

Unit: 31 Computer Aided Manufacturing

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

An understanding of how computer aided manufacturing (CAM) systems operate within an engineering business is important for anyone thinking of a career in the design and manufacture of products.

This unit aims to develop an appreciation of the use of computer systems in a world-class manufacturing environment and how they are applied to product design and manufacture. Emphasis is placed on the need for a total approach to product development, in particular the interface between the various functions of the design and make process and the use of simultaneous engineering.

Learners will start by investigating how CAM systems are used to increase the profitability of a business by reducing manufacturing costs, improving quality and being more responsive to customer needs. This is followed by a look at how simultaneous engineering is used to bring together the many functions of a manufacturing business so that there is a team-based, multi-disciplinary approach to problem solving. Learners then investigate how simultaneous engineering can be used to meet the demands of a customer-driven economy where people expect an off-the-shelf service for customised products.

The unit also covers how newly designed components are modelled using three-dimensional CAD software so that their functionality can be assessed and any errors corrected before the machining process is simulated using CAM software. Cutting metal is expensive and getting it right first time is a crucial aspect of economic manufacture.

Learners will investigate how manufacturing processes can be automated by using industrial robots to move materials and components between the machine tools and the workstations that make up a flexible manufacturing system (FMS). Finally, learners will be given the specification for a component, use CAD software to design it and use CAM software to produce a set of instructions for downloading to a machine tool which could be used to make it.

Learning outcomes

On completion of this unit a learner should:

- 1 Understand the benefits of CAM and the significance of simultaneous engineering
- 2 Understand how the CAD/CAM interface operates and modelling is used to simulate the manufacturing process
- 3 Understand the use of industrial robots and flexible manufacturing systems in engineering
- 4 Be able to design a simple component and generate a programme for a computer numerical control (CNC) machine using a CAD/CAM software package.

Unit content

1 Understand the benefits of CAM and the significance of simultaneous engineering

Benefits of CAM: increased profitability eg reduced machine set-up times, greater flexibility in terms of batch sizes, reduction in lead times, reduction of labour costs, lower unit costs, optimised use of cutting tools, production of complex shapes; improvements in quality eg elimination of human error, consistent accuracy; greater responsiveness to the requirements of the customer; competing in the world market place

Simultaneous engineering: parallel operation of tasks; multi-discipline team-based working eg marketing, design, modelling, rapid prototyping, manufacturing, development; time-based management eg integration of activities, lean manufacturing, total quality management (TQM), shorter development times, faster time to market, right first time, improved communication

2 Understand how the CAD/CAM interface operates and modelling is used to simulate the manufacturing process

CAD/CAM interface: CAD eg product design using industry-standard CAD software, modification of design ideas, production of working drawings; CAM eg generation of part programmes, scheduling of raw materials; specialised linking software eg edgeCAM, Autodesk Inventor/Esprit, SolidWorks; universal formats eg extensions (such as DXF, IGS, AI, EPS, PLT, NC), propriety formats (such as DWG, CDR, CDL, GE3, NC1, BMP, MSP, PCX, TIF)

Modelling: use of CAD/CAM software eg 3D modelling of the product, simulation of tool changing and toolpaths in the machining process, simulation of sequential manufacturing processes, rapid prototyping; benefits eg elimination of machining errors, reduction in scrap rates

3 Understand the use of industrial robots and flexible manufacturing systems in engineering

Robots: applications eg pick and place systems, product handling, product assembly, machine loading, safe operation, codes of practice (Health and Safety Executive HSG43, Provision and Use of Work Equipment Regulations); advantages eg consistency of performance, 24/7 continuous working, reduced cycle times; limitations eg high standard of maintenance required, precise programming needed, computer systems failure will cause breakdown, new products require complete reprogramming, certain processes still need a skilled operator, complex and expensive equipment

Flexible manufacturing systems: benefits eg production of different parts without major re-tooling, efficient production of customised products, ease of responding to changes in product mix and production schedules, lean manufacture; processing machines eg CNC machine tool, machining centre, flexible cell, welding station, assembly; loading and unloading systems eg material handling, pick and place, fixed position robot, conveyors; coordination of the working schedule eg process monitoring by computer, optical recognition, inspection, total quality management (TQM)

