Unit 23: Engineering Design

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

For anyone considering a career in the design and manufacture of products, an understanding of how the design process operates within an engineering business is an important step. This unit provides learners with the opportunity to consider design in a holistic way. It combines study of the technical aspects of engineering design with wider issues such as the environment, sustainability and legislation.

The unit introduces and develops the concept of design for manufacture. It is crucial that the design process be effective. Success in the marketplace can only be achieved if products are manufactured that are fit for purpose, marketable and meet customer requirements. The importance of market research, generation of new ideas and the consequences of poor design are investigated.

Learners will also investigate the issues which influence whether a design proposal should be developed into a final solution suitable for manufacture. These issues include the impact of legislation and standards, the need to conform to environmental and sustainability requirements, materials selection and the types of manufacturing process available. On completion of the unit learners will understand the wider implications of engineering design and the reasons why it cannot be carried out in isolation from the rest of the manufacturing/production process.

The unit content is linked together through a practical task which starts with learners interpreting the requirements of a customer and producing a product design specification (PDS). This is followed by an investigation into the legislation, standards and reference sources that are used by designers who work in manufacturing engineering. This knowledge is then used to influence the production of their own design proposals. These proposals are refined and developed into a final design solution which meets the requirements of the customer. Design ideas will have been communicated using a number of techniques including sketching and formal engineering drawing, design calculations and written commentary.

The unit draws together learners' understanding of the principles and process used in manufacturing engineering when developing marketable products and provides a deeper appreciation of the sector.

Learning outcomes

On completion of this unit a learner should:

1 Know how the design process operates when dealing with customers

2 Understand the impact of legislation, standards and environmental and manufacturing constraints on the design function

3 Be able to prepare design proposals that meet the requirements of a product design specification

4 Be able to produce and present a final design solution.

Unit content

1 **Know how the design process operates when dealing with customers**

The design process: triggers eg market pull, demand, profitability, technology push, innovation, market research; process of design for manufacture; decision making; use of new technologies eg computer aided design (CAD), simulation, rapid prototyping, computer integrated manufacture (CIM); lines of communication

Customer: customer/client relationship; types of customer eg external, internal; requirements of customer eg performance specifications (physical dimensions, mass), compliance to operating standards, reliability and product support, end of life disposal, production quantities (custom built, modification to an existing product, small batch, large volume)

Product design specification (PDS): analysis of customer requirements; production of an agreed PDS; documentation eg physical dimensions, materials, mass, operation and performance

2 **Understand the impact of legislation, standards and environmental and manufacturing constraints on the design function**

Legislation and standards: relevant and current legislation, standards and codes of practice eg British Standards (BS), electromagnetic compatibility (EMC) directive, European legislation (European Conformity (CE marking))

Environmental and sustainable constraints: energy efficiency; environmental impact; constraints eg Environmental Protection Act, Waste Electronic and Electrical Equipment Directive; end-of-life disposal eg refurbishment, recycling, disassembly, material recovery, non recyclable components

Manufacturing constraints: availability of resources eg labour, material, equipment; influence of physical and mechanical properties of a material in relation to manufacturing methods; cost effective manufacture eg set up cost (jigs, tools), production quantities; health and safety in the workplace eg Health and Safety at Work Act, Control of Substances Hazardous to Health (COSHH) Regulations

3 **Be able to prepare design proposals that meet the requirements of a product design specification**

Requirements of a PDS: interpretation of technical requirements eg operating performance, physical dimensions; interpret economic requirements eg production quantities, product life, market place positioning

Prepare design proposals: ideas generation eg research into existing products, freehand sketching, simulation, flow charts; realistic design proposals eg fitness for purpose, manufacturability, aesthetics, ergonomics

Design reference material: manufacturers' catalogues eg screw fixings, bearings, seals, electrical connectors, drive belts, gear drives; materials databases eg mechanical properties, physical properties; design databases eg structural beam sections, corrosion protection, anthropometric data

4 **Be able to produce and present a final design solution**

Final design solution: evaluation of proposals and selection of most appropriate for further development eg suitability for available manufacturing processes, cost effectiveness, contribution to profits, visual appearance; development of design proposal into a feasible solution suitable for prototype manufacture eg specify materials, appropriate manufacturing processes, estimation of manufacturing cost, quality; conformity to relevant legislation and design standards

Presentation techniques: 2D engineering drawings eg general arrangement drawing, assembly drawing, detail drawings, circuit diagrams, flow diagrams, schematic diagrams; drawing conventions and relevant British Standards eg BS308, BS8888, BS7307, BS3939, BS2197; documentation eg design diary, logbook, product specification; design calculations eg sizes of materials to meet strength requirements, electric motor power, electronic circuit performance, battery life

