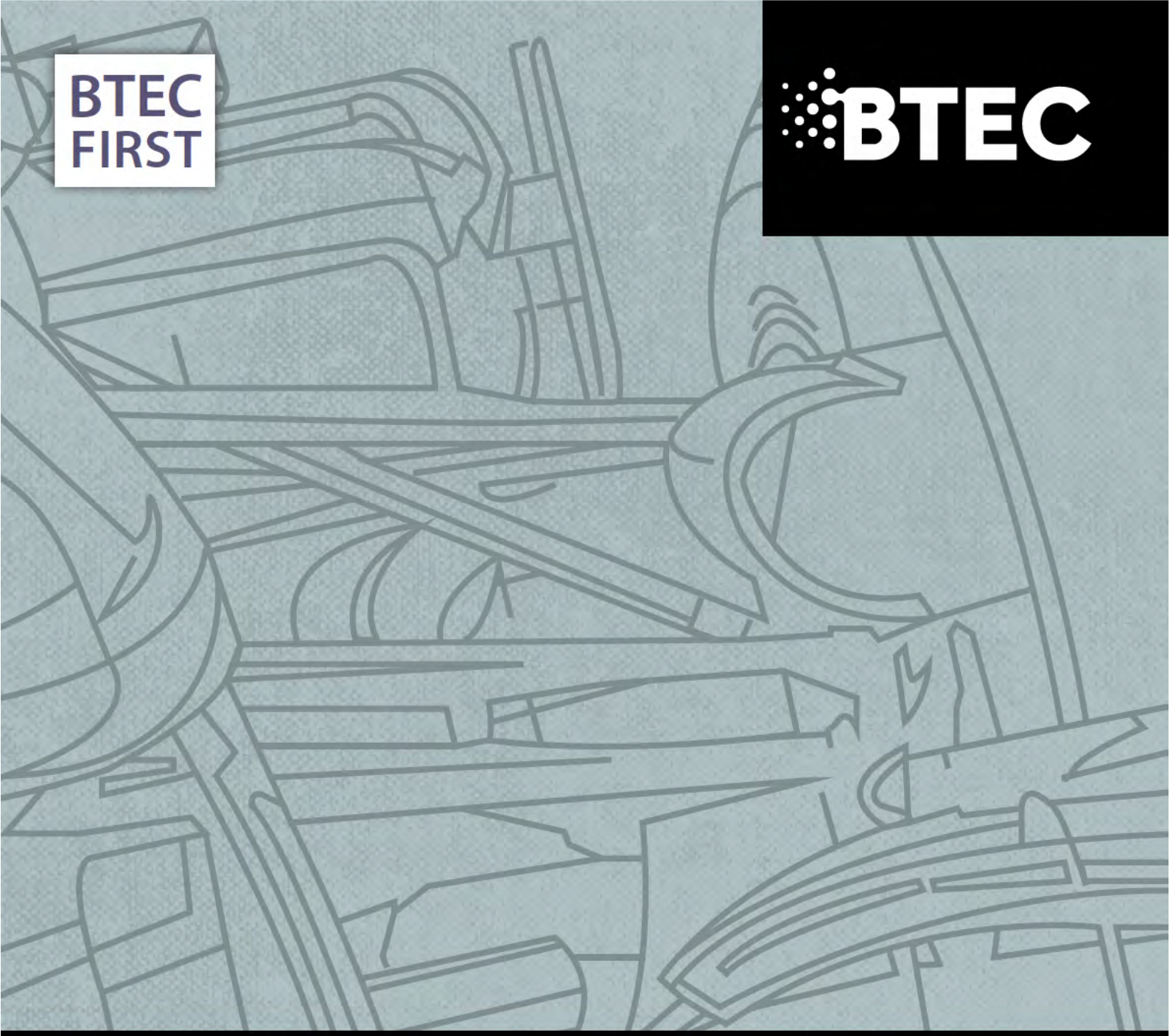

BTEC FIRST

BTEC

# Delivery Guide

## ENGINEERING

**From Autumn 2012**

Pearson BTEC Level 1/Level 2 First Award in Engineering
Pearson BTEC Level 1/Level 2 First Certificate in Engineering
Pearson BTEC Level 1/Level 2 First Extended Certificate in Engineering
Pearson BTEC Level 1/Level 2 First Diploma in Engineering

ALWAYS LEARNING

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# Welcome to your BTEC First delivery guide

This delivery guide is a companion to your BTEC First specifications. It contains a wealth of ideas for practical activities, realistic scenarios and independent learning, helping to bring the content of the units to life. The aim of this guide is to show how the content of the specifications might work in practice and to inspire you to start thinking about different ways to deliver your course. The guidance has been put together by teachers who understand the challenges of finding new and engaging ways to deliver a BTEC programme, which means you can be sure the guidance is relevant and achievable.

Unit-by-unit guidance is given and includes suggestions on how to approach the learning aims and unit content, as well as providing ideas for interesting and varied activities. You will also find a list of carefully selected resources for each unit, including suggestions for books, websites and videos that you can either direct your learners to use or that you can use as a way to complement your delivery.

Guidance about the new features of the BTEC Firsts is also included, providing an explanation of how these work and what you will need to consider as you plan the course. You will also find comprehensive coverage of assessment, including useful advice about external assessment, as well as extensive guidance about how to plan, design and deliver your assignments. Information about the Quality Assurance process will help you understand the different roles and responsibilities of individuals within your centre, and how you can work closely with Pearson to enable the successful running of your programme.

This delivery guide is intended to be read in conjunction with the qualification specifications.

- The specifications tell you what must be taught and gives guidance about how it should be assessed.
- This delivery guide gives suggestions about how the content could be delivered.

The suggestions given in this delivery guide link with the suggested assignment outlines in the specifications but they are not compulsory; they are designed to get you started and to spark your imagination.

**Remember that all assignments must go through internal verification before being delivered to learners.**

**When combining units for a BTEC First qualification, it is the centre's responsibility to ensure that the qualification structure(s) in the specification are adhered to.**

# Contents

# 1 BTEC First Qualifications

BTEC Firsts are vocationally-related qualifications designed to develop learners' knowledge and understanding through the application of learning and skills in a work-related context. BTEC Firsts are designed to allow learners to progress to other level 2 qualifications or apprenticeships, to junior roles in the industry they are learning about or level 3 qualifications.

Around 100 BTEC First qualifications are available for level 2 learners, each linked to an industry sector. Learners may take BTEC Firsts alongside core GCSEs subjects such as English, maths and science giving them the balanced curriculum recommended by the majority of schools.

There are four sizes of qualification available in the BTEC First suite:

| Qualification | Size – Guided Learning Hours | Equivalent in size to | Age group | Delivered predominantly in |
|---|---|---|---|---|
| Award | 120 | 1 GCSEs | 14-19 | School |
| Certificate | 240 | 2 GCSEs | 14-19 | School |
| Extended Certificate | 360 | 3 GCSEs | 14-19 | School/FE College |
| Diploma | 480 | 4 GCSEs | 14-19 | FE College |

# 2 Introducing the new BTEC Firsts in Engineering

The BTEC Firsts in Engineering provide an engaging, robust, broad-based introduction to engineering. Learners can gain knowledge, skills and understanding through practical participation in engineering activities. This allows them to become familiar with the language, skills and processes required to work in the engineering industry. The BTEC philosophy of 'learning through doing' remains at the heart of these qualifications. Learners are given the opportunity to gain and broad understanding and knowledge of skills in engineering.

## Developing the qualifications in response to change

The new suite of BTEC Firsts is now available on the National Qualifications Framework (NQF). The NQF fully supports both academic and vocationally related progression pathways.

The BTEC Firsts have been designed to reflect recommendations as set out in independent reviews, consultations and government guidance on vocational education. As part of the development of all of the new BTEC Firsts, we have also taken into account many consultations with schools, further education, higher education institutions and employers.

## The Wolf Review

Professor Alison Wolf's *Review of Vocational Education* was published in March 2011. The Government has since accepted her proposals in full and the Department for Education (DfE) has produced a list of seven characteristics that all high-value vocational qualifications for learners aged 14+ should demonstrate. Specifically, they should:

1. be at least as big as a GCSE in terms of guided learning hours (GLH), i.e. 120 GLH
2. contain an element of external assessment, e.g. an externally set and marked test taken under specific conditions
3. contain some synoptic assessment so that learners appreciate the breadth of their course and the links between its different elements, rather than just taking units in isolation from each other
4. be graded, e.g. Pass, Merit, Distinction and Distinction*
5. contain content appropriate for learners aged 14+
6. enable progression to further study in the same subject at the next level, and also support progression to broader study at the next level
7. have a proven track record, measured by an uptake of at least 100 learners in five centres.

## The Extended Certificate and Diploma within Study Programmes for 16–19 yr olds

The BTEC Level 1/Level 2 First Extended Certificate and Diploma in Engineering have been designed to meet the requirements of the government's *Study Programmes for 16–19 year olds*. The Department for Education, as part of its *Study Programmes for 16–19 year olds* requires learners aged 16+ to be offered a high quality study programme giving them the best opportunity to progress to higher education or to secure skilled employment.

As part of this requirement learners should be able to study a qualification of substantial size which provides them with the opportunity to progress to the next stage of learning. The BTEC Level 1/2 First Extended Certificate and Diploma in Engineering have been designed to meet this requirement and provide learners who wish to progress their learning and development in Engineering with the opportunity to study topics and aspects of the Engineering sector appropriate for post-16 learners.

The qualification meets the requirements of the *Study Programmes for 16–19 year olds* by:

1. Providing learning appropriate for learners aged 16+ who have chosen to focus their learning in the sector.
2. Providing learners with an opportunity to extend learning from pre-16 to post-16.
3. Encouraging learners to explore relevant specialisation in their learning, through new optional units designed specifically for learners aged 16+
4. Supporting learners who may also be working towards achieving level 2 English and/or mathematics qualifications in a post-16 setting and wish to complement their study programme with a qualification that supports preparation for work or progression.

# 3 Pathways in the BTEC Level 1/Level 2 Firsts in Engineering

## Introduction

The core and mandatory units listed in the specification provide the learner with a general introduction to the world of engineering.

Each of these units includes hands-on practical work and it is important to stress to your learners the importance of keeping themselves and others safe when working. Before starting on any practical task they should confirm with you that they understand the health and safety implications and have thought through how to work safely.

When delivering and assessing Unit 10 Mathematics for Engineering you will be focusing on how to solve problems through the application of mathematical techniques. Several units within each pathway require the application of these mathematical skills.

Learners starting on the programme will probably have little knowledge of job roles within the engineering industry so it is useful to deliver Unit 2 Investigating an Engineered Product in the first term. The choice of product can be tailored to the interests of the learner.

As well as General Engineering there are four endorsed pathways for you and your learners to choose from:

- BTEC Level 1/Level 2 First Diploma in Engineering (Technology)
- BTEC Level 1/Level 2 First Diploma in Engineering (Maintenance)
- BTEC Level 1/Level 2 First Diploma in Engineering (Manufacturing)
- BTEC Level 1/Level 2 First Diploma in Engineering (Mechanical)

### Technology Pathway

The technology pathway is designed for learners who have a general interest in engineering with possibly a bias towards science and want to keep their options open before they progress to level 3 or other types of qualification. There is a focus on the application of computers in engineering and the inclusion of mathematics and science provides a good foundation for further technical studies.

It will benefit your learners if you reinforce links with mathematics, for example, with Unit 12: Engineering Design when preparing cost estimates for a new design.

The technology pathway provides progression opportunities to the various BTEC Nationals in Engineering programmes.

### Maintenance Pathway

The maintenance pathway is designed for learners interested in how engineering equipment works and what to do to keep it in good order so that it is reliable and does not break down or malfunction.

The aim of this pathway is to introduce the learner to the skills which a maintenance technician would employ when servicing and repairing systems such as electrical, electronic, fluid power and mechanical.

It will benefit your learners if you reinforce links with mathematics, for example, with Unit 25: Operation and Maintenance of Electronic Systems and Components, when

processing numerical data gathered during testing against specification after carrying out maintenance on a system.

The maintenance pathway provides progression opportunities onto BTEC Nationals in Operations and Maintenance Engineering.

## Manufacturing Pathway

The manufacturing pathway is designed for learners interested in how products can be produced using a variety of manufacturing techniques, for example, cutting, forming and fabricating.

The aim of this pathway is to introduce the learner to the skills which a technician would employ when working with machine tools, welding equipment or a range of hand tools. Although it is not intended that they become industry standard, skilled machinists, fitters or welders it is important that you emphasise to your learners the need to work to specified degrees of accuracy. The intention with this pathway is that learners carry out manufacturing operations on simple components – interpreting drawings and given data, setting up and using equipment, making dimensional measurements and checking against specification to assess quality.

It will benefit your learners if you reinforce links with mathematics, for example, with *Unit 7: Machining Techniques*, when calculating the speed and feed rates for a workpiece to be turned in a lathe.

The manufacturing pathway provides progression opportunities onto BTEC Nationals in Engineering and Manufacturing Engineering.

## Mechanical Pathway

The mechanical pathway is designed for learners interested in how products are designed and brought to the market place.

The aim of this pathway is to introduce the learner to the range of skills and expertise which engineers use when carrying out design, production planning, manufacture and quality control. Compared to the manufacturing pathway there is less emphasis on actual making (using tools and equipment).

It will benefit your learners if you reinforce links with mathematics, for example, with *Unit 12: Engineering Design*, when preparing cost estimates for a new design.

The mechanical pathway provides progression opportunities onto BTEC Nationals in Engineering and Mechanical Engineering.

## Curriculum Modelling

These models relate to the 480 GLH Diploma programmes.

### Possible curriculum models for the Technology Pathway

Example 1 – delivered over 1 year.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 1: The Engineered World (30 GLH)<br>• Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH)<br>• Unit 5: Engineering Materials (30 GLH)<br>• Unit 9: Interpreting and Using Engineering Information(30) |
| 2 | • Unit 6: Computer-aided Engineering (30 GLH)<br>• Unit 8: Electronic Circuit Design and Construction (60 GLH)<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 3 | • Unit 10: Mathematics for Engineering/ Unit 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH). Co- delivered because mathematics must be delivered in an engineering context.<br>• Unit 12: Engineering Design (60 GLH)<br>• Unit 34: PC Software and Hardware in Engineering (60 GLH) |

Example 2 – delivered over 2 years.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 1: The Engineered World (30 GLH)<br>• Unit 2: Investigating an Engineered Product (30 GLH) |
| 2 | • Unit 3: Health and Safety in Engineering (30 GLH)<br>• Unit 9: Interpreting and Using Engineering Information (30) |
| 3 | • Unit 8: Electronic Circuit Design and Construction (60 GLH)<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 4 | • Unit 6: Computer-aided Engineering (30 GLH)<br>• Unit 5: Engineering Materials (30 GLH)<br>• Unit 12: Engineering Design (60 GLH) |
| • 5 and 6 | • Unit 10: Mathematics for Engineering/ Unit 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH)<br>Co-delivered because mathematics must be delivered in an engineering context.<br>• Unit 34: PC Software and Hardware in Engineering (60 GLH) |

## Possible curriculum models for the Maintenance Pathway

Example1 – delivered over 1 year.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH)<br>• Unit 4: Engineering Maintenance/ Unit 9 Interpreting and Using Engineering Information (30 + 30 GLH).<br>These units could be co-delivered because Unit 4 requires working with reference data (e.g. component part numbers) when performing maintenance tasks.<br>• Unit 5: Engineering Materials (30 GLH) |
| 2 | • Unit 1: The Engineered World (30 GLH)<br>• Unit 10: Mathematics for Engineering/ Unit 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH).<br>Co-delivered because mathematics must be delivered in an engineering context.<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 3 | Electrical maintenance theme:<br>• Unit 8: Electronic Circuit Design and Construction (60 GLH)<br>• Unit 25: Operation and Maintenance of Electronic Systems and Components (60 GLH)<br>• Unit 26: Operation and Maintenance of Electrical Systems and Components (60 GLH) or Unit 23: Electronic Devices and Communication Applications (60 GLH)<br>or, Mechanical maintenance theme:<br>• Unit 13: Engineering Assembly (30 GLH)<br>• Unit 19: Bicycle Servicing and Maintenance (30)<br>• Unit 24: Operation and Maintenance of Mechanical Systems and Components (60 GLH)<br>• Unit 27: Operation and Maintenance of Fluid Power Systems and Components (60 GLH) |

Example 2 – delivered over 2 years.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH) |
| 2 | • Unit 1: The Engineered World (30 GLH)<br>• Unit 4: Engineering Maintenance/ Unit 9 Interpreting and Using Engineering Information (30 + 30 GLH).<br>These units could be co-delivered because Unit 4 requires working with reference data (e.g. component part numbers) when performing maintenance tasks. |
| 3 | • Unit 5: Engineering Materials (30 GLH)<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| | |

| | |
|---|---|
| 4 | • Unit 10: Mathematics for Engineering / Unit: 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH).<br>• Co- delivered because mathematics must be delivered in an engineering context. |
| 5 and 6 | Electrical maintenance theme:<br>• Unit 8: Electronic Circuit Design and Construction (60 GLH)<br>• Unit 25: Operation and Maintenance of Electronic Systems and Components (60 GLH)<br>• Unit 26: Operation and Maintenance of Electrical Systems and Components (60 GLH) or Unit 23 Electronic Devices and Communication Applications (60 GLH)<br>or, Mechanical maintenance theme:<br>• Unit 13: Engineering Assembly (30 GLH)<br>• Unit 19: Bicycle Servicing and Maintenance (30)<br>• Unit 24: Operation and Maintenance of Mechanical Systems and Components (60 GLH)<br>• Unit 27: Operation and Maintenance of Fluid Power Systems and Components (60 GLH) |