4 Be able to design a simple component and generate a programme for a CNC machine using a CAD/CAM software package

Using CAD/CAM software: hardware eg CAD workstation, data storage, hard-copy equipment, network system to download data to machine tools; software eg 2D/3D CAD, databases, single-component CAD files, part programming, macros, cutter path simulation; post-processing eg transfer of post-processed files/data between systems, download to machine tools, inspection and quality management

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describe the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P1 explain the reasons why the use of a CAM system can benefit the operation of a manufacturing business	M1 describe the criteria used to assess the viability of introducing CAM and simultaneous engineering systems into a business	D1 analyse a current low-technology manual manufacturing system for suitability to move to a CAM environment.
P2 describe the strategies used in simultaneous engineering	M2 explain the cost benefits of moving from low-technology manual manufacturing to high-technology automated manufacturing	
P3 explain how the interface between design and manufacture can be integrated using suitable CAD/CAM software	M3 explain the use and operation of robots to move parts between workstations in a flexible machining system.	
P4 explain the reasons for carrying out modelling of a component and simulation before actually cutting metal		
P5 describe the applications, advantages and limitations of industrial robots		

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
<p>P6 explain why a flexible manufacturing system will produce productivity gains for a business deploying a range of processing machines, loading and unloading systems and coordinated work schedules</p> <p>P7 use appropriate software to design a simple component and produce a part program which could be post-processed and used to manufacture it on a CNC machine.</p>		

Essential guidance for tutors

Delivery

The four learning outcomes are strongly linked and the delivery strategy used should ensure that these links are emphasised.

There are close links between this and several other units within the qualification this needs to be taken into account when designing schemes of work, learning activities and assignments. The unit is best placed in the second year of a course as it does require a reasonable level of computer proficiency and knowledge of manufacturing processes.

Learners need to gain a coherent view of the manufacturing process within an engineering context. They need to understand that for a business to remain profitable it is crucial that an effective manufacturing system is in place. It should be impressed on learners that success in the market place can only be achieved if manufactured products are fit for purpose, marketable and meet customer requirements.

To establish the context of CAM, tutors could begin with a general overview of how computers can be used to plan, manage and control the operation of businesses involved in the manufacture of engineered products. This then leads into learning outcome 1. In order to deliver the unit content effectively, learners would benefit from the use of case studies based on companies which successfully use CAM and simultaneous engineering.

To effectively cover learning outcome 2, learners would benefit from visits to the design department of an engineering company to find out about the systems in place and the links between design and manufacture. If learners are employed, it may be useful to base their research on their own company, if appropriate.

To achieve learning outcome 3 learners must investigate the use of industrial robots and flexible manufacturing systems in engineering. The intention here is not to get bogged down in looking at the detailed operating principles of this type of equipment as this is done in other units. Emphasis should be placed on the safe operation of robot devices and the selection of a particular type of robot to carry out a specific task. Learners need to be guided both here and when designing the assignment that covers P5 specific situations which require the use of a robot should be given. P5 is written as a plural and a sensible number of applications would be three. These need to be carefully chosen so that a range is considered (eg a pick-and-place system for assembling components onto a circuit board, loading of raw material into a machine tool, moving components between stations in a machining cell). Some of the evidence for learning outcome 3 may be best found by carrying out a case study based on a visit to local industry.

When delivering learning outcome 4 it should be remembered that some learners will have limited CAD experience. It is not the intention of this unit to make them experts in the use of CAD or CAM software. Additionally, they may have limited or no knowledge of CNC machining. To meet the learning outcome they should only be

required to look at a very simple component suitable for manufacture on a three-axis machine. A rectangular block with radiused corners and a simple profile which is end milled into its top surface would be perfectly acceptable. A key fob with the initials of the learner machined into its surface will provide enough scope to achieve grading criterion P7. It should be noted that there is no requirement for the component to be manufactured but where a centre does have the necessary equipment it will add interest for learners if they are able to see their design being machined.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Assessment

Assessment of this unit could be through five assignments.

To achieve a pass grade learners are expected to be able to explain the reasons for using CAM, simultaneous engineering and flexible systems when designing and manufacturing products. They should also be able to design a simple product which could be produced using a CNC machine. It is suggested that the first assignment covers P1 and P2, with learners being asked to support their own thoughts with evidence taken from published case studies relating to well known companies (eg Toyota and Airbus Industries). It is important that learners demonstrate a good understanding of the reasons why, in a customer driven, global market environment, a manufacturing company can only survive if it uses smart systems in the operation of its business. There is scope to expand this first assignment to include M1. A visit to an engineering company which has moved to using world class manufacturing systems would be a good way of gathering research information.