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 describe the operation of the design process in an engineering company P2 interpret the requirements of a given customer and produce a product design specification (PDS) P3 describe the appropriate legislation and standards which apply to the design of two different products P4 describe the environmental, sustainability and manufacturing constraints which influence the design of a given product P5 produce design proposals which meet the requirements of a given PDS P6 extract reference information from component manufacturers' catalogues and materials and design databases	M1 explain the possible impact of a poor design process on customer relationships and requirements M2 explain the importance of using a range of accurate design reference materials when developing design proposals M3 explain the issues which influence whether a design proposal should be developed into a final solution suitable for manufacture.	D1 evaluate the impact of legislation and standards on the design process in relation to the profitability of the business D2 evaluate a final design solution against customer requirements and a PDS, and suggest improvements.

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:**
P7 use a range of techniques to present a final design solution which meets the requirements of a given PDS and relevant legislation and design standards.		

Essential guidance for tutors

Delivery

There are strong links between the four learning outcomes and the delivery strategy should ensure that these links are emphasised. Learners need to gain a coherent view of the design process within engineering and understand that for a business to remain profitable it is crucial that the design process is effective. Learners must be made aware that success in the market place can only be achieved if manufactured products are fit for purpose, marketable and meet customer requirements.

Delivery of the unit should start with some case study analysis. This is best done in the form of a group discussion examining example products that learners are familiar with. It is important to contrast successful design icons, like the Sony Walkman™ and the Apple iPod™, with those that have failed, such as the Sinclair C5. A wider discussion could follow about why some products are hugely successful whereas others are not.

It would also be useful to provide an overview of the design process as it applies to automotive engineering, starting with the initial 'concept' and following through to the production model for the mass market. Why is the production model different to the designer's original? Tutors need to get across the idea of compromise in the design process — the trade off between what we would like and what we can actually have when economics, legislation, manufacturability etc are taken into account.

To effectively cover learning outcome 1, learners will benefit from a visit to the design department of an engineering company in order 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. Delivery should be, as far as possible, activity based but care must be taken when covering learning outcome 2. There is a huge amount of data available which relates to the impact of legislation, standards and the environment on the design process, so learners will need to be given guidance when searching for information. Tutors need to consider how this data will be presented as evidence because there is a danger that some learners might include large amounts of unedited material.

Learning outcomes 3 and 4 are best covered by a learner-centered activity, based around a single assignment which will produce evidence for grading criteria P5, P6 and P7. Learners should be applying knowledge gained from *Unit 10*: *Properties and Applications of Engineering Materials*, particularly from the learning outcome covering material selection.

There is scope here for learners to be given a PDS that is tailored to their particular interest but it may be more interesting to give them all the same one and to treat the activity as a design competition. The tutor would assume the role of customer with each learner pitching to get their final design solution accepted. There may be scope to develop this activity into a group discussion with all the design solutions being evaluated and learners using it as a lead into what is required for the evaluation in criterion D2.

Some learners will have limited experience of technical drawing so the aim will be to achieve an acceptable working standard of drawing and design sketching which communicates ideas effectively. Learners should be able to identify key components from engineering drawings and use a restricted set of drawing standards accurately. The use of CAD and symbol libraries is encouraged but learners who wish to present all their work as hand drawn should not be penalised.

Centres need to carefully consider when this unit is to be delivered within the programmme of learning. To be effective, this unit requires learners to have knowledge of core aspects of engineering such as the selection of materials, manufacturing processes, business systems and communication methods.

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 covered through three assignments.

To achieve a pass grade learners are expected to describe how the design process operates in an engineering company and its links to other aspects of the business. It is suggested that during the first assignment the evidence for P1 could be gained by learners visiting the design department of an engineering company, carrying out an interview with an engineering designer and preparing a short report. It is important that learners understand that design cannot be carried out in isolation and that it is an income-generating function with the customer having the final say.

After the visit or similar activity, a written task for P2 should be given that asks learners to produce a PDS from the requirements of a given customer.

A second assignment could a research activity. Two different products need to be given to each learner and research carried out to allow them to describe the legislation and standards that apply to each product (P3) and the environmental, sustainability and manufacturing constraints that influenced the design of one of these products (P4).

Learners will need to demonstrate a basic mastery of design and drawing skills and they should be producing sketches and drawings which are broadly in line with British Standards and which use simple drawing conventions. There should be some evidence of design calculations when presenting evidence for P5, P6 and P7.

