Unit 17: Computer Aided Drafting in Engineering

Unit code: A/600/0267

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners the knowledge and skills needed to use computer aided drafting (CAD) techniques in an engineering context.

Unit introduction

Computer aided drafting is fast becoming the primary means of communicating design information in many industry sectors, particularly in engineering and manufacturing. Two-dimensional (2D) CAD drawings and three-dimensional (3D) CAD data can be shared with computer numerical control (CNC) machines using computer aided manufacturing (CAM) software. 3D models can be rendered to produce photo-realistic representations, or can be animated to produce moving views of products and components as they would appear in service. Additionally, models can be used to analyse features such as mass, volume and mechanical properties.

This unit will enable learners to produce a variety of CAD drawings, from single-part 2D components to complex 3D models. Advanced techniques, such as using pre-prepared symbols to construct circuit diagrams and assembly drawings, will provide opportunities for learners to develop their skills. Learners will also investigate the use of CAD in industry, the hardware and software required and the links with other software packages. In doing this learners will appreciate the advantages of CAD over more conventional methods of drawing production.

Finally, learners will generate 3D models, make comparison with 2D CAD drawings and evaluate the impact of this technology on manufacturing companies and their customers.

The unit as a whole provides an opportunity to carry out practical CAD activities using a full range of commands and drawing environments. In addition, learners will gain an understanding of the use and impact of CAD on the manufacturing industry.

Learning outcomes

On completion of this unit a learner should:

1 Know the advantages of using CAD in comparison with other methods

2 Know about the software and hardware required to produce CAD drawings

3 Be able to produce and interpret CAD drawings

4 Be able to use CAD software to produce 3D drawings and views.

Unit content

1 Know the advantages of using CAD in comparison with other methods

Advantages of CAD: quality; accuracy; time; cost; electronic transfer of information; links with other software eg CAD/CAM, rendering software, animation software, finite element analysis (FEA)

Other methods: manual drafting; model making

2 Know about the software and hardware required to produce CAD drawings

Software: operating systems; CAD software packages eg AutoCAD, AutoCAD/Inventor, Microstation, Catia, Pro/ENGINEER, Solidworks; minimum system requirements eg hard disk space, memory required, processor, video card

Hardware: keyboard; mouse; other input devices eg light pen, digitiser, joystick, thumbwheel; monitor; printer; other output devices eg plotter, rapid prototyping; storage eg floppy disk, hard disk, memory stick, CD, network

3 Be able to produce and interpret CAD drawings

CAD drawings: orthographic projections; circuit diagrams eg hydraulic, pneumatic, electronic; exploded/assembly drawing; standards eg BS8888, BS3939, BS2917

Commands: absolute/relative/polar coordinates; features eg linetypes, grids, snaps, circle, text, hatching, dimensioning, layers/levels, colour; viewing eg zoom, pan; inserting other drawings eg symbols, blocks; modifying eg copy, rotate, move, erase, scale, chamfer, fillet

Interpret: determine properties of drawn objects eg list, distance, area, volume

4 Be able to use CAD software to produce 3D drawings and views

3D environment: 3D views eg top, front, side, isometric

3D models: 3D techniques eg addition and subtraction of material, extrude, revolve, sweep, 3D coordinate entry (x, y, z), wire frame drawing, 2D to 3D (thickness, extrusion); surface models; solid models

Assessment and grading criteria

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

Assessment and 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 describe the advantages, compared to other methods, of producing drawings electronically using a CAD package	**M1** explain the relationship between CAD and other software/hardware used in manufacturing	**D1** justify the use of CAD in a manufacturing company
P2 describe the software and hardware required to produce CAD drawings	**M2** explain how the range of commands used to produce CAD drawings can impact drawing production	**D2** evaluate the impact of the use of 2D and 3D CAD models on final design requirements.
P3 produce 2D CAD detail drawings of five components that make up an assembly or sub-assembly to given standards, using appropriate commands [CT1, CT5, SM3]	**M3** explain how 3D CAD models can be used in the design process.	
P4 produce a circuit diagram containing at least five components to appropriate standards, using appropriate commands [CT1, CT5, SM3]		
P5 produce an assembly drawing and exploded view of an assembly or sub-assembly containing at least five parts, using appropriate commands [CT1, CT5, SM3]		
P6 interpret the properties of an engineering component or circuit from a given CAD drawing [IE4]		
P7 within a 3D environment construct a 3D CAD drawing as a surface and solid model.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit is best suited to a practical delivery approach. Since many learners are unlikely to have had prior experience in this area of work, it is essential that some formal introduction to the unit content is given.