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## Possible curriculum models for the Manufacturing Pathway

Example 1 – delivered over 1 year.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH)<br>• Unit 9: Interpreting and Using Engineering Information/ Unit 13 Engineering Assembly (30 + 30 GLH).<br>These units could be co-delivered because Unit 13 involves reading engineering drawings, job instructions and assembly procedures.<br>• Unit 5: Engineering Materials (30 GLH) |
| 2 | • Unit 1: The Engineered World (30 GLH)<br>• Unit 10: Mathematics for Engineering/ Unit 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH). Co- delivered because mathematics must be delivered in an engineering context.<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 3 | • Unit 31: Production Planning for Engineering (30 GLH)<br>• Unit 7: Machining Techniques (60 GLH)<br>• Unit 6: Computer-aided Engineering (30 GLH)<br>• Unit 15: Operating an Efficient Workplace (60 GLH) |

Example 2 – delivered over 2 years.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH) |
| 2 | • Unit 1: The Engineered World (Externally Assessed – 30 GLH)<br>• Unit 9: Interpreting and Using Engineering Information/ Unit 13 Engineering Assembly (30 + 30 GLH).<br>These units could be co-delivered because unit 13 involves reading engineering drawings, job instructions and assembly procedures. |
| 3 | • Unit 5: Engineering Materials (30 GLH)<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 4 | • Unit 10: Mathematics for Engineering (30 GLH)<br>• Unit 13: Engineering Assembly (30 GLH) |
| 5 and 6 | • Unit 31: Production Planning for Engineering (30 GLH)<br>• Unit 7: Machining Techniques (60 GLH)<br>• Unit 6: Computer-aided Engineering (30 GLH)<br>• Unit 15: Operating an Efficient Workplace (60 GLH) |

## Possible curriculum models for the Mechanical Pathway

Example 1 – delivered over 1 year.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH)<br>• Unit 9: Interpreting and Using Engineering Information/ Unit 32 Engineering Marking Out (30 + 30 GLH). These units could be co-delivered because Unit 32 involves reading engineering drawings and job instructions.<br>• Unit 5: Engineering Materials (30 GLH) |
| 2 | • Unit 1: The Engineered World (30 GLH)<br>• Unit 10: Mathematics for Engineering/ Unit 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH).<br>Co-delivered because mathematics must be delivered in an engineering context.<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 3 | Engineering Processes theme:<br>• Unit 7: Machining Techniques (60 GLH)<br>• Unit 12: Engineering Design (60 GLH)<br>• Unit 29: Casting Techniques (60 GLH)<br>Or, Design and Manufacturing theme:<br>• Unit 12: Engineering Design (60 GLH)<br>• Unit 6: Computer-aided Engineering (30 GLH)<br>• Unit 31: Production Planning for Engineering (30 GLH)<br>• Unit 28: Fabrication Techniques (60 GLH) |

Example 2 – delivered over 2 years.

| Term | Unit(s) |
|---|---|
| 1 | • Unit 2: Investigating an Engineered Product (30 GLH)<br>• Unit 3: Health and Safety in Engineering (30 GLH) |
| 2 | • Unit 1: The Engineered World (Externally Assessed – 30 GLH)<br>• Unit 9: Interpreting and Using Engineering Information/ Unit 32 Engineering Marking Out (30 + 30 GLH). These units could be co-delivered because Unit 32 involves reading engineering drawings and job instructions. |
| 3 | • Unit 5: Engineering Materials (30 GLH)<br>• Unit 21: Introduction to Communications for Engineering (60 GLH) |
| 4 | • Unit 10: Mathematics for Engineering/ Unit 11 Electrical and Mechanical Science for Engineering (30 + 30 GLH). Co- delivered because mathematics must be delivered in an engineering context. |
| 5 and 6 | Engineering Processes theme:<br>• Unit 7: Machining Techniques (60 GLH) |

| | |
|---|---|
| | • Unit 12: Engineering Design (60 GLH)<br>• Unit 29: Casting Techniques (60 GLH)<br>Or, Design and Manufacturing theme:<br>• Unit 12: Engineering Design (60 GLH)<br>• Unit 6: Computer-aided Engineering (30 GLH)<br>• Unit 31: Production Planning for Engineering (30 GLH)<br>• Unit 28: Fabrication Techniques (60 GLH) |

## Progression

Each of the pathways provides learners with the opportunity to progress to level 3; this could be a full time course or part-time linked to an apprenticeship. Mathematics and Science are core building blocks for a career in engineering and for this reason feature in each of the four pathways. If a learner has aspirations to progress to level 3 engineering, it would be sensible for them to opt for a pathway that includes *Unit 10: Mathematics for Engineering* and *Unit 11: Electrical and Mechanical Science for Engineering*.

The possible curriculum models presented earlier all have core units in term one. If more than one pathway was offered by the centre this would allow transfer between pathways before learners specialise.

Jobs in engineering extend over a huge range; a few examples for each of the four pathways are:

Technology-engineers and technicians working on:

- CAD design
- electronic circuit design and prototyping
- testing equipment against specification
- technical sales
- customer liaison – troubleshooting technical and delivery issues
- project management
- implementing 'best practice' systems (e.g. kaizen, lean manufacturing) in a factory.

Maintenance technician servicing:

- a machine tool drive system
- packaging machinery (e.g. a mass-produced product)
- an electric motor
- hydraulic equipment (e.g. the off-loading crane on a delivery lorry)
- lifts and escalators
- aero engines and airframes.

Manufacturing engineer:

- working out the sequence of operations for manufacturing a product
- designing the layout of a workshop
- setting up and running a CNC machine
- welding the frame of a custom built mountain bike
- carrying out quality assurance.

Mechanical engineer:

- designing a new product
- prototyping a new product
- checking the quality of products coming off a production line
- testing a new design of car engine
- assembling and testing the pipework of a hydraulic system


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# 4 Key features of the BTEC Firsts explained

We are always working to ensure our qualifications are relevant, and that they support opportunities and progression for young people. We have updated the current BTECs to meet the needs of today's learners, teachers, educators, employers and universities, and also to reflect the policy decisions being introduced following *The Wolf Report* (March 2011) on vocational education. Our new BTECs contain a number of new features and it is important that you understand these and how they relate to your delivery of the course.

## Employability skills within BTEC

Helping learners to progress into employment has always been a cornerstone of BTEC qualifications. Equipping learners with the skills they will use in the workplace is at the very heart of BTEC and remains an important driver in determining the content of each qualification. When developing our qualifications we work closely with employers to understand the skills they are looking for in new entrants to their industries. The vast majority of employers not only require learners to have certain technical skills, knowledge and understanding to work in a particular sector, but they are also looking for what is termed **employability skills**. These are the skills which underpin the different tasks and duties which a person can be expected to undertake in their role and which are applicable across sectors.

Unlike technical skills, which may become outdated over time, employability skills enable learners to adapt to the ever-changing roles needed to survive in the global economy.

The CBI definition of employability skills is based on a positive attitude (readiness to take part, openness to new ideas and activities, desire to achieve) which underpins seven characteristics.

1 **Self-management**: readiness to accept responsibility, flexibility, time management, readiness to improve own performance.

2 **Teamworking**: respecting others, co-operating, negotiating/persuading, contributing to discussions.

3 **Business and customer awareness**: basic understanding of the key drivers for business success and the need to provide customer satisfaction.

4 **Problem solving**: analysing facts and circumstances and applying creative thinking to develop appropriate solutions.

5 **Communication and literacy**: application of literacy, ability to produce clear, structured written work, and oral literacy (including listening and questioning).

6 **Application of numeracy**: manipulation of numbers, general mathematical awareness and its application in practical contexts.

7 **Application of information technology**: basic IT skills including familiarity with word-processing, spreadsheets, file management and use of internet search engines.

In a recent CBI/Pearson education and skills survey, *Learning to grow: What employers need from education and skills 2012*, it was noted that employers (71 per cent) believe schools and colleges should prioritise developing employability skills. They also want to see more done to develop literacy (50 per cent), numeracy (45 per cent) and technology skills (30 per cent).

### How employability skills are promoted and developed in BTEC courses

All internally assessed units in BTEC are based on set assignments that require learners to produce evidence of learning applied to a work-related scenario. Within the scenario, learners will typically be put into a junior role in the sector, asked to do some research or preparation, and then asked to provide evidence in the form of a presentation, information leaflet, performance or artefact, depending on the assignment. Suggestions for high-quality assignments are provided in the specification and in the authorised assignment briefs. For example, in *Unit 9: Lifestyle and Well-being* the following scenario is given:

> Assignment – Physical Activity: Are You Doing Enough?
>
> You are working as a trainee in a health promotion team. You have been asked to produce a series of articles for a lifestyle magazine.
>
> In your first article you need to look at how much physical activity individuals need to carry out in order to gain health benefits and how they can increase their activity levels.

As assessment evidence, learners are asked to design documentation and prototypes.

Many of the assignments are group assignments and so involve **teamwork**. **Problem solving** is developed through the research and/or practice part of the assignment. All assignments require **self-management** in that it is the responsibility of the learners to complete the assignments and ensure they are submitted by the set deadline.

BTECs are vocational qualifications. This means that learners are preparing to work in a particular sector and so must have good **business and customer awareness**: an understanding of how the sector works, what makes it 'tick' and the business and/or customer drivers for the sector. This will vary depending on the sector. For example, in Business or I&CT the 'customer' is the person or organisation that buys or uses the products or services, so in order to make good products the learner has to understand customer needs primarily by doing research or surveys. In a sector like Health and Social Care, the customer is the client or a parent; again, the learner will need to learn by doing practical work and undertaking assignments that help develop their understanding and respect of clients' needs and wishes.

In most BTEC specifications, there is a unit that introduces the industry to learners. In Engineering, this is Unit 1: The Engineered World. This is a mandatory, core unit that underpins all the other units in the qualification. Through this unit, learners will gain an understanding of the world of engineering and the various engineering processes used within different engineering sectors. They will also study some of the new developments in materials and engineering technology that have an impact on life today.

## Knowledge and skills signposting for English and mathematics

The mastery of the essential skills of communication and numeracy are at the heart of a young person's ability to progress, as identified in the *Wolf Report*. In BTECs these skills are woven throughout and tackled in two specific ways.

1 **Embedded mathematics and English throughout the units, mapped to GCSE and functional skills**. Opportunities to practise these essential skills in naturally occurring and meaningful contexts are provided throughout units, where appropriate to the sector. In the specifications, *Annexes B and C* show where an assessment criterion in a BTEC First unit can provide an

opportunity to practise a subject content area from the GCSE English or mathematics subject criteria.

2 **Sector-specific mathematics and English units, where appropriate**. For some sectors, there are units specifically devoted to developing mathematical and communication skills in context, for example, *Mathematics for Engineering* and *Effective Communication in Health and Social Care*.

Throughout the course, learners are encouraged to **apply information and creative technology** by producing their assignment work to the highest standard, with forward-looking use of IT at the heart of their work, whether it be using the internet to do research, producing spreadsheets of evidence, or using sophisticated packages to record results aurally or visually. The assessment guidance for every unit provides suggestions for how evidence can be presented, and use of electronic portfolios is highly recommended.

In addition, the new external assessments have looked at innovative use of IT, for example, through the introduction of onscreen testing.

## Personal, learning and thinking skills

In addition to those qualities outlined by the CBI/Pearson, the qualifications were also developed with **personal, learning and thinking skills (PLTS)** in mind. The PLTS map closely to the CBI definition of employability skills in that they develop:

- independent enquirers
- creative thinkers
- reflective learners
- teamworkers
- self-managers
- effective participants.

A mapping grid showing coverage of these skills in each unit appears in *Annexe A* of the specifications.

## Contextualised English and mathematics

The new BTEC First qualifications provide opportunities for learners to develop and apply their knowledge, understanding and skills within vocational contexts. This provides opportunities for them to develop their essential skills in English and mathematics related to GCSE study.

You are encouraged to deliver these BTEC First qualifications in vocational contexts as these will allow learners to develop and apply their skills in English and mathematics. Within units we have identified opportunities for linking assessment to GCSE study in English and mathematics. These GCSEs are relevant to all learners at ages 14-16 and many learners post-16 who will be continuing to work towards attaining a GCSE at grade C or above in one or both of these subjects. We have also provided a more general mapping of how Learning Aims in units can be related to Functional Skills for relevant post-16 learners in the Diploma specification.

It is recognised that good literacy and numeracy skills are highly valued by employers and by wider society and that achievement of English and mathematics at GCSE level is key to progression through the education system and into employment. The current Government has refocused attention on this need with a number of education policy announcements, and development of English and mathematics was a key recommendation in *The Wolf Report*.

Research has shown that for many learners the most effective way of developing their mathematical skills and of improving their functional skills in English is to learn them within the context of a specific area of vocational interest. Therefore, in the new suite of BTEC Firsts we have provided opportunities for contextualised maths and English so that learners can practise these essential skills in a meaningful way within naturally occurring contexts.

GCSEs in mathematics and English are the current benchmark of achievement, so we have signposted the assessment criteria of the BTEC Firsts to content from these GCSE qualifications, specifically to the more functional parts of their content. This signposting, which is indicated by a * sign for maths and a # sign for English, shows where learners should be able to practise and develop their skills. These instances occur naturally within the BTEC Firsts, for example, when communicating or compiling reports, but can be emphasised and drawn out during teaching and learning. More detail on how this can be done is given on a unit-by-unit basis in the qualification specification.

Where signposting does occur in the unit specification, it indicates that English and mathematics knowledge and skills are a constituent part of the assessment requirements of the units. This does not mean that the BTEC assessment criteria cover the whole of the GCSE or Key Stage 4 requirements but that learners can practice specific areas of English and mathematics. You may want to highlight this opportunity to learners during delivery.

*Annexes B and C* in the specification show the exact relationship between the BTEC assessment criteria and the GCSE subject content. The mathematics content listed is a consolidation of the full requirements in GCSE Mathematics. Note that GCSE English and GCSE Mathematics already cover functional skills.

The following example demonstrates when learners will be able to develop their mathematics skills within the context of a specific vocational area.

- *Unit 7: Machining Techniques* – 1B.4, 2B.P4, 2B.M2, 2B.D2 – where learners are demonstrating simple and complex features of drilling and turning or milling techniques and ascertaining the appropriate speed of the tools, this could support development of mathematical skills by using appropriate measures in everyday settings, as well as recognising that measurements given to the nearest whole unit may be inaccurate by up to one half in either direction (Mathematics 10, 11).

## Delivery tips: examples of good practice

There are a number of different ways that centres can effectively manage the delivery of units to strengthen the provision of English and mathematics, as well as ICT for learners on the Diploma course. Below are two examples.

### Collaboration between the vocational teacher and mathematics/English/ICT teachers

- In this example the mathematics and English concepts are taught by subject teachers for English, mathematics and ICT but they use contextualised examples from the vocational sector to make the learning meaningful. The learners have timetabled slots for specific lessons.
- This approach works well in larger centres where there are many learners taking the same vocational route. It works less well when there is a range of vocational sectors in the same mathematics or English class, or learners are taking different pathways within the same sector.

**Mathematics / English / ICT are taught in specific lessons by the vocational teacher**

- In this example the learners have timetabled slots, as part of their vocational contact time, in which their vocational teachers focus on presenting and practising mathematics, English or ICT (for Diploma learners). This model is particularly motivating for learners because they see the direct link between skills and application, but it relies on vocational teachers being comfortable with teaching mathematics, English and ICT.

Whichever model is chosen, we recommend that timetables include specific slots to focus on the teaching of mathematics, English and ICT in the context of the vocational course.

## Supporting learners who are unable to achieve their level 2 qualification

The new suite of BTEC Firsts is for learners aiming to achieve a level 2 qualification. Most will achieve this, but some will not. These learners may have struggled to provide sufficient evidence in their assignments or they may have failed their external assessment.

The new BTEC First qualifications give you the opportunity to assess your learners at level 1 if they are not able to reach level 2 standards, recognising their learning and achievements.

All the assessments you create must be written against the level 2 criteria and be reliable and fit for purpose. You should not create a separate level 1 assignment. If a learner does not provide sufficient evidence to meet the level 2 criteria, only then should you assess their work against the level 1 criteria. The grade given will be Unclassified if the learner does not meet the level 1 criteria.

You should expect that learners will be able to achieve a Level 2 Pass or above in at least some of their units. Units where learners have achieved a Level 2 pass will be shown in their certification even if the qualification overall is achieved at Level 1.

If a learner is identified as having difficulty achieving at level 2 then you may want to consider switching the learner to a smaller size of qualification, such as an Award or Certificate, so that they can focus on achieving in a smaller range of units.