For assessment of these criteria a third assignment could be set where a PDS should be given and learners asked to produce a range of design proposals (P5). Three proposals would generally be sufficient although, if the solutions are complex, two would be enough. In doing this, it is important that learners use design reference material (P6) and a range of techniques to present the final solution (P7). The techniques used are dependent on the solution (eg if it involves an electronic system then circuit diagrams will be needed as well as perhaps general arrangement drawings).

Learners will demonstrate a basic understanding of the use of information sources such as books, technical reports, data sheets, catalogues, CD ROM and on-line databases. They should be selecting, interpreting and applying data extracted from a limited range of sources and will have been given guidance on what to look for.

Design work must show good evidence of knowledge gained from the linked units so that learners can be critical about their evolving designs and adapt them, rather than pursue a single idea.

Grading criteria P5 and P6 link the extraction of reference information about materials and components to the design proposals being put forward by the learner. This will give more focus when gathering resource material. It is intended that the assessment evidence for criterion P6 is based on development ideas generated in P5.

To achieve a merit grade learners will need to apply evaluative skills and explain the impact of poor design. To achieve M1 the manufacturer/client relationship should be explored in some depth with evidence supported by examples taken from case studies based on real products. These could be discussed during the visit in the first assignment.

M1 builds on knowledge used to achieve P1 and P2 and may be best attempted during assignment one.

To achieve M2 learners should support their reasons for having accurate reference material by using examples taken from documented sources of products which are mission critical (eg correct specification of dimensions and material for a load bearing structure such as a roof beam). As such, a further written task could be set in assignment three to facilitate M2.

M3 builds on P5 and P7 and as such a further written could be set task in assignment three. There should be evidence of thought being given to economic issues and the pressure on a designer to design to a price in order to be competitive. Explanations should be supported by examples relating to real products that learners are familiar with.

To achieve a distinction grade learners should be able to focus on specific legislation and standards when working towards D1. There are strong links here to learning outcome 3 of *Unit 1*: *Business Systems for Technicians*. Learners should support their evaluation of the impact of legislation and standards on the design process with examples drawn from documented sources (eg examples of businesses that have either lost market share by being caught out by changes in legislation or others that have benefited through anticipating changes and beating competitors in the market). As such a task targeting D1 could be set as part of assignment two.

To achieve the criterion D2, evaluation could relate to a design solution provided by the tutor but it may be better to link with P7 so that learners evaluate their own work. A written task in assignment three may be appropriate for this.

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

This unit links to other units within the qualification, such as *Unit 19*: *Business Systems for Technicians*, *Unit 20*: *Properties and Applications of Engineering Materials and Unit 24*: Engineering Drawing for Technician.

Essential resources

To meet the needs of this unit it is essential that learners have, or have access to, some if not all of the following:

- a range of customer design requirements
- a range of products to investigate design requirement features
- manual drawing equipment
- 2D commercial CAD software
- extracts and illustrations from appropriate drawing standards and conventions
- access to reference material which provides information about the physical and mechanical properties of materials (ICT and non-ICT based)
- access to legislation and design standards (ICT and non-ICT based)
- component and material suppliers' catalogues.

Indicative reading for learners

Textbooks

Poli C — *Design for Manufacture* (Butterworth-Heinemann, 2001) ISBN 0750673419

Samuel A and Weir J — *Introduction to Engineering Design* (Butterworth-Heinemann, 1999) ISBN 0750642823

Simmons C and Maguire D — *Manual of Engineering Drawing* (Butterworth-Heinemann, 2004) ISBN 0750651202

Tooley M and Dingle L — *BTEC National Engineering* (Newnes, 2002) ISBN 0750651660

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.

Application of number Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• carrying out design calculations.	N3.3 Interpret the results of your calculations, present your findings and justify your methods.
Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• describing the operation of the design process in an engineering company • describing the appropriate legislation and standards which apply to the design of two different products • describing the environmental, sustainability and manufacturing constraints that influence the design of a given product.	C3.3 Write **two** different types of documents, each one giving different information about complex subjects. One document must be at least 1000 words long.

Information and communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• searching for data on legislation and standards • extracting reference information from materials, component manufacturers' and design databases • presenting a final design solution.	ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case. ICT3.2 Enter and develop the information and derive new information. ICT3.3 Present combined information such as text with image, text with number, image with number.
Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• producing design proposals that meet the requirements of a given PDS.	PS3.1 Explore a problem and identify different ways of tackling it.