Although learners are likely to be relatively proficient in the use of a computer system, the differences (between software they may be familiar with and CAD) should be emphasised. Similarly an introduction to engineering drawing presentation and exercises on how drawings are constructed would be beneficial.

Learners should be given the opportunity to familiarise themselves with the fundamental drawing and editing commands, initially through a series of basic activities that will develop and build on these CAD skills. As learners acquire competence with the range of skills required then the complexity of the drawings tackled could be increased. It is not necessary for this formative work to be presented as assessment evidence. However, these formative activities will enable the tutor to provide practical support and guidance for the learner and enable them to gain a view of the learner's progress and potential.

The delivery strategy used should emphasise the strong links between the learning outcomes. Learners need to understand the impact of CAD within business and the advantages and uses of CAD information within industry. A practical approach is required to emphasise the ease and speed of drawing production.

The use of pre-printed activity sheets will allow learners to develop skills and knowledge at an appropriate pace and enable the tutor to focus on those learners who are less familiar with the system. Throughout this process it is important to emphasise the impact CAD has on the communication of information within organisations and on manufacturing, as well as the links with other software packages.

At key points in the learners' development the assignments can be introduced. For example the learners should be able to follow the conventions of constructing CAD drawings using orthographic projection and demonstrate this before the second assignment is introduced.

Similarly proficiency in the development of circuit diagrams would be expected before undertaking assignment three. Although CAD software can be used to construct circuit diagrams other proprietary software and/or circuit symbols may be used to develop this element as appropriate.

Finally proficiency in using appropriate 3D tools and techniques would be expected before learners undertake the final assignment.

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.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, scheme of work and methods of assessment • introduction to CAD systems • class exercise on using the operating system to identify and activate CAD software, including the system requirements for running CAD software and the relationship between CAD and associated software packages. *Individual practical activities*: • system configuration and setting up the drawing environment including the use of relevant toolbars and menus. *Whole-class teaching*: • class exercise on individual hardware elements of a CAD system and an exercise comparing the use of CAD with other methods • class exercise on the use of appropriate standards used in creating drawings, eg BS 8888, BS 3939, BS 2917.
Preparation for and carrying out **Assignment 1: CAD Report** (P1, P2, M1 and D1).
Whole-class teaching/tutor demonstration: • class exercise on alignment and presentation of views in 1st and 3rd angle projection systems and the use of standard drawing layouts • class exercises developing CAD skills and using relevant use of navigation commands, eg absolute, relative and polar entry systems • class exercises developing CAD skills and using relevant use of drawing commands, eg types of line, grids, snaps, circle, text, hatching, dimensioning, layers/levels • class exercises developing CAD editing skills including fillets, chamfers, copying, rotating and scaling objects • class exercises to produce, store, retrieve and modify CAD-generated drawings including circuit diagrams/ symbols.
Whole-class teaching/tutor demonstration: • individual class exercises on printing/plotting drawings using appropriate scale and paper size in order to produce hard copies of CAD-generated drawings of components and assemblies in 1st/3rd angle orthographic projection • individual class exercises on editing and modification commands, eg array, copy, move, rotate, erase, stretch, trim, scale, chamfer and fillet, change layers, colours and line types.
Preparation for and carrying out **Assignment 2: CAD Portfolio** (P3, P5, and M2).
Whole-class teaching/tutor demonstration: • individual class exercises to modify CAD-generated drawings including circuit diagrams and symbols and associated hardware used in circuit diagrams, eg hydraulic, electronic, electrical, pneumatic • individual class exercises on interpreting the properties of an engineering component or circuit from a given CAD drawing.
Preparation for and carrying out **Assignment 3: Circuit Diagram** (P4, P6, and D2).

