufacturing to process manufacturing, and automation and robotics. They apply this knowledge to create a manufacturing model within a simulation package such as industrial discrete events simulation software to simulate a manufacturing system or process. They should gain an understanding of the different types of simulation, covering:

- discrete event simulation (DES)
- finite element modelling
- mathematical or Monte Carlo simulation
- physics simulation
- computer-aided machining simulations
- verification software commonly used in industry

A worked example of a simulation along with a physical trial to verify the simulation would create the best evidence pack. They should use the simulation as a tool, for example, for scenario testing for new technology deployment, or for problem solving to find optimal batch sizes, operations sequencing or resource requirements.

Demonstrate an understanding of statistical process control and lean manufacturing principles (outcome 3)

Introduces learners to lean manufacturing methodologies and tools such as the 8 wastes, pull and push manufacturing processes, visual management, 5S, and just-in-time. They should understand lead times, takt times, overall equipment effectiveness, total productive maintenance and continuous improvement. They then use this knowledge to plan a lean transition on a manufacturing process.

Your centre should provide suitable CAD, CAM or CAE, and DES software.

Approaches to delivery

You should take a sequential approach to delivery, where learners study and complete the outcomes in order. However, you can deliver outcomes at the same time, as some of the content contains transferable knowledge that may be beneficial depending on the projects being carried out. Learners could also present evidence for all outcomes as a single project, as the subject matter is interconnected.

Do this in a learning space or virtual learning environment. You should teach primarily using problem-based-learning (PBL) techniques, such as case studies and mini projects, supported by other methods. The holistic teaching format of PBL encourages learners to consider the deeper context of the theory.

Approaches to assessment

We recommend that you assess this unit holistically. Learners should generate evidence principally using case studies and mini projects.

Opportunities for e-assessment

Assessment that is supported by information and communication technology (ICT), such as e-testing or the use of e-portfolios or social software, may be appropriate for some assessments in this unit.

If you want to use e-assessment, you must ensure that you apply the national standard to all evidence and that conditions of assessment (as specified in the evidence requirements) are met, regardless of the mode of gathering evidence.

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

Manufacturing Engineering: Simulation and Modelling (SCQF level 7)

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 specific knowledge and skills that are fundamental to manufacturing engineering. It has a particular focus on modelling and simulation elements that provide the foundation for working with digital twins.

Before starting the unit, you should have a basic knowledge of manufacturing engineering and understand basic equipment such as lathes, milling machines and grinders. You should also have a basic understanding of engineering drawings and design.

The unit is digital in nature and provides the fundamental platform within engineering to create the basis of digital twins. As you progress, the content shifts from creating 3D models to using them in simulations to predict manufacturing performance. This digital approach is then complemented with knowledge of lean manufacturing principles to provide the theory of manufacturing improvements that can be deployed virtually in simulations and validated through practical trials.

You learn how to create engineering drawings using a CAD package, covering geometric dimensioning and tolerancing (GD&T), assembly sequencing, manufacturing instructions and how to create a bill of materials. You also learn about various advanced manufacturing technologies and systems, as well as simulating and modelling processes, to work towards creating a digital twin. Finally, you learn about lean manufacturing principles and how to put them into practice; Six Sigma; the define, measure, analyse, improve and control (DMAIC) framework; and statistical process control covering data analysis, control charts and capability studies.

Unit outcomes

On completion of this unit, you can:

1. produce 3D engineering models and create 2D model-driven drawings using CAD packages
2. demonstrate simulation and modelling techniques used in manufacturing engineering
3. demonstrate an understanding of statistical process control and lean manufacturing principles

Further learning is available at degree level in manufacturing engineering and digital manufacturing. Employment opportunities exist as direct hire or through graduate or modern apprenticeship schemes.

Meta-skills

Throughout the unit, you can develop meta-skills to enhance your employability in the engineering sector.

These skills include self-management, social intelligence and innovation.

Self-management

As you work through the course material and case studies, you develop the skills of adapting and using initiative through critical reflection and independent thinking.

Social intelligence

You develop communicating and collaborating skills as you work with other learners on case studies and assignments.

Innovation

You develop critical thinking, curiosity and sense-making skills as you analyse problems related to mechanical engineering principles.

Administrative information

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Superclass: VF

History of changes

Version	Description of change	Date

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