Grading criteria P3 and P4 complement each other and can be assessed through a second assignment. Learners should not be expected to demonstrate proficiency in the use of CAD/CAM software. A visit to a company to look in detail at the way a component is designed and manufactured would be a useful way to gather evidence. This could involve talking to a CAD designer and being shown the processes of design, modelling and manufacturing. There is scope to include M2 in this assignment.

A third assignment could cover grading criteria P5 and P6. Thought needs to be given to structuring the tasks so that learners restrict themselves to just the applications of robots and do not get sidetracked into explaining in great detail their operating principles. As recommended earlier, restricting learners to three applications will be enough to produce valid evidence to meet P5. As criterion M3 builds on P5 and P6 it can be a part of the third assignment.

The fourth assignment could be a practical activity to produce evidence for P7. The component to be designed should be kept very simple as learners are not required to prove competence in using high-level design skills. As suggested earlier, a simple embossed key fob design which uses the line, arc, diameter and text commands in its design will produce a profile sufficiently complex for a part programme and its post-processing. Screen prints could be used as evidence of tool path simulation. A witness statement or observation record could consolidate learner generated evidence.

M1 builds on P1 and P2. To achieve it there should be evidence of thought having been given to the pressure on design and manufacturing engineers to optimise resources and use business improvement techniques.

M2 links into P3 and P4 but also draws on knowledge from P1 and P2. Explanations should be supported by examples taken from real companies who have successfully moved from low-technology to high-technology manufacturing systems and might include figures for the amounts of cost savings achieved.

M3 requires a greater understanding of how a robot operates and will build on knowledge gained when achieving P5 and P6. Evidence presented should be at a systems (black box) level and the assignment tasks should not be asking for detailed knowledge about, for example, the internal workings of a specific drive or sensor unit within the robot. Tasks based on a scenario which relates to a specific machining system could be used to generate evidence. Learners are not expected to explain how the actual machining functions operate because the criterion relates only to the handling and moving of parts.

Grading criterion D1 builds on content covered in learning outcomes 1, 2 and 3 and could be a very detailed piece of writing based around a scenario. For this reason it might be best covered by a fifth assignment. Learners could assume the role of a manufacturing engineer who has been tasked with presenting proposals to senior management on the implications and suitability of moving from low-technology manufacturing to a CAM environment. There are a lot of well documented examples of how this has been achieved successfully by well-known companies and care must be taken to ensure that what learners present as evidence is authentic. Where appropriate, employed learners should be given the option of analysing their own company.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit links to *Unit 8: Engineering Design*, *Unit 17: Computer Aided Drafting*, *Unit 26: Computer Numerical Control of Machine Tools* and *Unit 29: Manufacturing Planning*.

Essential resources

Centres will need to provide learners with access to 2D/3D commercial CAD software and CAM software which integrates with the CAD package used for designing. Extracts from appropriate standards and legislation and access to industry-standard CNC machining centres and flexible manufacturing systems is also needed.

Indicative reading for learners

Textbooks

Amiriouche F M – *Principles of Computer Aided Design and Manufacturing* (Prentice Hall, 2004) ISBN 0130646318

Colestock H – *Industrial Robotics: Selection, Design and Maintenance* (TAB Books Inc, 2004) ISBN 0071440526

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Staff should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> explaining the reasons why the use of CAM can benefit the operation of a manufacturing business describing the applications, advantages and limitations of industrial robots. 	<p>C3.3 Write two different types of documents, each one giving different information about complex subjects.</p> <p>One document must be at least 1000 words long.</p>
Information and communication technology Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> searching for information about the applications, advantages and limitations of industrial robots. 	<p>ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case.</p>
Problem solving Level 3	
When learners are:	They should be able to develop the following key skills evidence:
<ul style="list-style-type: none"> using appropriate software to design a simple component and produce a part program which could be post-processed and used to manufacture it on a CNC machine. 	<p>PS3.1 Explore a problem and identify different ways of tackling it.</p>