Topic and suggested assignments/activities and/assessment
Whole-class teaching/tutor demonstration: • individual class exercises on using 3D tools to construct surface and solid models of engineering components • individual class exercises on the use of appropriate scale and paper size in order to produce hard copies of 3D models.
Preparation for and carrying out **Assignment 4: 3D Modelling** (P7, M3 and D2).
Feedback and review of unit.

Assessment

It is likely that the assessment evidence for P1 and P2 will be produced through a case study or through studying the company in which learners may be employed. Typically, it would take the form of a written report or presentation. To achieve P1, learners must demonstrate an understanding of how CAD is used in comparison with more traditional drawing methods, stating its advantages and explaining how CAD systems can be linked with other software. A description of basic hardware and software requirements to operate a CAD system will be required to achieve P2.

The remaining pass criteria could be evidenced through a series of competence based practical activities. Evidence could be in the form of witness statements, tutor observation records or a portfolio, although it is likely that electronic files will be used for the majority of the assessment. Screen dumps can often be a good source of evidence to show the range of commands used during the development of the drawings. The process evidence for these remaining pass criteria (P3 to P7) might be obtained from three further assignments. In the first of these learners would be required to produce five separate CAD drawings of the components which make up an assembly or sub-assembly. The full range of commands must be used and the drawings should be dimensioned to an appropriate standard, enabling P3 to be achieved. These drawings could then be used to produce an assembly and exploded view drawing (P5).

The second assignment would require production of a circuit diagram to achieve P4. This might reflect the learner's occupation or area of interest and should be assembled from symbols previously introduced by the tutor and/or externally sourced. This assignment could also ask learners to interpret and provide a summary of the information contained in a given detail drawing or circuit diagram (P6).

The final assignment would require production of a single 3D model using both surface and solid modelling techniques to enable achievement of P7. This might be a 3D version of one of the part drawings used as evidence for the assembly and exploded view drawing.

To achieve a merit grade learners will need to look beyond how drawings are produced and evaluate their use and application. This will typically be through looking more closely at the relationship between CAD and other software. Learners should be able to explain how linking CAD to other software/hardware impacts on an organisation (for example improving production, reducing waste, reducing lead times). This will build upon the evidence generated for P1 and enable the M1 merit criterion to be achieved.

An evaluation of the range of commands for criterion M2 and how they impact on drawing production in terms of efficiency (for example speed, accuracy, repeatability) links with P3, P4 and P5. Similarly, knowledge for the M3 criterion of how 3D models can be used in the design process links with the 3D activity in P7.

To achieve distinction criterion D1, learners should be able to justify the use of CAD and will need to analyse other factors (for example disadvantages, costs, training requirements). This links with P1 and P2 as well as the M1 and M2 criteria. Learners should be able to evaluate the relative merits of using CAD software. This could be as part of the case study outlined as possible evidence for the P1 criterion.