### An example of a learner being assessed against a level 1 criterion

Below is an example of an assessment grid, taken from *Unit 5: Engineering Materials*. Each assessment grid includes level 1 assessment criteria.

| Level 1 | Level 2 Pass | Level 2 Merit | Level 2 Distinction |
|---|---|---|---|
| **Learning aim A: Know about the properties of common engineering materials and selection for engineering applications** | | | |
| 1A.1 Identify an example of each type of material used in given engineering applications. | 2A.P1 Describe examples of each type of material and the properties of these materials in engineering applications. | 2A.M1 Explain the choice of material for engineering applications. | 2A.D1 Compare advantages and disadvantages of material choices for engineering applications. |

In the scenario below learners are given the following assignment:

**Assignment title**: Properties of Engineering Materials and their Applications

**Scenario**: You have been asked by your supervisor to prepare a presentation to your peers about different types of engineering materials, their properties and their applications. You will conduct some tests on the materials and interpret the results. You will be asked to describe some heat treatment processes.

**Assessment evidence**: PowerPoint® presentation, materials list, report.

To achieve a Level 2 Pass, learners must describe examples of materials and their properties. In the scenario below, the learner has been given the same assignment as everyone else in the group; however, they are clearly not working at level 2.In the scenario below, the learner has been given the same assignment as everyone else in the group; however, they are clearly not working at a level 2 standard.

Ian has been investigating a range of materials from the different engineering sectors. He is comfortable in identifying particular materials for a range of engineering applications just by looking at each material and using prior knowledge of each materials use. However, he is having difficulty in establishing why these materials have been used for each application. [This indicates that Ian is not able to describe certain properties of materials that make them suitable for a particular application]. After further investigation, Ian found out that copper is used for domestic hot water pipes because of its thermal conductivity and ductility. His teacher provided him with alternative materials and Ian identified these as being PVC and mild steel. He cannot, however, state why these materials may or may not be used instead of copper. [Ian has provided sufficient evidence for 1A.1 but not for 2A.P1.]

Learners who achieve at level 1 can consider the following progression routes.

- Use the skills, knowledge and experience they have gained to retake their level 2 qualification.
- Choose to study a different subject at level 2.
- Work towards an Apprenticeship at level 2.

## Learners moving onto a larger qualification: Recruitment with integrity

After completing a next generation BTEC a learner may wish to continue their studies on a BTEC First in order to top up to a larger qualification, for example, from an Award to a Diploma. This could be at the same centre or at a new one.

It is often appropriate to recruit learners onto further study at level 2 following a BTEC First certification. In these cases you should ascertain that the learner is demonstrating that they are still engaged and challenged at level 2, rather than demonstrating that they are capable of progressing to study at Level 3. This can usually be judged from a learner's BTEC, GCSE and other grades and the quality of their application. It is also important that further qualification at level 2 will benefit the learner by furthering their progression into their chosen career.

*Remember:* Your groups may contain a mix of learners studying the qualification for the first time as well as learners who are topping up. Care should be taken to ensure that all members of these groups are equally engaged and challenged, for example, by ensuring all team members in group activities have an opportunity to perform the leadership roles.

### Learners moving onto a larger qualification: Top-up registration

After you have made a top up registration for your learner, the achievement of the certificated units will be imported into your records on Edexcel Online. There is no opportunity to retake the assessments in the internally assessed units via a top-up

registration so the imported grades are final. It is possible for a learner to retake externally assessed units.

### Learners moving onto a larger qualification: Re-registration

If your learner did not realise their full potential in an NQF BTEC that they have been certificated for, and wishes to study a larger size BTEC at a new centre, then an entirely new registration may be more appropriate than a top-up registration to enable a fresh start. In this case the learner must produce entirely new evidence for assessment generated by your centre's assignment briefs.

# 5 Assessment guidance

## Assessment for the new BTEC Firsts

BTEC assessment has always been about:

- ensuring that learners are assessed for their skills as well as their knowledge
- ensuring that learners are given the chance to show what they have learned in vocational and applied contexts
- allowing learners to be assessed when they are ready and when a centre is able to fully support them.

While updating the BTEC Firsts, we have not changed these fundamentals – BTEC assessment will remain a positive statement of achievement.

The introduction of external assessment will reinforce learner engagement, giving them clear goals and targets in a way that helps them to understand the challenges of working life.

Experienced BTEC teachers should think about whether or not they need to change their delivery pattern to make sure they can provide access to external assessment at the best time. At the same time, there are some important developments in internal assessment that you should also be aware of as you plan your assessment for the year.

### External assessment

After careful discussion with centres and other stakeholders, we have tailored the type of external assessment to meet the needs of the sector. All the assessments will be distinctively vocational, enabling learners to apply their learning in vocational or applied contexts.

For your sector you need to check:

- which unit(s) are to be externally tested
- the assessment method
- the availability of assessment for the first time
- the availability of retake opportunities (allowing for results)
- the delivery pattern we are recommending for these units and for other units as given in the specifications.

Remember that you have plenty of time to prepare for assessments because you will be delivering over a one- or two-year period. For some sectors, completion of the externally assessed unit at or very near the end of the programme will be the recommended pattern. In others, it may be suggested that learners take the assessment earlier in the programme, but you should always make sure that learners are fully prepared.

The externally assessed unit will often be one that provides a core of knowledge that will be enhanced, developed and applied through other units. Learners' depth of understanding of the content of externally assessed units is likely to be enhanced by applying knowledge through other units. Therefore, when you are planning and delivering your units, think about how you can bring out examples that would be useful illustrations of issues covered in the external unit(s).

Each specification has details about when assessment is available. To gain access to the assessments, learners have to be registered for a programme – the

arrangements for this will be the same as for all BTECs. Please refer to the *Information Manual* on the website.

We will do everything we can to make external assessments relevant, engaging and suited to learner needs so that they support the overall development of the learner rather than being a hurdle or distraction. You should not enter learners for external assessment to check how they are doing or to give them practice – we provide sample materials for use in preparation.

The table below shows the type of external assessment and assessment availability for this qualification.

This assessment forms part of the core knowledge of the programme and is likely to be delivered towards the start of the programme but may be complemented by study in the other core unit(s). The learner's overall readiness to undertake external assessment should be considered before entering for the assessment.

| **Unit 1: The Engineered World** | |
|---|---|
| Type of external assessment | This unit is externally assessed using an onscreen test. Pearson sets and marks the test.<br>The assessment must be taken by the learner under examination conditions. |
| Length of assessment | The external assessment will be 1 hour. |
| No. of marks | 50 |
| Assessment availability | On demand |
| First assessment availability | November 2013 |

| **Unit 9: Interpreting and Using Engineering Information** | |
|---|---|
| Type of external assessment | This unit is externally assessed using a paper-based test. Pearson sets and marks the test.<br>The assessment must be taken by the learner under examination conditions. |
| Length of assessment | The external assessment will be 1 hour. |
| No. of marks | 50 |
| Assessment availability | January and June |
| First assessment availability | January 2014 |

## Assessment and grading for internally assessed units

Internal assessment remains the main assessment method for BTEC qualifications because we believe that assignments set and marked within the centre provide the most relevant vocational learning experience for your learners.

You should guide both the teaching and the learning to then ensure that learners are assessed validly and reliably in a way that is relevant for a vocational qualification. Your teaching of the knowledge, skills and vocational applications will underpin a learner being able to demonstrate achievement through assessed assignments. Learners should be given formative feedback on their learning and skills development during the teaching and learning phase. You should consider carefully when your learners are ready to undertake an assessment. An assessed assignment must have a clear structure and timescale, and encourage the learner to work independently to show relevant evidence. You should make sure that the assessment is a clear, discrete activity. You can then make a qualitative judgement on the evidence using the assessment criteria.

Those who are used to teaching BTEC will find that not much has changed, but we are putting more emphasis on some requirements and helping to build good practice.

- You should make sure that the assessment is a clear, discrete activity. Evidence from the guided learning phase is not admissible because evidence for assessment must be produced independently.
- You should use the new presentation of units, where learning aims are placed with associated assessment criteria, to provide building blocks for assessment – these are clear and simple to use and we recommend that you work through them with your learners.
- Your assessment plan for each unit and for the programme must be clear at the outset of the programme and signed off by the Lead Internal Verifier.
- Your Lead Internal Verifier must authorise your assignments. If you don't have a Lead Internal Verifier who has been through standardisation, you should use support from us to ensure that your assignments are fully fit for purpose. You can use the endorsed assignments or you can access the assignment checking service through our website.
- You need to be explicit about the timescales and the evidence for assignments – there is nothing new about this but we will be expecting centres to follow best practice and to be very clear with their learners.
- You need to set out expectations through tasks and evidence – remember that the criteria are used to judge evidence and are not tasks in their own right.
- **Summative** assessment takes place after the final submission date. A learner may be given **one** opportunity to resubmit a completed assessment after a summative grade has been given where this has been correctly authorised.
- You should ensure that all work has been produced authentically and that you have checks in place to ensure that learners are submitting their own work.

## How assignments are used

Assignments are used to assess learner achievement. You should work with the other people in your programme team to design a plan of activity for the year, or the programme as a whole so that assignments have a clear schedule of start, finish and internal verification dates.

Ask yourself how many assignments you will need. Your assessed assignments should cover a minimum of one complete learning aim within a unit. You may choose to set an assignment for a whole unit or even bring units together for assessment.

Remember that this means your **assessed** assignments. Of course you may set small activities before assessed assignments to provide opportunities for learning from formative feedback and through skills building. These preparatory activities may often use group work and research as a preparation for undertaking the assessment itself but cannot be contributory evidence towards an assessment.

In making a decision about how many assignments to use, you can think about what resources you have in your centre, what is available in the locality, how you could use links with local employers, and what opportunities there are for relating assessment to realistic vocational themes.

### Top tips

- If a unit builds up – for example, by 'plan' and then 'do' and then 'review' – then one large assignment may work best.
- If a unit requires several forms of evidence then several assignments may be best.
- It is good to emphasise the links between units but it is harder to manage assessment across units – if you feel this is a good approach then be clear on how you will reach one decision for a unit.

You need to think about how the evidence that the learner will produce can be verified and about how you will know that what each learner has done is authentic. You can only accept for assessment learner work that you know has been produced in a way that demonstrates the learner's own achievement.

### Assignment 'warm-up' – active teaching and learning

Your learners will do their best if they are motivated through engaging and realistic activities. All units involve 'teaching the basics' but learners need to get involved in order to understand where what they are learning fits in.

You can use your resources and your imagination to really bring learning alive. You can encourage learners to try things out in groups, role plays, presentations and practical demonstrations. You can use visits and talks for research – remember you will need to structure what you do so that learners get the information they need, such as by providing a question sheet for them to use during a talk or visit.

You can encourage learners to 'get their hands dirty' by trying something out. You can build up their skills so that they will be able to show them off confidently in the assessed assignment.

You can use this 'warm-up' time to emphasise practical links between units, so that when learners are carrying out tasks they appreciate that they are often simultaneously drawing on skills/understanding from different units. It is important that learners appreciate the holistic way that their learning prepares them for further study or employment.

### Introducing the assignment

Your teaching and learning phase is going to lead directly into the assessed assignment. You may be setting this up in a very specific way – such as everyone completing a practical activity in a timed slot – or this may be independent work spread over a number of weeks.

It is important to remind learners preparing work for assessment that they have to produce it themselves and that they have to meet the deadlines you give them. Once

learners begin work on an assignment, no specific assessment feedback can be given.

**Remember:** you should be sure that your learners understand all the requirements for an assessed assignment before the assessment begins. Look at each unit carefully for how the evidence generated will be judged using the assessment criteria, and what degree of input you can make.

## Evidence for assignments

You can use different types of evidence for assignments. A description does not have to be written and a presentation could be given in a number of styles – for example, PowerPoint®, verbal or a digital/video recording. You need to think about what is fit for purpose. So, if learners need to explain a plan, why not have them present it to an audience with a question and answer session?

You should check that the type of evidence you are planning is feasible – for example, if you ask learners to 'write a memo', the coverage of one or two sides of A4 must be capable of generating sufficient evidence. Likewise a poster may not be a suitable evidence format for a detailed evaluation. Remember that whatever evidence your learners produce must be capable of being verified as well as assessed. So, if they are actually producing a model, a performance, a meal, a coaching session, a demonstration etc, you need to think about how it will be observed or recorded so that it can be checked during verification.

**Remember:** no activity can be evidenced solely by an assessor's observation log or by a witness testimony. All observed evidence must be able to be authenticated to the learner. This means that observation logs must always be supported by learner-generated evidence such as preparation notes or reflective logs, or by photographic or video evidence in which the learner can be identified. The totality of this evidence must be available to the assessor at the point of the assessment decision, which must follow the handing in of an assignment. An assessor should not award criteria during an activity – for example, at the point of completing an observation log.

## Learning aims and assessment criteria

A learning aim sets out what you should be covering in order to prepare the learners for assessment. It may define knowledge, understanding, skills and contexts, and the wording of the aim will suggest appropriate learning experiences. You may set an assessed assignment on more than one learning aim but you should not normally split a learning aim over assignments. The evidence the learner produces in response to the assignment brief is judged using the assessment criteria, so you must make sure that what you have stated in the task fully covers those criteria.

## What about the final grade for a unit?

The final grade for a unit is at level 2 (Distinction, Merit or Pass), level 1 or Unclassified. The assessment criteria are detailed in each unit so that you can clearly see what is required. You need to be aware that a unit grade can only be given once all the activities and assignments for that unit are complete. In giving assessment decisions to learners, you need to be clear about when you are giving a formal decision and how this relates to the assessment for the unit as a whole.

If you choose to include a learning aim in more than one assignment, you should be very clear with learners how a judgement will be reached through looking at the evidence *across* the assignments. For example, the learner may be being asked to show the same skills in two different contexts. If so, they need to know if their

performance in either is sufficient for assessment, or if they must perform to the same standard in both.

## Keeping clear assessment records

You can only use assignments as assessment instruments effectively if you work closely with other members of the assessment team and keep accurate records of what you are doing. Your records help you and the team to plan, review, monitor and support learners and ensure that assessment is authentic and accurate.

The Lead Internal Verifier has a very important role in ensuring that each teacher, assessor and internal verifier on the programme understands the standards and the processes for keeping assessment documents.

Your records are there to help you get it right for your learners. The main documents that you use, which can be used electronically, are:

- an assessment and verification plan for the programme, showing when each assignment starts and finishes, when it is verified, and which unit(s) or learning aims it covers
- an assignment brief template, ensuring that all the key requirements of an assignment are covered
- a record of internal verification for the assignment brief
- a record that the learner completes when submitting an assignment, which should include the date and a declaration of authenticity
- a record of internal verification for an individual sample of learner work
- a record of progress for each learner, showing the assignments that have been completed and the assessment decisions given.

## Giving grades

At the end of an assignment you will need to reach a decision on assessment. If an assignment covers a whole unit then this will be a final grade; if it covers part of a unit then it will be a component of a final grade. In either case, it counts as an assessment decision and should be subject to internal verification and then finalised.

Your decisions must be checked according to the internal verification plan signed off by the Lead Internal Verifier. For each assignment, a sample of learner work must be reassessed fully by the Lead Internal Verifier or another person acting as an Internal Verifier who has been directed by the Lead Internal Verifier. Once your decisions have been checked you can give these to the learners as 'final'.

**Remember:** you will then be able to accept only **one** further attempt from the learner to provide further or better evidence for the learning aim(s) covered in that assignment.

The assessment decision must be given to the learner on an appropriate assessment record document which contains the assessment decision, the assessor's declaration of authentication of the learner work, space for the Lead Internal Verifier to authorise a resubmission and specify the conditions where applicable, and the assessment feedback comments. Feedback to the learner for each learning aim must be constructive and criterion-based. The learner should understand why they have been awarded each criterion, and why they have not been awarded any others. It is also helpful to annotate the learner work to show exactly where evidence for each criterion can be found.

The assessment feedback must **not** offer any further guidance to the learner. Further guidance means guidance that is beyond that available to them at the start of the

assignment; they must not be told individually or specifically what they can do to be awarded further criteria. Care must be taken to maintain the independence of the learner to enable a resubmission opportunity to be authorised.

You can only award higher grades if a learner has demonstrated the requirements of lower grades. This does not mean that the criteria represent different tasks or stages – you should be able to apply the criteria to the same evidence if the assignment is structured carefully.

A summative unit grade is awarded after all opportunities for achievement are given. A learner must achieve all the assessment criteria for that grade. Therefore:

- to achieve a Level 2 Distinction a learner must have satisfied all the Distinction criteria in a way that encompasses the Level 2 Pass, Merit and Distinction criteria, providing evidence of performance of outstanding depth, quality or application
- to achieve a Level 2 Merit a learner must have satisfied all the Merit criteria in a way that encompasses all the Level 2 Pass and Merit criteria, providing performance of enhanced depth or quality
- to achieve a Level 2 Pass a learner must have satisfied all the Level 2 Pass criteria, showing breadth of coverage of the required unit content and having relevant knowledge, understanding and skills
- a learner can be awarded a Level 1 if the level 1 criteria are fully met. The award of Level 1 is not achieved through a failure to meet the Level 2 Pass criteria.

A learner who does not achieve all the assessment criteria at level 1 has not passed the unit and should be given a grade of U (Unclassified).

