Unit 16: Engineering Drawing for Technicians

Unit code: T/600/0266

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will enable learners to produce engineering drawings of different components, assemblies and circuits using a variety of sketching, drawing and computer-aided drafting techniques.

Unit introduction

It is important that when a product has been designed it is manufactured correctly and to specification. To achieve this it is crucial that the people making the product in a workshop are provided with well-presented engineering drawings, produced to international standards and conventions. This avoids errors of interpretation which can lead to the scrapping of expensive parts.

An understanding of how graphical methods can be used to communicate information about engineering products is an important step for anyone thinking of taking up a career in engineering. This unit gives learners an introduction to the principles of technical drawings and their applications using hand drawing and computer-aided drafting (CAD) techniques.

Learners will start by carrying out freehand sketching of simple engineering products using pictorial methods that generate three-dimensional images. A range of standard components, such as fixing devices, will be sketched together with other solid and hollow items. Learners are then introduced to a more formalised drawing technique that conforms to British Standards and will put this into practice through a number of drawing exercises. A consistent presentation style will be used as learners draw single part components and simple engineering assemblies.

These drawings will contain all the information needed to manufacture or assemble the product, including information such as dimensions, manufacturing notes and parts lists. The use of conventions to represent standard items will be investigated, such as screw threads and springs in mechanical type drawings or circuit symbols such as solenoids and resistors in electrical/electronic type drawings.

Having learned the principles of engineering drawing, learners will then move on to using a two-dimensional (2D) CAD system for the production of drawings using basic set-up, drawing and editing commands. The first task is to produce a drawing template which can be saved to file, as this reinforces the concept of standardisation and consistency of presentation. This is followed by drawing exercises of single-part components, a simple multi-part assembly and circuit diagrams.

Overall, the unit will develop learners' ability to create technical drawings and allow them to compare the use of manual and computer aided methods of producing engineering drawings.

Learning outcomes

On completion of this unit a learner should:

1 Be able to sketch engineering components

2 Be able to interpret engineering drawings that comply with drawing standards

3 Be able to produce engineering drawings

4 Be able to produce engineering drawings using a computer aided drafting (CAD) system.

Unit content

1 Be able to sketch engineering components

Sketches: regular solids eg cube, rectangular block, 900 angle bracket; hollow objects eg circular tube, square section tube; standard components eg nuts, bolts, screws, pulleys; engineering components eg pulley support bracket, machine vice

Sketching techniques: sketching equipment eg paper (plain, squared, isometric), pencil, eraser; pictorial eg oblique drawing (cavalier and cabinet), isometric; orthographic eg single and linked views; sketching in good proportion; dimensions eg overall sizes, detail

Benefits and limitations of using pictorial techniques: benefits eg speed of production, visual impact; limitations eg lengths and shapes not true, not produced to a recognised standard, dimensions difficult to read; consequences of interpretation errors eg incorrect manufacture, incorrect assembly, cost to scrap

2 Be able to interpret engineering drawings that comply with drawing standards

Interpret: obtaining information from engineering drawings eg component features, dimensions and tolerances, surface finish, manufacturing detail, assembly instructions, parts list, circuit operation

Drawing standards: British Standards eg BS8888, BS3939, BS2917, PP7307; company-standardised layouts eg drawing number, title and issue number, projection symbols (first angle, third angle), scale, units, general tolerances, name of person responsible for producing drawing; line types eg centre, construction, outline, hidden, leader, dimension; lettering eg titles, notes; orthographic projection eg first angle, third angle; views eg elevation, plan, end, section, auxiliary; representation of common features eg screw threads, springs, splines, repeated items; section views eg hatching style, webs, nuts, bolts and pins, solid shafts; symbols and abbreviations eg A/F, CHAM, Φ, R, PCD, M; circuit symbols eg electrical, electronic, hydraulic, pneumatic

3 Be able to produce engineering drawings

Detail drawings of single-piece engineering components: projection method; scale; title block; line work; views; sections; dimensions; tolerances; surface finish; notes

Assembly drawings: line work eg centre lines, construction, outline, cutting plane, sectional view, hatching; representation of standard components eg nuts, bolts, screws, keys; parts referencing eg number referencing, parts list; notes eg assembly instructions, installation features, operating instructions