To achieve the D2 criterion learners will need to evaluate 2D and 3D drawings from a customer perspective. This links directly with the P7 and M3 criteria. Learners will need to compare and contrast the impact on customers of producing drawings using 2D and 3D CAD and how customers might use the information produced.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1 and D1	CAD Report	Learners to research and compare the use of CAD with other methods and determine the software and hardware required to produce CAD drawings; in addition an investigation of how CAD links to other software and hardware and a justification of the use of CAD in manufacturing.	A report containing written responses about the use of CAD and alternative methods; in addition the software and hardware requirements of a CAD system should be listed and explained. An explanation of how CAD links with other software and hardware should support a justification of the use of CAD in a manufacturing context.
P3, P5 and M2	CAD Portfolio	Learners to create an assembly drawing of at least five parts and detail CAD drawings of the five components; in completing the task learners should be able to explain how they used a range of commands in the CAD software to efficiently produce drawings.	A portfolio of five component drawings and an assembly drawing containing the five individual parts; in addition a short report containing written responses and/or screen dumps explaining how a range of CAD commands were used to efficiently produce the completed drawings.
P4, P6	Circuit Diagram	Learners construct a circuit diagram to using either supplied or pre-drawn circuit symbols; in addition properties of elements of the drawing should be determined using appropriate tools.	A drawing of a circuit constructed from pre-drawn symbols which have been inserted, aligned and connected to form a cohesive circuit diagram; in addition screen dumps or other evidence of the use of tools to determine the properties of the drawn objects.
P7, M3, D2	3D Modelling	An activity requiring learners to construct accurate 3D surface and solid models; in addition a research activity producing an explanation of how these models are used in the design process and an evaluation of both 2D and 3D CAD on final designs.	Two drawings of the same component, a 3D surface model and a 3D solid model; in addition written responses should explain how 3D CAD drawings are used in the design process and an evaluation should consider how 2D and 3D techniques impact on final design solutions.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Using Computer Aided Drawing Techniques in Engineering	Engineering Design
		Engineering Drawing for Technicians
		Computer Aided Manufacture

The unit has been mapped against the SEMTA National Occupational Standards and current NVQs at Level 3. Achievement of the learning outcomes of this unit can contribute skills, knowledge and understanding towards the following units from the Level 3 NVQ in Engineering Technical Support:

- Unit 4: Producing Mechanical Engineering Drawings Using Computer Aided Techniques
- Unit 5: Producing Engineering Drawings/Models Using 3D Computer Aided Techniques
- Unit 6: Producing Electrical Engineering Drawings Using Computer Aided Techniques
- Unit 7: Producing Electronic Engineering Drawings Using Computer Aided Techniques
- Unit 8: Producing Fabrication/Structural Engineering Drawings Using Computer Aided Techniques
- Unit 9: Producing Fluid Power Engineering Drawings Using Computer Aided Techniques
- Unit 10: Producing Engineering Systems/Services Drawings Using Computer Aided Techniques.

Essential resources

Centres will need to have access to a suitably equipped IT facility with access to a printer/plotter. Access to software with 2D and 3D capabilities, such as AutoCAD and Inventor is also required. Whilst general graphics packages would not be suitable, any CAD software capable of generating the evidence required for this unit would be acceptable.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the work can be set using real engineering drawings and drawings from local employers or gathered during work placements should be referenced. Company visits will allow the learners to observe the use of CAD generated drawings in manufacture, inspection, CAD/CAM etc.

Indicative reading for learners

Textbooks

Ambrosius L – *AutoCAD 2009 and AutoCAD LT 2009: All-in-one Desk Reference for Dummies* (John Wiley and Sons, 2008) ISBN 0470243783

Cheng R – *Using Pro/Desktop 8* (Delmar Publishing, 2004) ISBN 1401860249

Conforti F – *Inside Microstation* (Delmar, 2002) ISBN 1401814816

Simmons C and Maguire D – *Manual of Engineering Drawing to British and International Standards* (Newnes, 2004) ISBN 0750651202

Yarwood A – *Introduction to AutoCAD 2009: 2D and 3D Design* (Newnes, 2008) ISBN 0750689838

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	analysing and evaluating information when interpreting CAD drawings
Creative thinkers	generating ideas and trying out alternative solutions when producing CAD drawings
Self-managers	organising time and resources when producing CAD drawings.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Team workers	collaborating with others when working in small groups to produce CAD drawings.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using a CAD system to create a variety of drawings for use in different contexts
Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used	comparing the use of CAD with traditional techniques
Manage information storage to enable efficient retrieval	creating a file/folder system for the storage and retrieval of CAD drawings and symbols
ICT – Develop, present and communicate information	
Present information in ways that are fit for purpose and audience	plotting/printing a variety of CAD drawings
Evaluate the selection and use of ICT tools and facilities used to present information	justifying the use of a CAD system in a manufacturing company.