A learner must achieve all the defined learning aims to pass the internally assessed units. There is no compensation within the unit

## Enabling higher achievement

Your assignments should provide opportunities for learners to achieve at the highest level and should promote stretch and challenge. Not all learners will finally achieve a Distinction or a Merit, but it is important that they are provided with the opportunity to do so.

You must look to structure assignments so that learners produce evidence that can be used across the grade levels – learners should not have to 'get a Pass out of the way first'. To 'aim high' learners must be well prepared before they start the assignment and be encouraged to attempt to reach the highest standards. All assessed activities must ask the learner to produce evidence that can be assessed against the full range of grades available.

## Assignment design

Your assignments are a tool for encouraging learners to provide evidence for you to make assessment judgements. Good assignments are interesting and motivate learners well.

The components of an assignment are:

- **scope** – outlines which unit(s) or learning aims are being covered and which criteria are being addressed
- **a scenario** – provides a setting and rationale for the assessment
- **tasks** – set out what a learner needs to do to provide the evidence
- **evidence requirements** – set out exactly what the learner is expected to produce and how the assessment will take place.

- **a timescale** – sets out start and hand-in dates.

### Assignment briefs

Your assignments must be given to a learner formally as an assignment brief so that the learner knows they are being assessed and what is required of them.

The assignment brief includes:

- the qualification
- the title and number of the unit(s)
- an assignment title and number (if more than one per unit)
- the learning aims
- the assessment criteria
- the evidence requirements
- the start date
- the hand-in deadline.

You should include a record that it has been given to the learner, normally by inserting the learner's name into a copy of the assignment brief, but this could be recorded electronically.

Your learners should be provided with a form or other record for declaring that their work is their own and for confirming the date of submission.

### Using an authorised assignment brief

We are preparing a bank of authorised assignments briefs that you will be able to access at www.btec.co.uk/authorisedassignments. It will include at least one authorised assignment brief for every internally assessed unit. For mandatory units, there will be enough authorised assignment briefs to cover all assessment criteria.

We ask you to verify every assignment every year, regardless of whether it is your own or one sourced from elsewhere. Once your assignment is verified, you can put it in your timetable and check that you have planned delivery of the appropriate unit content. This can be as simple as making sure you have planned an event, visit or performance as suggested.

- The Lead Internal Verifier should fit these assignments into the overall plan and know when they will be assessed.
- You may want to adjust the assignment to make it fit your learners' needs and your centre's resources.
- You should think about exactly how the evidence is going to be produced and whether or not your learners need guiding to relevant activities that they have already completed.
- You may need to plan for practical activities to be carried out and recorded.
- It is important that you are as familiar with the authorised assignment brief as you would be if you had created the assignment yourself. Understanding the assignment will ensure that you plan activities that properly reflect the scenario given in the assignment and that you are prepared for the evidence learners submit.

### The scenario

The assignment should be set in a vocational context that helps your learners to show what they have learned in a relevant way. This can often be achieved by asking learners to imagine they are in an appropriate job setting with a job role and job tasks. It could involve providing them with a brief of an activity that would be of value to a local employer, or without using a job context directly. It could draw on a real case study in order to allow application and analysis. You can draw on understanding of your sector to develop appropriate assessment contexts.

### Evidence

You can choose suitable forms of evidence – and it is possible to use a wide range; from reports to presentations, from performances to diaries, from record sheets to digital/video recordings.

Of course you should match the evidence type(s) selected to the requirements of the unit(s) or learning aims(s). For example, if a learning aim requires a practical demonstration then you should think about how that is going to be set up and recorded.

Be careful not to suggest a type of evidence that may be too short – for example, a 'leaflet for new buyers' may be a realistic form of assessment for business learners to produce but may not provide for sufficient breadth in itself, depending on the assessment requirements.

For some evidence, the period for its production must be time-constrained and in some cases you may want to ensure authenticity by having some evidence produced in supervised conditions.

### The tasks

The tasks should be a clear statement of what a learner needs to do to produce the evidence. You may explain the tasks to learners in more detail during delivery, but the assignment itself should be clear. You should remember to relate tasks to the scenario and to the evidence. If learners have been carrying out preparatory work – such as visits, rehearsals or skills exercises – then you may want to refer to this in the tasks.

Your tasks must:

- specify the nature and extent of the evidence
- be clear and include any specific materials or steps with times or dates when necessary
- refer to the assessment criteria that the evidence will be judged against
- encourage the generation of evidence that can be judged against the criteria
- be presented in a way the learner can understand – remember that the criteria are not in themselves tasks
- fit together to cover the learning aim sensibly, allowing learners to achieve to the best of their ability.

You must make sure that the tasks can generate evidence which cover the criteria. When you create tasks you should not use the exact wording of the criteria, but you should pay close attention to it and the associated assessment guidance.

You should always list the criteria covered by each assignment – and also normally each task. When you quote the assessment criteria, please don't change their wording. You can, of course, use a glossary of the wording of tasks to highlight what certain words mean. Many words will be repeated across criteria for different grades and your learners may find it useful if you highlight the changes.

### Scope

You can choose the scope of an assignment provided that it fits well into the overall assessment plan for the unit(s) and the programme. For some qualifications it is normal practice to bring several units together for large-scale projects, while for others initial coverage of a topic in one unit may then be picked up in later, more specialist units.

When planning a unit-by-unit approach to assessment, you should make sure that learners understand through their learning how the units relate to each other, and that the requirements for synopticity are addressed.

Assignments that span several units should be carefully controlled, and you need to decide whether it is only the learning or both learning and assessment that is considered together.

### Learner responsibility

You should make sure that learners know they must meet their deadlines and provide work that is genuinely their own, otherwise their grades will be affected. To support learners, you should explain how to reference the work of others and how to work in such a way that ensures they can declare that their work is their own.

We recommend that learners are given a guide to their assessment at induction to the programme. You can reinforce the expectations when assessed assignments are handed out.

## Quality assurance

### What is quality assurance?

Quality assurance is at the heart of vocational qualifications. For many BTEC units, assessment is completed by your centre and your centre is responsible for the grading and standard of assessments.

- You use quality assurance to ensure that your managers, internal verifiers and assessors are standardised and supported.
- We use quality assurance to check that all centres are working to national standards. This is done by sampling your marked assignments.

### What is the purpose of quality assurance?

In your centre, quality assurance allows you to monitor and support your BTEC staff and to ensure that they understand, and are working to, national standards. It gives us the opportunity to identify and provide support where it is needed in order to safeguard certification. It also allows us to recognise and support good practice.

### How does it work?

First of all, you need approval to deliver BTEC qualifications. By signing the approval declaration you confirm that you have in place all necessary resources, appropriately experienced staff, and quality-assurance policies and procedures. You should have standardised systems and procedures for registering and certificating learners, tracking learner achievement and monitoring assessment and internal verification.

During the delivery of a programme, internal verification is the quality-assurance system that you use to monitor assessment practice and decisions, ensuring that:

- assessment is consistent across the programme

- assessment tools are fit for purpose
- assessment decisions judge learner work accurately using assessment criteria
- standardisation of assessors takes place.
- Internal verification is a recorded discussion between two or more professionals to ensure accuracy, fairness, consistency and quality of assessment. Internal verification procedures must:
- check all the assignment briefs or assessment tools used in every internally assessed unit
- check a sample of assessment decisions made for every internally assessed unit
- check a sample of assessment decisions from every assessor
- ensure that within the sample:
- the range of assessment decisions made is covered
- the experience of the assessor is taken into account when setting the sample size
- the sample size is sufficient to assure the accuracy of the assessment decisions for the whole group
- plan and document the process.
- Our external quality-assurance processes include:
- annual visits to each centre to look at quality-assurance systems and procedures (Quality Review and Development)
- standards verification by a subject specialist to sample assessment and internal verification of learner work
- standardisation activities to support assessors, internal verifiers and lead internal verifiers.

Every year we publish an updated *BTEC Quality Assurance Handbook* to explain our external quality-assurance process for the next academic year. Along with the programme specification, the handbook should provide your programme team with everything they need to run vocational programmes successfully.

## Centre roles and responsibilities

- **Senior managers**
  The Head of Centre is formally responsible for ensuring that your centre acts in accordance with our terms and conditions of approval. These include ensuring the provision of appropriate resources, recruiting learners with integrity, providing full and fair access to assessment, maintaining full and accurate records of assessment, complying with all quality-assurance processes, and ensuring that all certification claims are secure and accurate. Day-to-day responsibility is normally delegated to the centre's BTEC Quality Nominee.
- **BTEC Quality Nominee**
  Each centre is asked to identify a member of staff as its Quality Nominee for BTEC provision. This person is the main point of contact for information relating to quality assurance. Quality Nominees will receive regular information from us about all aspects of BTECs, which they should share with the relevant staff in their centre. Therefore, it is very important that Quality Nominee details are kept up to date on Edexcel Online. We recommend that your Quality Nominee is someone with responsibility for the BTEC curriculum because they will be involved in monitoring and supporting staff in your centre. The Quality Nominee should

ensure that BTEC programmes are managed effectively and actively encourage and promote good practice in your centre.

- **Examinations Officer**
  The Examinations Officer is the person designated by the centre to take responsibility for the correct administration of learners. This person normally acts as the administrator for Edexcel Online – our system for providing direct access to learner administration, external reports and standardisation materials.
- **BTEC Programme Leader**
  The Programme Leader (or Programme Manager) is the person designated by your centre to take overall responsibility for the effective delivery and assessment of a BTEC programme. The Programme Leader may also act as the Lead Internal Verifier.
- **Lead Internal Verifier**
  The Lead Internal Verifier is the person designated by your centre to act as the sign-off point for the assessment and internal verification of programmes within a principal subject area (for example, BTEC Firsts and Nationals in Business, or BTEC Firsts and Level 1 in Engineering). We provide Lead Internal Verifiers with access to standardisation materials. The Lead Internal Verifier should be someone with the authority to oversee assessment outcomes. Ideally this would be the Programme Leader, because this would normally be a key part of their role. They should be directly involved in the assessment and delivery of programmes and able to coordinate across assessors and other internal verifiers for a principal subject area.
- **Assessors and internal verifiers**
  The *programme team* consists of the teachers who are responsible for the delivery, assessment and internal verification of the BTEC qualification. An assessor is anyone responsible for the assessment of learners. An Internal Verifier can be anyone involved in the delivery and assessment of the programme. Please note that if a teacher writes an assignment brief they cannot internally verify it. Someone else should perform this function. Where there is a team of assessors, it is good practice for all to be involved in internally verifying each other. If there is only one main person responsible for delivery and assessment then arrangements must be made for their assignments and assessment decisions to be internally verified by someone appropriately experienced.

### Tips for successful BTEC quality assurance

- Recruit with integrity. Ensure that the learners you register on the programme are able to achieve at level 2 and have a specific interest in the vocational sector.
- Ensure that you have sufficiently qualified and vocationally experienced staff involved in delivery and assessment. BTECs are vocational qualifications, designed to be delivered by staff with expertise in their subject.
- Provide induction, training and ongoing development opportunities for your staff. Best practice comes from having staff that understand the BTEC ethos and assessment methodology and have up-to-date knowledge of their vocational sector.
- Use the free resources available. There is a wealth of guidance in the specifications and delivery guides that will help you with delivery and assessment.
- Make quality assurance part of everyone's role. Quality assurance is a fundamental aspect of every role, from assessor to senior manager. Recognising this and providing time and resources to support quality assurance is the key to success.

- Plan ahead. You should begin a programme with a clear schedule for handing out assignments, assessment deadlines and internal verification, so that you are well prepared to ensure ongoing quality and able to address any issues quickly.
- Ensure good communication. Assessors, Internal Verifiers, Lead Internal Verifiers and managers should all be clear on their roles and how they interact. The Lead Internal Verifier must have a clear overview of the plan of assessment and how it is being put into practice.
- Provide clear, consistent feedback to learners during the guided learning stage. Give clear and accurate assessment feedback based on the grading criteria after the final submission only. **Remember:** care must be taken to maintain the independence of the learner during assessment activities. This allows learners to know exactly how they are achieving on the programme, identifies areas for development, and encourages them to take responsibility for their own learning.
- Undertake internal verification in a timely way. Assignment briefs must be internally verified before they are given to learners. A sample of assessment decisions should be internally verified as soon after assessment as possible to ensure that learners receive accurate and supportive feedback on their achievement.
- Track assessment and internal verification accurately as you go along. Assessment records should be kept at the level of the learning aim and assessment criterion/criteria. This gives a clear confirmation of individual achievement and identifies areas for improvement.
- Using standardised templates for all quality-assurance documents helps to ensure a consistent approach. We provide templates via our website that you can use for:
  - internal verification of assignment briefs
  - internal verification of assessment decisions
  - observation records and witness statements.
- These templates are not mandatory and you are free to design your own, but using them will help to ensure that you are meeting requirements.
- Ensure that learner work is kept secure but is accessible during the programme. You will be required to provide learner work for external quality assurance while learners are on programme.

# Units

# Unit 1: The Engineered World

## Delivery guidance

### Approaching the unit

Learners should be encouraged to identify with the world of engineering and you should focus on practical everyday examples to identify the impact engineering has on everyday life. Examples may include the supply of goods and services via a variety of transport networks or the manufacture of everyday items such as smartphones or games consoles. Other examples include advanced polymers and carbon-fibre composites that have influenced the biomedical industry with the production of lighter and stronger prosthetic limbs, or how chemical engineering is fundamental to the development of make-up and the mass production of medicine. It is essential that learners find examples from all areas of engineering, including those listed in the specification content. This unit links closely with *Unit: 5 Engineering Materials* and you may like to consider opportunities to combine teaching.

Group work and open discussions will help learners to develop an awareness of engineering and the way it enables us to live. Learners could be motivated by highlighting personal links to engineering. Encourage learners to identify friends and family employed within the industry and get them to engage in conversations relating to their particular field of engineering. With this in mind, you should encourage links with engineering organisations and arrange visits or work placements for learners, as this will significantly enhance their first-hand experiences within the world of engineering. The use of role play, group research and presentations will also enhance your delivery, while guest speakers, videos and case studies may also be beneficial.

Learners will be assessed through externally-marked, onscreen examinations. You should ensure that learners are sufficiently prepared for the examination and that they are able to demonstrate the following knowledge and skills.

### Delivering the learning aims

For learning aim A, learners should be able to demonstrate knowledge of, and be able to categorise, products for each of the following sectors of engineering: aerospace, automotive, communications, electrical/electronic, mechanical, biomedical and chemical. Coverage of all sectors is essential to prepare learners for the exam. Learners could investigate the range of engineering organisations within your locality and the types of products manufactured, linking them to the named engineering sectors. Learners should also know about a range of mechanical and electrical/electronic engineering processes, including machining, forming, fabrication and PCB manufacture. Visits to engineering organisations could be arranged to view the materials and processes used to support this part of the unit. In addition to this, learners need to understand the characteristics of the scales of production and how the use of modern production methods, such as robots, influences the manufacture and assembly of products.

For learning aim B, learners need to know about developments in engineering materials and the associated new technologies. You could present learners with a range of modern and smart materials and discuss their characteristics and uses in the world of engineering. Learners should also consider the form of supply that these materials are produced in and how they are processed. This could lead to individual or small-group investigations about new technologies and in particular how these technologies are changing the world.

For learning aim C, learners should describe the factors that engineers should consider to ensure that the manufacture of engineering products is environmentally friendly. Using group discussions, you could encourage learners to consider the current environmental issues associated with manufacturing, such as use of non-renewable energy sources and carbon emissions. Learners will need to know about the Life Cycle Assessment (LCA) and its importance to the environment at various stages of a product's life. You could ask learners to select a product of interest to them and then carry out an LCA on that product. They could then deliver a presentation to the rest of the group with regards to their findings. Learners will also need to be familiar with ways of reducing waste and the associated terms such as reusable, recyclable and sustainable, along with lean manufacturing techniques. Learners could examine current recycled materials and methods of recycling and re-using in the local community, and discuss ways of improving these. You will need to ensure that learners are familiar with a range of renewable energy sources and their impact on society and the environment. For instance, in preparation for external assessment, learners could investigate a particular renewable energy source and produce an information sheet/worksheet setting out their advantages and disadvantages.

## Getting started

**This provides you with a starting place for one way of delivering the unit. Activities are provided in preparation for the external assessment.**

### Unit 1: The Engineered World

**Introduction**

You could introduce this unit by taking learners through the world of engineering. This can be done by examining engineered products, the materials and processes used during manufacture, and how engineers contribute to a sustainable future.

### Learning aim A: Know about engineering processes used to produce modern engineered products

You could start with whole-group teaching:

To introduce learners to the world of engineering, you could produce an introductory PowerPoint® presentation comparing some famous engineering landmarks/designs from past and present, such as bridges, aircraft, cars and mobile communication devices.

Then, in small-group activities, you could:

- get learners to investigate the type of engineers that would work in the engineering sectors found in the unit content. They could then produce a short presentation detailing some of the tasks that they might carry out.
- present learners with a range of engineering products to examine and make suggestions on materials and processes used during manufacturing.