Circuit diagrams: circuits eg electrical, electronic, hydraulic, pneumatic; components eg transformers, rectifiers, solenoids, resistors, capacitors, diodes, valves, pumps, actuators, cylinders, receivers, compressors

4 Be able to produce engineering drawings using a computer aided drafting (CAD) system

Prepare a template: standardised drawing sheet eg border, title block, company logo; save to file

CAD systems: computer systems eg personal computer, networks; output devices eg printer, plotter; storage eg server, hard disc, CD, pen drive; 2D CAD software packages eg AutoCAD, Microstation, Cattia, Pro/Engineer, Pro/Desktop

Produce engineering drawings: set-up commands eg extents, grid, snap, layer; drawing commands eg coordinate entry, line, arc, circle, snap, polygon, hatch, text, dimension; editing commands eg copy, move, erase, rotate, mirror, trim, extend, chamfer, fillet

Store and present engineering drawings: save work as an electronic file eg hard drive, server, pen drive, CD; produce paper copies eg print, plot, scale to fit

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 create sketches of engineering components using a range of techniques	**M1** explain the importance of working to recognised standards when producing engineering drawings	**D1** evaluate the use of different methods of producing engineering drawings including manual and computer aided methods.
P2 describe the benefits and limitations of using pictorial techniques to represent a given engineering component	**M2** explain how a given engineering drawing would be used and the reasons it is suitable for its intended audience.	
P3 interpret the main features of a given engineering drawing which complies with drawing standards [IE4]		
P4 produce detail drawings of three given single-piece components [CT1]		
P5 produce an assembly drawing of a product containing three parts [CT1]		
P6 produce a circuit diagram with at least five different components which uses standard symbols [CT1]		
P7 prepare a template drawing of a standardised A3 sheet using a CAD system and save to file		

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:**
P8 produce, store and present 2D CAD drawings of a given single-piece component and an assembly drawing of a product containing three parts [CT1].		

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

All four learning outcomes of this unit are strongly linked and the delivery strategy should ensure that these links are emphasised. The method of delivery should be activity based with learners being shown examples of engineering drawings sourced from actual companies.

Learners need to understand that if products are to be manufactured correctly it is crucial that the people cutting metal or assembling components are given accurate and unambiguous information to work from. Whilst it is not intended that learners become expert draftspersons, it is expected that they will gain the necessary skills in manual and computer aided drafting to be able to communicate effectively using graphics. Delivery of this unit will need to develop practical skills in graphical communication and knowledge of drawing standards.

The starting point for delivering this unit is pictorial freehand sketching using pencil and paper. Very simple items such as a cube of wood can be used to get learners thinking about size and proportion and how to fit the drawing onto a piece of paper. It is useful, even at this introductory level, to introduce the idea of standardisation and to encourage learners to put a border and simple title block onto their work. During the course of studying the unit learners will produce a portfolio of sketches and drawings and it is good practice to develop the concept of a corporate presentation, as would happen in industry.

Some learners will have no knowledge of engineering components and delivery needs to be supported with actual examples that they can hold, look at and sketch. This brings in the idea of pictorial sketching in good proportion. There is no need to use colour or shading effects; just produce outline shapes which can be looked at and used as the basis for development into orthographic form. For example, a simple bracket with a single hole could be sketched using isometric projection and a few leading dimensions added. Then, discuss the problem of drawing the hole so that it appears to be circular (time need not be wasted using the geometrical construction method) and lead on to the idea that, if the component is drawn out using a set of linked 2D views, circles can be easily drawn and lengths become true.

Care should be taken when delivering learning outcome 2 because there is a huge amount of information relating to drawing standards and learners will need to be given a structure to work to when being asked to interpret drawings.

Learning outcome 3 is practical and should be achieved by carrying out a number of developmental drawing exercises, starting with a very simple component. Some centres may wish to start learners on CAD at this point and there is nothing in the unit content to prevent this happening. However, care should be taken to ensure that learners do not get sidetracked by the technicalities of the CAD system and lose sight of what they should really be learning (ie the principles of engineering drawing). When deciding on a method of projection to use, either first or third angle can be chosen but there should be an understanding of the principles of both.

In learning outcome 4 learners are required to produce a standard drawing template. This is a straightforward task and some learners may want to do this early on in the unit so that they can print off their own personalised drawing paper. When delivering this part of the unit, thought needs to be given to authentication of learners' work.

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. For example, grading criterion P6 asks for a circuit diagram to be drawn. This may depend on the learner's workplace experience or chosen area of expertise – they could choose an electrical, electronic, hydraulic or pneumatic system provided that the correct components are picked and represented properly.

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/practical demonstration: • introduction to unit, scheme of work and assessment • explain and demonstrate the use of sketching equipment and different sketching techniques • explain the benefits and limitations of pictorial techniques and the consequences of making interpretation errors. *Practical activities*: • practise use of a range of techniques to sketch regular solid objects, hollow objects, standard and engineering components.
Preparation for and carrying **Assignment 1: Producing Engineering Sketches** (P1 and P2).
Whole-class teaching: • explain how to interpret and obtain information from engineering drawings • explain the use and purpose of relevant British and company standards and their use when presenting line types, lettering, orthographic projections, views and common features • explain use of symbols, abbreviations and circuit symbols.
Preparation for and carrying **Assignment 2: Interpreting and Using Drawing Standards** (P3 and M1).
Whole-class teaching/practical demonstration: • explain and demonstrate the production of detail drawings of single-piece components • explain and demonstrate the production of assembly drawings including line work, representation of components, the use of parts referencing and notes • explain and demonstrate the production diagrams of circuits and circuit components. *Practical activities*: • practise the production of component drawings, assembly drawings and circuit diagrams.
Preparation for and carrying **Assignment 3: Producing Engineering Drawing** (P4 and P5).
Preparation for and carrying **Assignment 4: Producing Circuit Drawings** (P6).
Whole-class teaching/practical demonstration: • explain and demonstrate the production of standardised drawing sheets and saving them to file • demonstrate the use of computer systems, output devices, storage and CAD software • demonstrate the use of set-up, drawing and editing commands to produce engineering drawings using CAD • demonstrate how to store, retrieve and present drawings. *Practical activities*: • use of CAD systems and software to produce engineering drawings.
Preparation for and carrying **Assignment 5: Producing Engineering Drawings Using CAD** (P7 and P8).
Preparation for and carrying **Assignment 6: Using Engineering Drawings** (M2 and D1).
Feedback on assessment, unit review and close.

Assessment

Assessment of this could be through the use of six assignments. To achieve a pass learners are expected to show competence in a number of graphical techniques and to be able to apply these to the production of engineering drawings which meet recognised standards.

The first assignment, to cover P1 and P2, could consist of a small portfolio of sketches and written explanations. Items drawn must include regular solids and hollow objects, standard and engineering components. The techniques used must involve sketching equipment, pictorial and orthographic representation and sketching in good proportion with the addition of some dimensions (as specified in the unit content).

The second assignment, to cover P3 and M1, will need to be carefully structured and should be based on a drawing of a component or assembly rather than a circuit diagram so that the unit content can be properly covered.

The third assignment could cover P4 and P5, with the three single-piece components being used for the assembly drawing. This would then make the assignment more realistic in terms of what happens in industry.

The fourth assignment could cover P6, with learners being given a choice of the type of circuit they produce depending on their interest (ie from electrical, electronic, hydraulic and pneumatic). The circuit can be drawn by hand but using CAD may be the preferred method if a library of components is available.

P7 and P8 can be covered by a fifth assignment, which could ask for increased competence in the application of standards when producing drawings. To help authenticate learners' work, additional evidence could be in the form of witness statements, tutor observation records and 'screen dumps' which show the range of commands used during the development of the drawings.

As mentioned above, M1 builds upon the evidence presented for P3 and these two criteria could be assessed using a single assignment. The wider issues of standardisation and manufacturing for the global market place should be addressed with learners supporting their explanations with case study evidence. There are links here to *Unit 21: Engineering Secondary and Finishing Techniques* from which some supporting evidence could be drawn.