Through whole-group teaching, you could:

- introduce learners to a range of engineering processes, which could be achieved by touring the centre's workshop or visiting local industry to view processes not commonly found in your centre
- explain about the different scales of production and show learners examples of products covering each type
- explain the role of modern production methods in engineering, which could be achieved through the use of video clips/CDs of robotic or CNC machinery.

Then, in small-group or individual activities, you could:

- ask learners to produce a quiz that tests the knowledge of the range of processes contained in the unit content
- allow learners to develop posters showing the different scales of productions, with examples
- discuss the different uses of modern production methods, looking at both the advantages and disadvantages of using such machinery.

### Learning aim B: Know about developments in engineering materials and technologies

Through whole-group teaching, you could:

- introduce learners to a range of engineering materials – learners could examine a variety of materials used in everyday engineered products and discuss the reasons for their use
- explain about the use of metals in engineered products – learners could then suggest how these metals could be used in different engineering sectors

*continued*

| Unit 1: The Engineered World |
|---|
| • explain about modern material processes used in engineering. Learners could produce comparison charts of a range of processes covering the advantages and disadvantages of both.<br>Then, in small-group activities, you could:<br>• get learners to examine a range of simple engineered products and suggest particular material forms that would be appropriate for their manufacture by using the internet to search for materials stockists<br>• get learners to suggest suitable materials for simple engineered products and ask them to justify their selection<br>• guide learners to produce a report about a material of their choice and feed back their findings to the rest of the class through a presentation<br>• encourage learners to discuss a range of new technologies through a brainstorming session; learners could then produce a case study of one type of new technology. |
| **Learning aim C: Understand how engineering contributes to a sustainable future** |
| Through whole-group teaching, you could:<br>• introduce learners to the concept of Life Cycle Assessment. Learners could be given the headings from the unit content and discuss the stages in small groups.<br>• explain the 4Rs when dealing with minimising waste production in engineering – learners could looks at existing methods of minimising waste and discuss how they could be improved<br>• explain lean manufacturing techniques. Deliver a presentation about JIT, Kaizen and Poka-Yoke. Learners could then use the internet to investigate each technique and provide reasoned judgments for their use in engineering.<br>Then, in small-group activities, you could:<br>• get learners to perform an LCA on a chosen engineered product<br>• ask learners to produce a questionnaire or survey for their local community to discover primary information about minimising waste<br>• give learners a series of scenarios and prompt debate about the most appropriate renewable sources of energy to be used. |

## Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

BTEC Firsts in Engineering:

- *Unit 2: Investigating an Engineered Product*
- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 7: Machining Techniques*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

These textbooks provide a wealth of information with regards to materials use and selection as well as processing methods for a variety of applications.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Award edition)*, Pearson Education, 2012 (ISBN 9781446905630)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

Fulay, P., Wright, W. and Askeland, D., *The Science and Engineering of Materials* (6th edition), Nelson Engineering, 2011 (ISBN 9780495668022)

Includes chapters covering metals, polymers and composite materials, along with production techniques.

Shackleford, J., *Introduction to Materials Science for Engineers: International Version* (7th edition), Pearson, 2008 (ISBN 9780132083706)

### Websites

www.key2study.com
This is a materials database.

www.matweb.com
This is a materials database.

www.sustainability.com
This site has a range of case studies available that examine sustainable issues within business.

www.towards-sustainability.co.uk
This site takes a closer look at a variety of sustainable issues.

# Unit 2: Investigating an Engineered Product

## Delivery guidance

### Approaching the unit

For this unit learners should be given access to a range of commercial products, each consisting of at least two component parts that are made from different materials, e.g. a hand drill or an office stapler. The selected product must use at least two different processes in its manufacture. Although learners will investigate a single product, it is desirable that this is not shared among the whole cohort. A range of products investigated within your teaching group will stimulate interest as learners see other products being analysed.

### Delivering the learning aims

Lead learners through an initial product investigation to establish an understanding of the requirements for each learning aim, before letting them embark on their own investigation. For example, when investigating a hand drill, you could discuss

- its technical specification in terms of why the designer decided on its form
- how it achieves its function
- what user and performance requirements were considered
- what properties and qualities of materials were necessary to its success
- what considerations for manufacture and maintenance were made
- what legal and safety requirements had to be met.

When considering materials used in the hand drill, the properties and qualities required for its success should focus on the needs of the drill and should not be generic.

Similarly, processes identified in the manufacture of the drill should be justified for their use in the product and should not be a general description of a process.

When discussing quality control and quality assurance, emphasise to your group that the hand drill did not come to the market place without controls being placed on it to ensure its fitness for purpose. The drill could be used to discuss and identify QC checks and how these fit into a wider QA system.

All learning aims are achievable through investigating a single product, which learners could physically disassemble, photograph and sketch to investigate component parts and discover how they are assembled into a whole product. For example, if an office stapler was being investigated, internal parts are not easily seen in the final assembly, so learners should be encouraged to disassemble the product in order to investigate the component parts through handling, to familiarise themselves with shapes and to research appropriate manufacturing processes.

Learning aim A requires learners to put themselves into the place of the designer of the product before a prototype has been produced, so teacher-led class discussion of design needs and resulting specification points relating to a product is crucial in guiding learners when writing a specification for their selected product.

Learning aims B and C are closely linked and offer opportunities to investigate the properties and qualities of materials and the manufacturing processes used in the product under investigation, why they were selected specifically to meet the needs of the product and what the environmental impact of their use is. These opportunities

might include a teacher-led discussion and group work regarding products investigated in preparation for individual work. Learning aims B and C link to *Unit 5: Engineering Materials* and to some aspects of *Unit 6: Computer-aided Engineering* and you should encourage learners to transfer knowledge and understanding from unit to unit where appropriate.

Learning aim D requires learners to understand that products are rigorously checked before they are allowed into the marketplace and that quality assurance and quality control are tools used to ensure fitness for purpose. Teacher-led activities in identifying quality checks and designing a quality assurance system, for example, for the hand drill already mentioned, would serve as a foundation for independent work when learners embark on individual product investigations.

Much of the work done on this unit will be carried out in the classroom, using research tools such as the internet, materials databases and textbooks. Additionally, one or more factory visits would stimulate interest and demonstrate commercial manufacturing processes realistically. Quality issues could be explained in a practical situation through contact with expert personnel on such visits. Learners should be encouraged to view television programmes such as 'How things are made' and use the excellent resources found on the internet that demonstrate manufacturing processes for a range of similar products to those selected for investigation, in order to broaden their experience of materials and manufacturing processes.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

| **Unit 2: Investigating an Engineered Product** |
|---|
| **Introduction**<br>You could lead a whole-group activity to familiarise learners with the requirements of the learning aims and how to approach each one effectively. |
| **Learning aim A: Understand the performance requirements of an engineered product** |
| • Have a range of familiar products available and discuss with learners their functions and features.<br>• Select one product and ask learners to use the headings form, function, user requirements, performance requirements, and material requirements to write one statement under each heading to form a short specification. Discuss as a group the points made and why it is important to have a well-designed technical specification that is a checklist for designing and how this would be developed by a product designer as a guide for designs.<br>• Referring to the headings form, function, user requirements, performance requirements and material requirements, make clear what each heading means. This could be reinforced by use of PowerPoint® slides or hand-out information.<br>• As a team effort, learners compile a specification for the product under joint investigation. This could be done in small groups with a teacher-led plenary where each group feed back through a team leader. |
| **Assignment 1:** Product Performance* |
| **Learning aim B: Understand the selection of specific materials for use in the components that make up an engineered product** |
| • Prepare a PowerPoint® presentation that compares and contrasts the properties of the materials used in the selected exemplar product and discuss each property. Learners could go on to evaluate these products.<br>• Learners record which of the properties would be required by the product and why.<br>• Learners suggest an alternative for each of the two materials used in the product and justify their choice by researching via the internet and referring to properties of the named materials.<br>• Prepare PowerPoint® slides or use a short video clip to show how the extraction and processing of raw materials affects the environment and why product design should consider lifespan and disposal. |
| **Assignment 2:** Materials and Components* |
| **Learning aim C: Understand the selection and use of manufacturing processes in an engineered product** |
| • Using the range of products prepared for the beginning of learning aim A, compare and contrast some manufacturing processes used in each product.<br>• Show short videos of identified processes (Stanford University/YouTube/How things are made) to demonstrate manufacturing process. Discuss why the products were made using particular processes.<br>• Prepare a drawing or photograph(s) of the selected exemplar product. Learners label component parts with appropriate manufacturing processes and justify their selection.<br>• Leaners suggest alternative manufacturing processes that could have been used and use websites you have suggested to research processes. |

| **Unit 2: Investigating an Engineered Product** |
|---|
| • Arrange a visit to a local manufacturing company. Learners prepare questions regarding processes and materials used, safety and quality control procedures, and the environmental consequences of the processes in use. Learners could go on to evaluate the processes used within the company. |
| **Assignment 3:** Manufacturing Processes* |
| **Learning aim D: Understand the quality issues related to an engineered product** |
| • You could prepare a worksheet that learners may use, working in small groups, to identify quality control (QC) checks and a quality assurance (QA) system for the selected product. QC checks should focus upon the inspection and testing of batches of products at critical control points in the production of the product. The QA system should cover the three main production phases: pre-production (i.e. materials supply and control), production (i.e. manufacture, assembly and finishing) and post-production (i.e. guarantees and customer satisfaction).<br>• Next, you could lead a plenary to record results from each group and to finalise appropriate and realistic quality control checks. Record an appropriate quality assurance system using group feedback.<br>• You could ask learners to record the final group outcome to use as a guide when working individually. |
| **Assignment 4:** Quality* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 1: The Engineered World*
- *Unit 5: Engineering Materials*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Award edition)*, Pearson Education, 2012 (ISBN 9781446905630)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

### Websites

There are many links to manufacturing processes through a search for 'How things are made'. Stanford University supply a very good range.

The following websites are both excellent resources for engineering materials.

www.key2study.com

www.matweb.com

# Unit 3: Health and Safety in Engineering

## Delivery guidance

### Approaching the unit

You should deliver this unit using a combination of lectures, teacher demonstrations and practical engineering activities.

### Delivering the learning aims

Examples are provided in the unit content to give you an idea of the typical range of areas that might be covered within the learning aims. For example, when covering risks and risk assessment with learners, it is clear that 'the hazard could be an object, a property of a substance, a phenomenon or an activity' and a number of examples are provided. For assessment purposes, three of these would be sufficient. However, it is expected that learners will be provided with the skills to identify a wider range of hazards found in an engineering environment and you should consider this when preparing your delivery.

Ensure that when you plan activities for this unit there are plenty of opportunities for practical application. For example, identifying hazards and the risks associated with an engineering activity from an image (e.g. drawing, sketch or photograph) does not have the same value that real practical experience in a working environment can bring.

You should look for innovative ways of bringing the unit to life, giving it true relevance for learners. This will be best achieved through the use of practical, hands-on experience using your centre's workshop facilities or, if possible, through actual workplace experience. You could arrange a visit to a workplace and ask learners to keep a log of any risks they identify as they are shown around the premises.

Delivery of the engineering work activity will require access to an engineering workshop environment and relevant tools and equipment. Learners could be provided with a range of simple engineering tasks, such as the manufacture of a drill drift, toolmakers clamp or screwdriver. This will enable them to practise their skills, during which you should ensure support and guidance is given. You could appoint a health and safety officer during workshop activities to monitor and intervene when legislation is not applied.

The opportunity to work with individuals during the delivery of this practical work can be used to good effect to underpin learning. In particular, it can be used to reinforce working practices and skills, help learners to deal with problems affecting engineering processes or support them when they need to work with others more effectively in order to achieve the task.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

| **Unit 3: Health and Safety in Engineering** |
|---|
| **Introduction**<br>You could introduce this unit to learners with a group discussion on health and safety in engineering. This could be followed by a brief outline of the scope of the unit and how it could be linked with other units. |
| **Learning aim A: Understand safe and effective working in an engineering workplace** |
| You could start with whole-class teaching, and a health and safety induction.<br>● Introduce the Health and Safety at Work Act and other current and relevant legislation, e.g. Personal Protective Equipment at Work Regulations, Manual Handling Operations Regulations, Use of Work Equipment Regulations, Display Screen at Work Regulations, Control of Substances Hazardous to Health (COSHH) and Reporting of Injuries Diseases and Dangerous Occurrences Regulations (RIDDOR).<br>● Learners could select a particular piece of legislation and feed back to the rest of the group through a PowerPoint® presentation.<br>● You could then explain the responsibilities, under the Health and Safety at Work Act and other current and relevant legislation, of employees and employers – using guest speakers from local industries and visits to engineering organisations. Learners could develop a quiz to test knowledge and understanding.<br>In whole-class teaching, you could then:<br>● explain the emergency procedures as a result of engineering workshop incidents, including types of fire extinguisher and their uses, incident reporting routines and identification of appropriate qualified persons<br>● simulate for learners an emergency procedure within the centre and observe/record their actions<br>● explain the importance of adherence to correct legislation, policy and procedures in an engineering environment<br>● ask learners to produce posters and/or policy booklets to inform others of the importance of adhering to correct legislation.<br>You could follow this with a practical workshop activity/demonstration:<br>● identification and safe operation of firefighting equipment – with a practical demonstration of using such equipment<br>● alarms and evacuation procedures – simulated emergency procedure<br>● identification and location of warning signs and notices – give learners a tour of the centre to locate relevant signs and notices. |
| **Assignment 1:** Accident and Emergency Procedures and Workplace Roles and Responsibilities* |
| **Learning aim B: Know how to follow procedures and undertake a work activity safely** |
| Through whole-group teaching, you could:<br>● introduce learners to personal protective equipment (PPE) and provide a demonstration of the safe use of such equipment<br>● explain the requirements of the PPE at work regulations and consider personal and protective equipment appropriate to a range of engineering tasks |

| **Unit 3: Health and Safety in Engineering** |
|---|
| • ask learners to develop a PowerPoint® presentation or develop a poster to present the legislation.<br>You could follow this with a practical workshop activity/teacher demonstration on:<br>• the use of PPE, including overalls, protective footwear, eye protection, masks/respirators<br>• selecting the most appropriate PPE for given engineering tasks.<br>Through whole-group teaching, you could then:<br>• introduce hazards and risks associated with the working environment and simulate a range of hazards and risks within a workshop, then observe learners responses. For example, this might be removing the guard from a specific machine, creating a tripping hazard with wires and leads, or blocking an emergency exit within a room.<br>• explain the five-step approach to risk assessment – examine current risk assessment material for a particular operation/activity within a workshop, for example, a risk assessment for a drilling operation.<br>You could follow this up with a practical workshop activity – learners carry out a hazard identification and risk assessment.<br>Through whole-group teaching, you could then explain the importance of preparation for work activities, including:<br>• environment – relevant safety procedures and equipment requirements<br>• preparation – requirements and documentation for work activity<br>• authorisation – drawings, specifications, job instructions<br>• materials and components.<br>Learners could then produce a range of worksheets using some of the headings above to allow a work activity to be carried out safely and effectively.<br>You could follow this with a practical workshop activity to:<br>• obtain all necessary drawings and equipment for learners to carry out the selected work activity.<br>• provide learners with access to workshops and machinery to carry out engineering work activities. |
| **Assignment 2:** Preparing for and Carrying Out an Engineering Activity* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

Health and safety is essential to all engineering activities. This unit of work is closely linked to the units below, as they all require appropriate health and safety guidance prior to any practical activities.

BTEC Firsts in Engineering:

- *Unit 4: Engineering Maintenance*
- *Unit 5: Engineering Materials*
- *Unit 7: Machining Techniques*

## Resources

It is essential that centres provide opportunities to access relevant legislation applicable to the working environment, including access to computers and the internet to research current legislation and regulations.

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Health and Safety Executive, *Essentials of Health and Safety at Work*, HSE Books, 2006 (ISBN 9780717661794)

Health and Safety Executive, *Health and Safety in Engineering Workshops*, HSE Books, 2004 (ISBN 9780717617173)

### Websites

www.hse.gov.uk
Health and Safety Executive

# Unit 4: Engineering Maintenance

## Delivery guidance

### Approaching the unit

This is a practical unit where learners will explore the causes of equipment failure, learn about maintaining equipment, learn about resourcing and planning a maintenance activity and discuss safety issues surrounding equipment maintenance.

You could deliver this unit using a combination of lectures, research tasks, teacher demonstrations and practical maintenance activities.

### Delivering the learning aims

Examples are provided in the unit content to give you an idea of the typical range of areas that might be covered within the learning aims. For example, when covering identification of resources for a planned maintenance activity with learners, there are examples of a range of resources that learners could identify and select, such as a permit to work, maintenance checklists, and so on. For assessment purposes, four of these would be sufficient. However, it is expected that learners will be exposed to the full range indicated and/or alternative appropriate resources depending upon the maintenance activity being considered, and you should consider this when preparing your delivery.

In order to address the learning aims for this unit, it is essential that learners have the opportunity to carry out practical maintenance activities.

When planning for the activity outlined in learning aim B, learners should have access to a setting that allows them to assess the working environment and appraise the available resources. Similarly, learning aim C requires learners to complete a maintenance activity and they will need to use suitable tools and equipment in order to carry out this activity in a safe manner. It would be advantageous to base this activity in an engineering workshop, to allow learners to experience the type of environment that they might encounter in the workplace. Teachers are encouraged to find inventive ways of providing a stimulating experience for learners, helping them to appreciate the relevance and importance of maintenance activities. This could be facilitated through visits to local companies along with the use of practical, hands-on experience, which can be achieved during workshop activities or through actual workplace experience.