The sixth assignment could cover M2 and would be based on knowledge gained to achieve P6, P7 and P8, together with a wider understanding of the use of engineering drawings to communicate information effectively. It will be a piece of explanative writing and can be extended to include D1. As there is only the one distinction criterion in this unit learners must produce some high-level reflective writing, using fully supported argument, if they are to achieve it. The assignment brief should ask for an evaluation of the various drawing techniques used by the learner and link directly with the criteria P1, P5, P6 and P8. To add depth to their evidence, learners could be asked to look more widely at what is used in industry – particularly the use of 3D CAD systems which generate solid models. This would then bring them full circle back to the start of the unit, where they were producing pictorial sketches.

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	Producing Engineering Sketches	Learners have been asked to produce sketches of a range of different objects.	A practical assignment requiring learners to produce a portfolio of engineering sketches with accompanying written explanations.
P3, M1	Interpreting and Using Drawing Standards	Learners have to read and interpret an engineering drawing in order to report the key features of the component, circuit or assembly to a colleague.	A written assignment for which learners need to produce a short report detailing the main features of a given engineering drawing that complies with drawing standards. A further task would require them to explain the importance engineering standards.
P4, P5	Producing Engineering Drawing	Learners need to produce an engineering drawings of three components and an assembly drawing for use by the manufacturing department of their company.	A practical assignment in which learners produce component and assembly drawings.
P6	Producing Circuit Drawings	Learners need to produce a circuit diagram for use by the manufacturing department of their company.	A practical assignment in which learners produce a circuit diagram.
P7, P8	Producing Engineering Drawings Using CAD	Learners need to prepare and produce 2D CAD drawings for use by the manufacturing department of their company.	A practical assignment in which learners produce 2D CAD drawings of a component and an assembly.
M2, D1	Using Engineering Drawings	Learners prepare a report explaining the use of a given drawing and evaluating the drawing techniques that they have used.	A written assignment requiring learners to justify the use of a given engineering drawing for its intended use and evaluate different methods of producing engineering drawings.

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
		Engineering Design
		Electro, Pneumatic and Hydraulic Systems and Devices
		Secondary/Finishing Processes and Techniques
		Computer Aided Drafting in Engineering

This unit covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Engineering Technical Support, particularly:

- Unit 2: Using and Interpreting Engineering Drawings and Documents
- Unit 4: Producing Mechanical Engineering Drawings using Computer Aided Techniques
- Unit 6: Producing Electrical Engineering Drawings using Computer Aided Techniques
- Unit 7: Producing Electronic Engineering Drawings using Computer Aided Techniques
- Unit 9: Producing Fluid Power Engineering Drawings using Computer Aided Techniques.

Essential resources

To meet the needs of this unit it is essential that centres have, or have access to, manual drawing equipment and a CAD system which uses a 2D commercial engineering software package. Centres will also need extracts and illustrations from appropriate drawing standards and conventions.

Employer engagement and vocational contexts

The use of relevant vocational contexts and real engineering information, documentation and materials should underpin the delivery and assessment of this unit. Much of the work could be set in the context of learners' work placements or be based on relevant local employers. Site and company visits could provide opportunities to reinforce learners' understanding of the use of engineering drawings in industry.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Byrnes, D – *AutoCAD 2009 for Dummies* (John Wiley and Sons, 2009) ISBN 3527704833

Cheng R – *Using Pro/Desktop 8* (Delmar Publishing, 2003) ISBN 1401860249

Conforti F – *Inside Microstation* (Onward Press, 2006) ISBN 1418020842

Simmons C, Maguire D and Phelps N – *Manual of Engineering Drawing* (Butterworth-Heinemann, 2009) ISBN 9780750689854

Tooley M and Dingle L – *BTEC National Engineering* (Newnes, 2007) ISBN 0750685212

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 an engineering drawing, judging its relevance and value
Creative thinkers	generating ideas and exploring possibilities when producing engineering 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 ...
Reflective learners	setting goals with success criteria for their development and work
Self-managers	working towards goals, showing initiative, commitment and perseverance organising time and resources, prioritising actions.

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 prepare a template drawing and produce 2D CAD drawings of components and assemblies
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	using a CAD system to prepare a template drawing and produce 2D CAD drawings of components and assemblies
Present information in ways that are fit for purpose and audience	using a CAD system to prepare a template drawing and produce 2D CAD drawings of components and assemblies
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the benefits and limitations of using pictorial techniques and explaining the importance and use of engineering standards and drawing techniques.