When accessing engineering workshops, learners must ensure they carry out risk assessment activities in order to prepare safely for their maintenance activities. This workshop environment should reflect the engineering product or system being investigated. Practical activities could be provided, utilising a range of tasks involving simple maintenance checks and fault-finding techniques. This will allow learners to practise their skills while support and guidance can be given.

Each activity should be planned to ensure learners are working safely and identifying risks and associated hazards as they prepare for assessment activities. These activities should allow learners to work individually and in groups in order to build confidence, and should allow teachers to give small-group demonstrations and provide individual support as appropriate.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

| **Unit 4: Engineering Maintenance** |
|---|
| **Introduction**<br>You could introduce this unit to learners with a group discussion on engineering maintenance. This could be followed by a brief outline of the scope of the unit and how it could be linked to other units. |
| **Learning aim A: Know about causes and effects of equipment failure and types of maintenance procedures** |
| You could start with whole-group teaching:<br>• describing, with the use of artefacts, the causes of failure of components and systems and the effects on productivity, health and safety, cost and the environment.<br>Using individual and small-group practical activities:<br>• learners could identify/determine the causes of failure of a range of exemplar components and equipment. This activity could take place in a workshop or classroom environment with learners being able to compare failed components such as worn bearings, burned out motors, leaking valves, etc, with those in good order. They should be able to use tools or equipment safely and under appropriate supervision to help them diagnose the reasons for failure.<br>In whole-group teaching, you could then:<br>• provide an explanation and comparison of different types of planned maintenance strategies, focusing on the benefits of these strategies<br>• provide an explanation and comparison of different types of unplanned maintenance strategies, focusing on the impact of these strategies. |
| **Assignment 1:** Engineering Maintenance Purposes, Procedures and Resources* |
| **Learning aim B: Be able to resource and plan a maintenance activity on an engineering product or system** |
| In whole-group teaching, you could:<br>• explain the different types of documentation used in the planning and recording of maintenance activities<br>• introduce learners to the resources required to plan and carry out maintenance activities, using a simple case study or workshop resource.<br>This could be followed by practical activities:<br>• in groups, learners could investigate the required resources for a given maintenance activity based on an everyday resource (such as a piece of garden machinery) or a workshop resource (such as a bench drill). Learners should generate a list of resources such as tools required, equipment, PPE, etc.<br>You could follow this with whole-group teaching:<br>• introduce learners to the purpose and features of a straightforward maintenance plan, then provide an example of straightforward and detailed checklists and maintenance plans for typical engineering products and systems. This could be based on the artefact or case study previously used.<br>This could be followed by practical activities:<br>• in groups, learners could investigate the requirements of a detailed maintenance plan by producing a plan for the example previously used in the resource planning exercise. |

| **Unit 4: Engineering Maintenance** |
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| **Assignment 2:** Resource and Plan Out a Maintenance Activity* |
| **Learning aim C: Be able to carry out a maintenance activity safely on an engineering product or system** |
| Learning aim C is a practical activity; this could be facilitated with group work.<br>Following on from the preparatory exercise, typically based on garden machinery or a workshop resource, you could allocate tasks in the group in preparation for the following activity.<br>● Learners could collate resources from the list previously prepared, such as tools, fault-finding aids, manuals and specifications etc.<br>● They should then plan the straightforward maintenance activity, to include the identification of risks/hazards, visual checks, fault-finding techniques and electrical and mechanical checks.<br>Using whole-group teaching:<br>● give an explanation of the importance of health and safety and risk assessment, including how to carry out a risk assessment with an example<br>● introduce learners to the use of maintenance documentation in the planning of maintenance activities, by demonstrating the use of maintenance logs, manuals etc, for a workshop example such as a lathe, compressor, etc.<br>Using small-group practical activity:<br>● learners could carry out a risk assessment of the planned maintenance activity by completing an appropriate risk assessment matrix<br>● learners could take part in a practical workshop activity, with guidance, involving the use of exemplar engineering products and systems, such as the lathe or compressor previously considered, in order to demonstrate the use of visual/mechanical/electrical checks, and fault-finding techniques.<br>This could be followed by a group activity where learners carry out the maintenance activity previously planned (typically a bench drill or a piece of simple garden machinery) in a safe manner under appropriate supervision. A witness statement could be produced to supply evidence about their work in the workshop. |
| **Assignment 3:** Carry Out a Maintenance Activity* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with

BTEC Firsts in Engineering:

- *Unit 3: Health and Safety*
- *Unit 5: Engineering Materials*
- *Unit 8: Electronic Circuit Design and Construction*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Kibbe, R., *Mechanical Systems for Industrial Maintenance*, Prentice Hall, 2001 (ISBN 9780130164902)

### Websites

www.howstuffworks.com
This website includes animations and videos showing the principle of operation of a wide range of engineering ducts and systems.

www.reliabilityweb.com/fa/pdm.htm
A resource that includes clips and links based on condition monitoring techniques.

# Unit 5: Engineering Materials

## Delivery guidance

### Approaching the unit

Most learners are unlikely to have studied the properties, uses and selection of materials so it is essential that you provide a formal introduction to the unit content. This could be done using a PowerPoint® presentation coupled with group discussion about what learners already know about materials.

Provide access to a broad range of materials and allow learners the opportunity to observe, touch and even work with these. The unit could then be delivered with an emphasis on investigation.

### Delivering the learning aims

Give learners the opportunity to handle a wide range of materials and ask them to describe how they are used in the workshop environment. You could devise some informal and improvised materials-testing techniques to allow learners to explore the properties of materials, for example: weight/density, appearance (colour/hue, texture), accompanied by an element of formal testing (hardness, impact, tensile tests) where facilities are available.

Providing a historical setting to the introduction and use of particular engineering materials is an effective way of helping learners understand how materials have developed from the small range available in ancient times to the wide range available today. This is a great opportunity to develop learners' awareness of how the spread of industry, demands of warfare and the advent of space travel have brought about advances in materials technology.

Ask learners to gather information on the properties and forms of supply of engineering materials, from textbooks or via the internet. A number of useful sites give access to a wide range of materials and their properties, such as www.matweb.com. Learners could then present their finding in the form of a simple table or a more complex database. A range of engineering drawings, specifications and documentation should be available for material identification and selection exercises.

You can choose to deliver the unit in a particular engineering context. However, it would be advantageous to choose an approach that draws on examples and applications from different areas of engineering. For example, identifying properties of materials required for parts of a Formula 1 racing car or the largest passenger aircraft in the world is an excellent way to examine different materials.

The materials can be described and classified in terms of their properties, typical applications, forms of supply and identification. Learners will need to consider the sustainable use of a range of engineering materials to support their selection and use in an engineering environment, including reducing, recycling and reusing materials.

You should look for innovative ways of bringing the unit to life, giving it true relevance for learners. This will be best achieved through the use of practical, hands-on experience using your centre's workshop facilities or, if possible, linking with higher education establishments and actual workplace experience. You could arrange a visit to a workplace or college that has materials testing facilities and carry out a range of tests such as tensile and hardness testing.

The analytical skills which are required at merit and distinction level can be developed early on in this unit by asking learners to relate material properties and forms of supply to a wide range of applications. Industry links would be particularly valuable in this respect – perhaps providing materials, components and applications that relate to local organisations and employers.

You could arrange a visit to a local company and ask them to talk through how they select and test materials to ensure they are fit for purpose. These visits would also provide a valuable insight into how these materials can be processed to produce an engineered product.


Delivery Guide – Pearson BTEC Firsts in Engineering –
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## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

**Unit 5: Engineering Materials**

**Introduction**

You could introduce this unit to learners with a group discussion about what they already know about materials. You could then give a presentation on the historical background of the application of materials followed by a brief outline of the scope of the unit and how it can be linked to other units.

**Learning aim A: Know about the properties of common engineering materials and selection for engineering applications**

You could start with whole-group teaching to:

- describe composition, appearance and properties of the range of ferrous and non-ferrous materials
- describe composition, appearance and properties of the range of thermoplastic and thermosetting polymer materials
- describe composition, appearance and properties of the range of composite and smart materials
- describe a range of industrial mechanical testing processes that could be performed on a range of materials. Learners could visit a local FE or HE facility to view mechanical tests, such as hardness, tensile strength and impact tests.

Learners could then discuss applications, and view and handle specimen components for each of the material types shown above.

Through individual or small-group activity, you could then:

- carry out investigations involving visual and tactile recognition of materials and informal property tests. For example, learners could be presented with a range of materials and wear blindfolds to try and identify different generic types of materials, allowing them to use their senses to assist their decisions.
- carry out a range of simple tests on a range of materials. Learners could devise some simple activities to test properties such as strength, hardness and toughness – for example, stretching a piece of wire by hanging weights from the end over the side of a table, or using a hammer and centre punch to produce an indent in the surface of a material to measure the materials hardness.

This could be followed by whole-class teaching, to:

- define mechanical, electromagnetic, chemical and thermal properties for learners
- produce information sheets defining a range of properties, such as tensile strength, ductility, hardness, toughness, elasticity, malleability and brittleness
- describe and discuss typical components and applications where knowledge of these properties is essential to good design
- study a range of products and apply new-found skills in property identification.

**Assignment 1:** Properties of Engineering Materials and their Applications*

**Learning aim B: Know about the supply and sustainable use of engineering materials and selection for an engineering product or activity**

Through whole-group teaching, you could:

- describe raw material extraction and processing – primary and secondary types – so learners can produce posters to describe material extraction and processing methods

| **Unit 5: Engineering Materials** |
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| • discuss ways of lowering volatile organic compounds<br>• discuss reducing, recycling and re-using materials when making products<br>• discuss reducing, recycling and re-using products to make new ones<br>• describe waste management and its importance to sustainability – learners could produce a report with regards to waste management for a selected product. Learners could examine the materials and processes used to manufacture a product, investigate current waste issues and look for ways to improve waste management.<br>• examine sustainability issues that impact on the global environment, for example, the use of fossil fuels to produce electricity or the over-production of engineered products.<br>Continuing with whole-group teaching, you could:<br>• discuss appropriate symbols, abbreviations and identification coding systems for a range of materials<br>• describe appropriate material selection for a range of engineering products – you could provide a range of engineered products for learners to examine and determine the most appropriate material used in their manufacture<br>• describe commonly available ranges of metal, polymer and composite forms – you could present learners with a range of materials that could be categorised into the appropriate types<br>• describe commonly available material sizes and surfaces finishes – learners could use the internet to visit local material stockists in order to identify the variety of sizes and material types available.<br>You could follow this with individual or small-group activity:<br>• Learners could carry out an investigation to identify the suppliers and costs of given materials. For example, you could provide learners with a list of parts/components for an engineered product and ask them to source (using local suppliers' catalogues or internet suppliers) the correct type, its form of supply, and cost. |
| **Assignment 2:** Identifying Engineering Materials* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 2: Investigating an Engineered Product*
- *Unit 3: Health and Safety in Engineering*
- *Unit 7: Machining Techniques. (There is a clear link between material selection when a product is being investigated or machined in some way.)*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Award edition)*, Pearson Education, 2012 (ISBN 9781446905630)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

Fulay, P., Wright, W. and Askeland, D., *The Science and Engineering of Materials* (6th edition), Nelson Engineering, 2011 (ISBN 9780495668022)

Includes chapters covering metals, polymers and composite materials, along with production techniques.

Shackleford, J., *Introduction to Materials Science for Engineers: International Version* (7th edition), Pearson, 2008 (ISBN 9780132083706)

### Websites

www.Key2study.com
This is a materials database.

www.matweb.com
This is a materials database.

# Unit 6: Computer-aided Engineering

## Delivery guidance

### Approaching the unit

This unit should be delivered using a largely practical approach. To facilitate this, give learners access to appropriate computer facilities to complete the Computer-aided Design (CAD) and programming elements of the unit. You also need to provide learners with subsequent access to an engineering workshop and Computer Numerical Control (CNC) machines to allow for the Computer-aided Manufacture (CAM) and checking of an engineering component.

### Delivering the learning aims

Examples are provided in the unit content to give you an idea of the typical range of applications that might be covered within the learning aims. For example, when covering the component features of a CAM system, there are examples of a range of CNC machines that could be identified and selected by learners. For assessment purposes, one of these would be sufficient. However, it is expected that learners will be exposed to a range of CNC machines and/or alternative CNC machines depending upon availability, in order to evaluate CAM as a means of producing different engineered components. You should consider this when preparing your delivery. This exposure to specialist technology may be facilitated by a research activity or visit to a local company, college or higher education provider.

Although learners are likely to be relatively proficient in the use of a computer system, you should emphasise to them the differences between software they may be familiar with and CAD packages. Similarly, an introduction to engineering drawing presentation and exercises on how drawings and circuit diagrams are constructed would be beneficial. Through these preliminary demonstrations you should also emphasise why CAD packages might be used specifically for an engineered product, thereby justifying its use. Learners should be given the opportunity to familiarise themselves with the fundamental drawing and editing commands. This could be done 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, the complexity of the drawings tackled could be increased.

It is not necessary for this formative work to be presented as assessment evidence. These formative activities will enable you to provide practical support and guidance for the learners and to gain a view of their progress and potential at the same time. The use of pre-printed activity sheets will allow learners to develop skills and knowledge at an appropriate pace and enable you to focus on those learners who are less familiar with the system.

When accessing engineering workshops, learners must ensure they carry out risk assessments in order to prepare safely for their CAM activities. This workshop environment should reflect the type of CAM being used by learners and will allow them to practise their skills while support and guidance can be given. Activities should allow learners to work individually and in groups, in order to build confidence, and allow you to give small-group demonstrations and provide individual support as appropriate.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

| **Unit 6: Computer-aided Engineering** |
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| **Introduction**<br>You could introduce this unit to learners with a group discussion about how computers are used in engineering. You could then show a video, or selected video clips, of how computers are used to generate designs and how these designs are realised using CNC and CAM techniques. |
| **Learning aim A: Use a CAD system to produce engineering drawings** |
| You could start with whole-group teaching:<br>• introduce the CAD system, system configuration and setting up of the drawing environment, including the use of relevant toolbars and menus, and demonstrate using a large screen presentation and/or electronic whiteboard<br>• explain the use of drawing conventions, drawing templates and BS8888 standards to the class; learners could use exemplar material to compare good practice and examples of poor use of drawing techniques, as a group-work exercise<br>• demonstrate to learners how to save the drawing data in an appropriate format and how to output to a printer/plotter.<br>You could then give learners individual practical activities using CAD software:<br>• they could follow an onscreen exercise or complete printed activity sheets which introduce the basic features of a CAD system, including basic drawing commands and editing commands to produce and erase lines, circles and text; learners could work through these practical activities, designed to allow them to develop appropriate skills, at their own pace, with in-built learning checks along the way<br>• carry out further individual practical activities that involve the use of more advanced tools; dimensioning, accurate geometry definition, the manipulation of views, zoom/pan techniques and options that allow drawing modification could be used to allow more advanced skills to be developed. |
| **Assignment 1:** CAD Component Drawing* |
| Through whole-group teaching, you could:<br>• introduce circuit diagrams, their function, layout and the use of circuit symbols<br>• introduce the use of standards, e.g. EN 60617, BS2917. This could be facilitated by matching exercises, e.g. using software resources to drag and drop or using cards to match symbols to components.<br>You could then give learners individual practical activities using CAD software:<br>• learners could follow onscreen exercises or complete printed activity sheets, which introduce insertion and editing commands to produce and erase circuit components and connections<br>• further activities could then be used to guide them on the use of appropriate software tools to allow an accurate geometry definition of the standard symbols used in circuit diagrams and the annotation of circuit diagrams that include component names or descriptions. |
| **Assignment 2:** Circuit Diagram* |

| **Unit 6: Computer-aided Engineering** |
|---|
| **Learning aim B: Use a CAM system to manufacture an engineering component** |
| Through individual learner activity using CAD software, learners can:<br>● follow onscreen exercises or complete printed activity sheets that involve them demonstrating competence in the modification and manipulation of drawn features – including scaling, revolving/rotating, copying/duplicating and moving, dimensioning and hatching<br>● carry out further activities that involve other CAD commands, including stretch, trim, absolute, relative and polar co-ordinates. |
| **Assignment 3:** Drawing and Modification Techniques* |
| Through whole-group teaching:<br>● learners can be introduced to computer-aided manufacture and the range of CNC machines used, through the use of video presentations, workplace visits and/or practical workshop demonstrations<br>● learners could see, via demonstrations, how CAD drawing information can be used in the preparation of files suitable for CAM systems, using a large screen presentation and/or electronic whiteboard.<br>Learners could then undertake individual practical activities:<br>● learners could explore the use of CAM software with reference to efficient cutter paths, the use of 3D co-ordinate systems, an appreciation of effective tool changes and the transfer of cutter path data into CNC code<br>● learners could map the movement of tools by annotating drawings and colour coding the different tools required<br>● learners could then follow onscreen exercises or complete printed activity sheets that involve them using software to demonstrate competence in transferring cutter path data into CNC code.<br>Through demonstrations, learners could then carry out further individual practical activities:<br>● using a risk assessment matrix, learners could identify hazards and risks for CAM activities<br>● learners could then annotate diagrams in order to evidence the identification of the component features of a CAM system<br>● learners could use downloading techniques or transfer files, using an appropriate storage medium such as USB flash drives, in order to load a CAM program onto a CNC machine and run the program to produce the desired component<br>● using appropriate measuring tools, learners could compare component sizes and tolerances against a specification or engineering drawing. |
| **Assignment 4:** Safe Use of Computer-aided Manufacture Techniques* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with BTEC Firsts in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 7: Machining Techniques*
- *Unit 8: Electronic Circuit Design and Construction*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Award edition)*, Pearson Education, 2012 (ISBN 9781446905630)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

Simmons, C., Maguire, D. and Phelps, N., *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards* (4th edition), Butterworth-Heinemann, 2004 (ISBN 9780080966526)

### Reference guides

*PP 8888-1:2007 Drawing practice. A guide for schools and colleges to BS 8888:2006, Technical product specification*, BSI Publications, 2006 (ISBN 9780580626739)

### Websites

www.howstuffworks.com
This website includes animations and videos showing the principle of operation of a wide range of engineering machines.

# Unit 7: Machining Techniques

## Delivery guidance

### Approaching the unit

In this unit learners will develop the knowledge and skills required for several material removal techniques. Delivery should therefore focus mostly on practical work. Note that, although only one learning aim is associated with machining a product, the assessment throughout relies on evidence generated by this activity.

### Delivering the learning aims

Each learner must be allowed to study, in detail, drilling machining techniques and then either milling or turning machining techniques to allow safe use in the workshop. However, they will need to have an understanding of all three techniques.

Learners will need to be able to describe how these techniques are used. Ensure that learners are aware of the design of the machine tool and how shapes can be either generated or formed when using secondary machining techniques. You can do this through your own demonstrations using the machines available to your centre, such as lathes, milling and drilling machines. Centres that have limited facilities for machining techniques could develop ways of rotating learners through different machining operations. For example, a number of 'bench fitting' activities could be taking place while simple machining operations could be formed simultaneously on a milling or drilling machine and a lathe.

A range of work-holding devices and tools should be introduced in practical sessions to ensure that learners think about the importance of their use. Learners could then discuss in groups the consequences of not using work-holding equipment. You could give learners an opportunity to achieve higher grades by asking them to evaluate the effectiveness of work-holding devices for different machines. The main part of this unit involves the learner using a secondary technique when operating a machine safely.

Care needs to be taken to ensure that all learners work safely and in a safe environment. To emphasise the importance of safety, you could hold workshop briefings and ask learners to take part in a test to check their knowledge before they begin operating machinery

Learners should also be taught how to monitor progress during machining. This could take place through continuous checking of workpiece sizes during manufacture and then making necessary adjustments to achieve accuracy. Learners could achieve higher grades through an assessment to identify their strengths and weaknesses in terms of precision and accuracy when machining.

To check the accuracy of workpieces subjected to material removal, you will need to ensure that learners are familiar with appropriate tools and instruments, for example, micrometers and vernier calipers.

You must ensure that learners are made aware of relevant UK health and safety legislation. They need to know the importance of the use of risk assessments appropriate to the techniques they are using.

You should always ensure that each learner has the correct protective clothing and has the machine correctly guarded before operation. Ask learners to check the Health and Safety Executive (HSE) website first and to produce a checklist for others prior to commencement of work activities so that they can confirm they are wearing the appropriate protective clothing requirements for each machining operation.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

**Unit 7: Machining Techniques**

**Introduction**

You could introduce this unit with a safety induction that includes a tour of the workshop facilities and a group discussion on health and safety. This could be followed by a brief outline of the scope of the unit and how it can be linked to other units.

**Learning aim A: Select and use tools and work-holding devices for drilling and for turning or milling**

You could start with whole-group teaching, to:

- introduce learners to the engineering workshop. For example, tour the workshop examining potential risks and hazards associated with each machine and demonstrate basic principles of their use.
- give learners an activity on identifying different machine tools. For example, present them with a range of tools associated with each machine and allow them to identify their use.
- provide learners with a health and safety briefing, including legislation and assessment of risk
- give learners an activity on risk assessments. For example, place the learners in pairs to identify hazards and risks associated with the workshop machines and processes.

Then, in small-group activity, you could:

- demonstrate to learners the use of work-holding devices for different manufacturing techniques
- ask learners to use the work-holding devices, for example, using a machine vice, angle plate or dividing head, or clamping directly to the table
- carry out a workshop demonstration for learners of the use of different tools
- demonstrate to learners the use of different tools for different applications
- ask learners to identify safety devices and equipment, for example, machine guards and emergency switches.

**Assignment 1:** Work-holding Devices and the Use/Types of Machining Tools*

**Learning aim B: Make workpieces using drilling and turning or milling techniques safely**

Through whole-group teaching, you could:

- explain the principles of turning, milling, drilling and grinding – show learners how to use each piece of machinery in a safe manner. You could use a class-rotation system with small tasks to complete on each piece of machinery.

You could then hold a workshop activity for learners:

- identifying individual component parts and features of machines and safety precautions – learners could label diagrams of relevant machines and equipment
- identifying key features of a range of components – you could provide a range of different shaped components
- using measurement tools, techniques and gauges to determine appropriate levels of accuracy – you could provide samples of components and measuring instruments to check sizes and determine the most appropriate tool and techniques for each component

| **Unit 7: Machining Techniques** |
| --- |
| • demonstrating the use of a manufacturing technique and the use of guards/safety devices, lubricants, etc<br>• organising a closely supervised small-group machining activity<br>• using appropriate techniques to manufacture a component to a given standard. |
| **Assignment 2:** Parameters, Techniques, Safe Working Practices and Accuracy Checks when Machining Workpieces* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

When machining any products, it is essential to understand the health and safety issues associated with particular machines/tools and equipment. Knowledge of a range of materials and processes is also paramount to manufacture quality engineered products.

This unit of work is closely linked to BTEC Firsts in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 4: Engineering Maintenance*
- *Unit 5: Engineering Materials*
- *Unit 6: Computer-aided Engineering*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

The textbooks listed below provide a wealth of information with regards to machining techniques associated with drilling, milling and turning.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Award edition)*, Pearson Education, 2012 (ISBN 9781446905630)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

Meyers, A. and Slattery, J., *Basic Machining Reference Handbook*, Industrial Press, 2005 (ISBN 9780831132095)

Timings, R., *Basic Manufacturing* (3rd edition), Newnes, 2004 (ISBN 9780750659901)

### Websites

www.engineershandbook.com
Provides general information about a range of traditional and non-traditional machining / processing techniques.

www.mfg.mtu.edu/marc/primers
Explores machining techniques.

www.hse.gov.uk
Website of the Health and Safety Executive.

# Unit 8: Electronic Circuit Design and Construction

## Delivery guidance

### Approaching the unit

It is important that this unit is delivered using as much practical activity as possible, avoiding theory lessons that do not link directly to assignments.

### Delivering the learning aims

All learning aims can be covered through electronic design and make tasks, but it is essential to build in guaranteed success for learners in their work. All the learning aims are linked, especially B, C and D, and all could be covered through a single practical exercise. However, a more effective and enjoyable way of delivering the unit is through 'layered' learning. This is where a series of assignments become progressively more challenging as learners move from one to the next, building on their skills, knowledge and understanding of electronics.

The unit is designed to be taught using the systems approach to electronic design, i.e. input, process, output, and in this way learners will appreciate that complex circuitry can be broken down into simpler, understandable building blocks that are assembled creatively to achieve a designed outcome. For example, learners should be able to recognise and select a sensing potential divider, put this together with a processing block such as a Darlington pair and drive an output device such as a buzzer, creating a circuit based on a good understanding of selected input, process and output building blocks. Assignments designed to cover learning aims B, C and D cannot be achieved successfully without knowledge of learning aim A, but this should be taught through assignments, where learners use iterative and recursive processes, rather than as a separate activity.

For this unit learners must have access to appropriate materials, components and equipment, which will include all of the components listed in the unit content. Safety practices in the use of soldering processes are of paramount importance and this should be reinforced in all practical activities. This aspect of Unit 8 links directly to *Unit 3: Health and Safety in Engineering* and those learners studying both units should transfer information from one unit to the other.

Teaching the use of calculations to determine electronic values should be made relevant and should relate to assignment tasks to demonstrate their realistic application. For example, in a time delay circuit, learners should be able to calculate resistor values given the required time delay and capacitor values. As part of learning aim D learners should compare calculated values with real values and learn that components have tolerances which affect their value and that trial and error when fine tuning electronic circuitry is quite acceptable.

All learning outcomes should be taught in workshops or laboratories, but factory visits to manufacturing companies involved in electronic design and construction will dramatically enhance learners' experiences and will give them an opportunity to see how electronic products are produced on a commercial scale.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments and tasks in the specification.**

**Unit 8: Electronic Circuit Design and Construction**

**Introduction**

You could introduce this unit with a safety induction that includes a tour of the workshop facilities and a group discussion on health and safety. This could be followed by a brief outline of the scope of the unit and how it can be linked to other units.

**Learning aim A: Know about electronic systems design**

You could start with whole-group teaching, to:

- introduce learners to the electronics workshop/laboratories. For example, tour the workshop/laboratory examining potential risks and hazards, including PPE, handling and storage of components and parts.
- provide learners with a health and safety briefing relating to power supplies, cells and batteries, electrolytic capacitors and transistors.

Then, in small-group activities, you could:

- give learners the opportunity to demonstrate their knowledge of safety in an electronic workshop/laboratory. Learners could design a poster to be placed around various parts of the workshop/laboratory warning of potential hazards.

Through whole-group teaching, you could:

- explain the purpose and function of the different components from the range, which include input, process, output and passive
- investigate a range of power sources and the corresponding units of measurement
- demonstrate the use of formulae for simple and complex calculations related to electronic circuits.

Then, in small-group or individual activities, you could:

- identify individual electronic components – learners could be given a range of components to identify and categorise into the correct component types
- describe a range of components from each category – learners could use the internet to source relevant information about the function of each component and give a use for each
- investigate a range of power sources – learners could use manufacturers' catalogues to investigate a range of battery types, looking at aspects such as cost, voltage, and material
- carry out calculations relating to electronic circuits – learners could use the resistor colour code system to calculate simple resistor values or answer more complex calculations by working out the total resistance in a given parallel circuit.

**Assignment 1:** Using Electronics to Give Warning of a Temperature Increase in a Greenhouse

**Learning aim B: Design and construct electronic circuits using electronic building blocks**

Through whole-group teaching, you could:

- explain the representation of components on a circuit diagram
- demonstrate the appropriate use of software used to create electronic circuits, such as PCB Wizard, Bright Spark, Croc Clips and Circuit Wizard.

**Unit 8: Electronic Circuit Design and Construction**

Then, in small-group or individual activities, you could:

- identify individual electronic components – learners could be given a range of components to identify and categorise into the correct component types
- identify component symbols – learners could develop a series of cards with electronic circuit symbols on them and match them to the correct name on another card
- identify a range of components from a circuit diagram – learners could be given some simple electronic circuits that use a range of components, from which they can then identify each component used and any related values.

Through whole-group teaching, you could:

- describe the different types of circuit boards and explain how to interconnect components to form a complete circuit – this should include input and output connections and power supplies with the aid of component layout and circuit diagrams
- explain and demonstrate the construction of electronic circuits using PCB, including designing the layout of the components and interconnecting tracks and power supplies
- explain the construction of mass-produced electronic circuits such as surface mount technology
- demonstrate the correct use of soldering irons when soldering components onto stripboard.

Then, in small-group or individual activities, you could:

- construct simple electronic circuits using breadboards
- construct the same simple circuit using soldering irons on stripboard.

**Assignment 2:** Electronic Timer Design*

**Unit 8: Electronic Circuit Design and Construction**

**Learning aim C: Know how to populate circuit boards permanently and construct electronic circuits safely**

Through whole-group teaching, you could:

- provide learners with information relating to current legislation/regulations and risk assessments
- demonstrate the correct use of a soldering iron when soldering components onto a PCB.

Then, in small-group or individual activities, you could:

- give learners an activity on risk assessments. For example, place the learners in pairs to identify hazards and risks associated with processes used in the electronics workshop/laboratory.
- construct simple electronic circuits using soldering irons on PCBs
- give learners the opportunity to describe the main features of an electronic circuit – learners could take a photograph of a circuit they have produced and label the appropriate features
- ask learners to investigate different circuit construction techniques – learners could examine the advantages and disadvantages of each type.

**Assignment 3:** Designing a Permanent Circuit*

**Learning aim D: Test and evaluate electronic circuits**

Through whole-group teaching, you could:

- demonstrate the use of a range of circuit-testing devices to check voltage, continuity and current

| **Unit 8: Electronic Circuit Design and Construction** |
| --- |
| • demonstrate how to detect breaks and bridges in connections.<br>Then, in small-group or individual activities, you could:<br>• give learners an opportunity to test electronic circuits – learners could be given some simple circuits to test the voltage of current across named components or they could just check the circuit for continuity. |
| **Assignment 4:** Checking Circuit Function* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units / qualifications

This unit has practical and theory-based content relating to optional specialist units within BTEC Firsts in Engineering, including:

- *Unit 1 Topic A2: Electronic engineering processes*
- *Unit 3 Topic B2: Risks and risk assessment*
- *Unit 6 Topic A2: Circuit design techniques*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Award edition)*, Pearson Education, 2012 (ISBN 9781446905630)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

# Unit 9: Interpreting and Using Engineering Information

## Delivery guidance

### Approaching the unit

This unit will provide your learners with a formal introduction to the selection and use of a range of engineering information sources. You should show them a broad range of documents such as engineering drawings and other related documents, e.g. manufacturers' manuals, reference tables and production details. It is intended that the unit should be delivered in the order of the learning aims. You should begin by introducing learners to the typical range of information required to carry out specific tasks, such as the production plan for making a toolmaker's clamp, the way that engineering drawings are produced and used, and the information that they can convey with symbols and abbreviations. Learners should then use this understanding of the range of information available and apply it to specific engineering tasks. Typical tasks could include determining the material requirements for manufacturing a product such as material types and sizes.

The relevance of the unit to learners will be significantly enhanced if your centre is able to link-up with local industries including those from the aerospace, automotive, chemical, communications, bio-medical, mechanical and electrical/electronics sectors to obtain working examples of engineering data and documentation.

As far as possible, you should deliver the unit through practical application rather than theory. To achieve this look at opportunities to link the learning with other practical units in this qualification, for example, *Unit 4: Engineering Maintenance* and *Unit 8: Electronic Circuit Design and Construction*. The practical activities undertaken in these units could then provide a focus for the 'interpretation' required for learning aim A and the context for the learners 'own work output' related skills of learning aim B.

Learners will be assessed by taking an externally-marked, paper-based examination. You should ensure that learners are sufficiently prepared for the examination and that they are able to demonstrate the necessary knowledge and skills.

### Delivering the learning aims

The two learning outcomes logically follow one another and it would make sense to deliver them sequentially. In the first learning aim the learners will need to work towards recognising a range of engineering drawings and related documentation. This could be achieved with learners working in small groups to discuss the information conveyed in drawings and documentation and trying to work out their meaning before any formal teaching takes place. This should enable them to interpret drawing information such as materials, manufacturing details, symbols and abbreviations. This unit will also examine data sources relevant to engineering or manufacturing process operations. For example, learners could refer to tapping charts to determine the hole size or diameter required for an M6 thread or the colour code of a resistor having a value of 1000 ohms. Finally, learners will need to interpret a range of health and safety information that is relevant to the engineering environment and that will help them to identify safe working practices, particularly when performing practical tasks for this and other units of the course.

Once learners have the necessary knowledge and skills to interpret a range of engineering information they can be introduced to the second learning aim. Learners

will have the opportunity to put these new-found skills to the test by using production documentation related to their own work output. You should ensure learners have the opportunity to carry out practical activities that engage them with the unit content. This should include working to instructions, quality checking their own and others' work, and checking compliance with given standards and specifications. The centre could link an activity with local industry where learners can work to a customer brief such as manufacturing simple alarm circuits. The client specification would need to detail the requirements of the alarm, and learners would need to build the circuit from a set of working instructions and finally test their product at various points to ensure it will be successful. Learners will also learn to handle and care for engineering drawings and documentation in an approved manner. They should develop an understanding of storage systems using ICT and more traditional storage methods and the effects of damage or graffiti when interpreting documentation. Centres could provide learners with drawings that have been damaged whether from handwritten comments, tears across crucial component details or simply well-used ones which have engrained dirt. The learner will then be able to appreciate how difficult it can be to read and interpret drawings.


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## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

| **Unit 9: Interpreting and Using Engineering Information** |
|---|
| **Introduction**<br>Introduce this unit to learners by providing them with a range of engineering drawings, technical manuals and other documentation to examine. Discuss the various ways that they are used to assist in the manufacture of engineered products. An established link with local industry could provide learners with an opportunity to view such drawings and documentation. |
| **Learning aim A: Know how to interpret drawings and other documentation** |
| You could start with whole-group teaching to introduce learners to:<br>● the unit content, method of working and assessment<br>● the use of engineering drawings and related documentation – you could prepare engineering drawings, job cards and a specification to carry out the manufacture of a traditional workshop product such as an engineer's square.<br>● You could explain the methods and range of use of engineering drawings and related documentation in manufacturing and process operations.<br>Then, in small-group activities, you could get learners:<br>● to select a particular type of information on the engineering drawings provided, such as symbols, abbreviations, dimensional detail and material or component detail<br>● to give an initial interpretation to other learners about what drawing information means<br>● to present from a range of engineering related documentation and describe their relevance to the activity/task, e.g. looking at a car maintenance manual and how this helps an engineer to carry out the task of replacing a brake disc.<br>Through whole-group teaching, you could introduce learners to:<br>● different interpretation of engineering drawings<br>● considering the style and presentation of drawings and graphical representations and the information that they convey<br>● examining information related to materials or components – learners could be presented with a range of mechanical fasteners such as nuts, bolts and screws, then use the internet and manufacturers' catalogues to determine their size and specific product name details.<br>The whole group could also look at the detail of specific types of drawing and:<br>● examine a range of appropriate dimensional detail commonly used on engineering drawings<br>● examine the manufacturing/production detail required to perform engineering tasks<br>● consider appropriate symbols/abbreviations that engineers use when producing drawings and documentation.<br>Then, in small-group activities, you could get learners to:<br>● investigate given engineering drawings such as those used to manufacture traditional workshop tools and equipment<br>● present their findings through a short presentation to the rest of the class.<br>Through whole-group teaching you could:<br>● examine a range of reference charts, data sheets and books that will assist engineers in performing an engineering activity effectively. |

**Unit 9: Interpreting and Using Engineering Information**

Then, in small-group or individual activities, you could get learners to:

- interpret information from a range of engineering charts, e.g. calculate resistor values using the resistor colour-code systems
- calculate bend allowances for materials with a given thickness.

Through whole-group teaching, you could introduce learners to:

- a range of health-and-safety signs and the implications they have on engineering activities, such as wearing eye protection to allow safe operation of a milling machine, or wearing protective gloves to prevent burns when carrying out a welding operation.

Then, in small-group or individual activities, you could get learners to:

- tour the workshop environment, interpreting a range of signs and why they are required for certain activities, such as 'emergency stop button' signs to allow engineers to shut off machines when an accident occurs, or clear 'emergency exit' signs to allow personnel to evacuate a building if a fire breaks out.

**Learning aim B: Be able to use information from drawings and related documentation**

Through whole-group teaching, you could:

- introduce learners to the skills of using engineering drawings and related documentation to carry out and check own work such as thorough reading of all information before commencement of an activity, planning what steps to take and in which order and understanding the range of abbreviations and symbols to allow clear interpretation
- introduce learners to the advantages and disadvantages of using engineering drawings and related documents to carry out and check own work output, such as ensuring that products are made to customer requirements and that the time taken checking documentation ultimately decreases costs
- demonstrate the use of production drawings and associated documentation – learners could be given a Gantt chart to determine the production times and order of tasks to complete the manufacture of a wind turbine used to generate low voltage electricity
- arrange a guest speaker or visit local engineering organisations to look at, firsthand, how engineering documentation is used. The centre could then produce a customer brief that would allow learners the opportunity to develop products with real purpose such as brackets for shelving systems, simple door locks for toilet cubicles or storage devices for stationary products.

Then, in small-group activities, you could get learners to:

- investigate a manufacturing case study relating to guest speaker presentation or industrial visit.

Through whole-group teaching, you could get learners to:

- examine engineering documentation used for working instructions, production planning, scheduling for manufacture and quality control information.

Then, in small-group or individual activities, you could:

- get learners to use working instructions to perform an activity, e.g. use an instruction manual to assemble a product such as a barbecue or weightlifting bench
- present learners with production plans for a given engineering activity, e.g. small traditional workshop practical activities such as a tap wrench or toolmaker's clamp
- get learners to use information for scheduling manufacture, e.g. determine the critical path of an engineered product from given data
- present learners with quality control information for successful completion of a given task, e.g. use the information from a statistical process control chart to determine the relevant action for an engineering activity.

| **Unit 9: Interpreting and Using Engineering Information** |
|---|
| Through whole-group teaching, you could:<br>• examine document care and control used in engineering, discussing storage and security of documentation along with physical handling of drawings and document control.<br>Then, in small-group or individual activities, you could:<br>• get learners to compare the pros and cons of ICT storage systems with more traditional paper-based systems and present their findings in a short presentation<br>• present learners with opportunities to physically handle engineering drawings, e.g. drawings could have a number of discrepancies/damage/graffiti – learners need to identify the problems and what effect this has for the engineer when trying to use such drawings<br>• get learners to appreciate the need for document control, e.g. when producing drawings, documentation for other units of the course, ensure correct procedures are followed such as recording issue and amendment dates and report problems or discrepancies. |

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering:

- *Unit 2: Investigating an Engineered Product*
- *Unit 3: Health and Safety in Engineering*
- *Unit 4: Engineering Maintenance*
- *Unit 5: Engineering Materials*
- *Unit 6: Computer-aided Engineering*
- *Unit 7: Machining Techniques*
- *Unit 8: Electronic Circuit Design and Construction*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

These textbooks provide a wealth of information with regards to engineering drawing and related documentation.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

Gupta, B. and Raja Roy, M., *Engineering Drawing*, I K International, 2009 (ISBN 9789380026879)

Maguire, D., Phelps, N. and Simmons, C., *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards* (3rd edition), Butterworth-Heinemann, 2009 (ISBN 9780750689854)

Simmons, C., *Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards* (4th edition), Butterworth-Heinemann, 2012 (ISBN 9780080966526)

### Videos

www.youtube.com/channel/HCZWOfCRODR8k
This link provides a wealth of information including tutorials for the production of engineering drawings.

www.youtube.com/watch?v=8PhgPdmm2lk
This link provides a short video introducing the correct use of health-and-safety signage.

### Websites

www.hse.gov.uk
This site provides a wealth of information with regards to health and safety matters.

http://machineshop.olin.edu/resources/documents/Technical%20Drawing%20-%20Class%20Handout.pdf
This PDF provides detailed information with regards to the range of engineering information found on engineering drawings.

www.qualitytrainingportal.com/resources/spc/spc_control_charts_types.htm
This link provides information about the range of control charts and their interpretation.

www.roymech.co.uk/Useful_Tables/Drawing/Drawing.html
This website provides links to technical product specifications.

www.wisc-online.com/Objects/ViewObject.aspx?ID=eng16204
This website provides an interactive presentation about interpreting engineering information.


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# Unit 10: Mathematics for Engineering

## Delivery guidance

### Approaching the unit

This unit should be delivered in the context of mathematics being another useful tool in the toolkit of any engineer. At all levels of engineering, working with numbers and applying analytical techniques are essential tools, for example, calculating the distance between two holes or evaluating the landing forces in the undercarriage of an aircraft. All of the topics in this unit are intended to be taught and assessed using traditional paper-based techniques but where appropriate, do encourage your learners to check out what they have done using an Excel® spreadsheet, e.g. using graph plotting. The benefit of computer packages is that it is very easy to change values and re-plot quickly so that 'what if' scenarios can be checked. Do try the software package listed at the end of this guide; it is very easy to navigate and does provide lots of opportunity for your learners at all levels to develop and hone their skills whilst away from the classroom.

### Delivering the learning aims

Learning aim A is about encouraging your learners to investigate and develop basic arithmetic, algebraic and graphical techniques, all of which will be put to good use in other units within the programme. The aim is to build up the confidence of your learners when problem-solving and to encourage them to become proficient in the use of a scientific calculator. Whilst it is useful to be able to do mental arithmetic, at First level it is more important to explore and develop techniques, using the calculator to do the 'number-crunching'. Do ensure that any materials you develop are written in a relevant engineering context; within the unit content there are lots of examples for you to draw on.

Learning aim B leads your learners into the interesting world of mensuration and trigonometry; topics which engineers put to very good use. Where possible get your learners to extract data from simple engineering drawings when asking them to calculate, for example, the volume of a turned component. Or give them the component, tell them to take its dimensions and calculate its volume.

It is important that your learners use the correct layout and mathematical conventions when presenting their work. The aim is to present work which can be easily read and understood by a third party; laying out a page of analytical work should be treated with the same degree of rigour as writing a page of text. Being able to see how your learners arrived at a solution is crucial because if they misread numerical data when starting out on a solution you can still assess if they understand the analytical principles involved even if the final numerical value may be incorrect. Applying mathematical principles to the solution of problems should not be seen as a memory test and so it is perfectly acceptable for your learners to be given access to a formulae sheet when you feel it is appropriate.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

| **Unit 10: Mathematics for Engineering** |
|---|
| **Introduction**<br>You could introduce this unit to learners with a group discussion about why engineers need to be able to work with numbers and use mathematical techniques to solve engineering problems. You could then look at some simple examples such as working out the cost of machining a component or the velocity of a moving object. |
| **Learning aim A: Be able to use arithmetic, algebraic and graphical methods in engineering contexts** |
| You could start with whole-group teaching:<br>• introduce basic arithmetic methods and working with a scientific calculator, demonstrations using an interactive whiteboard<br>• introduce the concept of working with powers and roots of numbers and expressing large and small numbers using powers of 10, for example, $5.35 \times 10^{-3}$.<br>You could then give learners individual activities:<br>• with the aid of a calculator work out simple engineering calculations and write out solutions to an agreed standard<br>• perform simple checks, such as approximation, to check if numerical answers are correct.<br>You could then continue with further whole-group teaching:<br>• introduce how to work with engineering formulae and to produce accurate numerical answers; it is very important here to show the link to other units, such as electrical and mechanical science, by using the formulae which feature in these other units<br>• explain the importance of correct and logical presentation when writing out solutions, e.g. logical sequence of mathematical operations, readability, tidiness<br>• explain why engineers present data in graphical form, demonstrate how to plot a linear relationship and extract/interpret information from it<br>• present in graphical form examples of non-linear engineering relationships, e.g. the charging of an electrolytic capacitor.<br>You could then give learners individual or small-group activities:<br>• solve problems set in engineering contexts; there is a list of examples given in the unit specification, all of which have synergy with the units linking to this unit<br>• plot and interpret graphs based on engineering data, by hand initially but then using data tabulated in a spreadsheet so that 'what if' scenarios can be investigated<br>• investigate the mathematics support website detailed later in this guide. |
| **Assignment 1:** Arithmetic and Graphical Methods* |

**Unit 10: Mathematics for Engineering**

**Learning aim A: Be able to use arithmetic, algebraic and graphical methods in engineering contexts**

You could start with whole-group teaching:

- demonstrate how to transpose and solve linear engineering equations
- demonstrate how to evaluate simple engineering formula; select from the list given in the unit specification so that the link to other units is maintained.

You could then give learners individual or small-group activities:

- solve engineering problems by transposing and evaluating equations presented in work sheets
- check out own progress by taking the tests on the mathematics support website.

You could then follow up with further whole-group teaching:

- demonstrate how to transpose and solve linear complex engineering equations
- demonstrate how to solve complex engineering formulae; this will involve the use of chained calculations
- explain how to set out complex calculations and work with a calculator so that accuracy is maintained; it is important to encourage learners to set out all the steps in a calculation so that if they make any carry-through errors, these can be identified. What they must not do is perform the whole calculation on a calculator and then just write down the answer.

Learners could then carry out further individual or small-group activities:

- plan how to solve complex electrical, gas and mechanical formulae and then do this with the aid of a scientific calculator.

**Assignment 2:** Algebraic Methods*****

**Learning aim B: Be able to use mensuration and trigonometry in engineering contexts**

Through whole-group teaching:

- demonstrate how to calculate the areas of simple regular shapes using given formulae
- explain how compound shapes, such as the cross-section of an I-beam, can be broken down into simple regular shapes and their areas calculated; exemplar items manufactured from thin plate could be shown to learners
- explain additive and subtractive methods when working with compound shapes, for example, subtracting the area of a hole out into a rectangular plate.

Learners then carry out individual activities. They:

- sketch out, annotate and calculate the areas of a range of simple shapes
- extract dimensional data from drawings of compound shapes and calculate their areas.

You could then follow up with further whole-group teaching:

- demonstrate how to calculate the volumes of simple regular objects using given formulae
- explain how compound objects can be broken down into simple regular objects and their volumes calculated; manufactured exemplar items, such as a cylinder with conical end, could be shown to learners.

Learners then carry out individual activities:

- they could sketch out, annotate and calculate the volumes of a range of simple solid and hollow objects
- they could extract dimensional data from drawings of compound objects and calculate their volumes.

| **Unit 10: Mathematics for Engineering** |
|---|
| Through whole-group teaching:<br>• explain the use of Pythagoras' theorem to determine the side lengths of right-angled triangles<br>• explain the use of the trigonometric relationships as applied to right-angled triangles<br>• demonstrate how to calculate the parameters of right-angled triangles.<br>Learners could then carry out individual activities to:<br>• investigate the use of the 'sin', 'cos' and 'tan' buttons on a calculator<br>• sketch out, annotate and calculate the side lengths and internal angles of right-angled triangles.<br>You could then follow up with further whole-group teaching:<br>• demonstrate how a non-right-angled triangle can be split into right-angled triangles and solved<br>• demonstrate how the resultant of two forces acting at right angles can be calculated.<br>Learners could then carry out individual activities to:<br>• sketch out, annotate and calculate the side lengths and internal angles of non-right-angled triangles<br>• calculate the resultant of two forces acting at right angles.<br>You could then follow up with further whole-group teaching:<br>• demonstrate how trigonometry can be used to calculate the dimensions and angles of two-dimensional shapes made up from triangles, rectangles and squares.<br>Learners then carry out individual or small-group activities:<br>• sketch out, annotate and calculate the side lengths and internal angles of two-dimensional engineering structures. |
| **Assignment 3:** Mensuration* |
| **Assignment 4:** Trigonometry* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 7: Machining Techniques*
- *Unit 8: Electronic Circuit Design and Construction*
- *Unit 11: Electrical and Mechanical Science for Engineering*
- *Unit 16: Vehicle Electrical Systems*
- *Unit 18: Computer Numerical Control Programming*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Bird, J., *Basic Engineering Mathematics* (5th edition), Newnes, 2010 (ISBN 9781856176972)
Content is aimed at students taking Level 2 courses

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

### Websites

www.mathcentre.ac.uk
Free mathematics support materials for professionals and learners. Provides access to teaching materials, worksheets, learner teach yourself, learners test yourself and videos. The site is very easy to navigate.

# Unit 11: Electrical and Mechanical Science for Engineering

## Delivery guidance

### Approaching the unit

This unit should be delivered in the context of science being an essential tool for engineers to use when carrying out functions such as design and product testing. Wherever possible do set up demonstrations and give your learners the opportunity to back up the theory with hands-on experimentation. A significant amount of the problem-solving in this unit will require the application of the mathematical skills developed by your learners in *Unit 10: Mathematics for Engineering*. Do try to relate topic content to actual engineering situations so that learners can see the relevance of what they are studying. The experimental investigations that your learners will carry out are all very low risk and will require normal classroom supervision by yourself or a technician.

### Delivering the learning aims

To achieve learning aim A your learners will start by investigating the parameters of direct current and magnetic circuits; this should be done in a relatively short time so that the bulk of the effort goes into the practical aspects of this learning aim. Your learners will design very simple low-voltage electrical circuits, calculate their operating parameters and follow this up by building, testing and comparing values – a process which mirrors what happens in industry. The final part of the learning aim covers very basic electro-magnetic theory; it is the application of this theory to the operation-engineered products, such as relays and motors, which will make the topic interesting to your learners. Do show them actual products and animations; there are many open source demonstrations on the web.

Learning aim B focuses on mechanical science and, with the exception of the topic about parameters, all other topics lend themselves to a combination of theory and experimentation. You should explain to your learners that where graphical techniques are required to solve engineering problems hand-drawing is the best option because it is quick and relatively straightforward; for higher levels of accuracy analytical methods could be used and this is something for the future.

Some assessment and grading criteria are addressed through tasks involving diagrams/sketches and written text; it is perfectly acceptable for your learners to use graphics clipped from data sources (which must be acknowledged) provided that they are accompanied by the learner's own writing. Applying scientific principles to the solution of engineering problems should not be seen as a memory test; it is perfectly acceptable for your learners to be given access to a formulae sheet and data sources where you feel appropriate. It is important that your learners use correct layout when preparing solutions to tasks. The aim is to present work which can be easily read and understood by a third party; laying out a page of mathematical/graphical/diagrammatic work should be treated with the same degree of rigour as writing a page of text. Being able to see how your learners arrived at a solution is crucial because if they misread numerical data when starting out on a solution you can still assess whether they understand the principles involved given that the final numerical value may be incorrect.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 11: Electrical and Mechanical Science for Engineering**

**Introduction**

You could introduce this unit to learners by showing them images of the internal workings of a washing machine and discussing the components whose operation depend on the application of electrical and mechanical principles.

**Learning aim A: Know about concepts and principles relating to electrical science**

You could start with whole-group teaching:

- explain that many of the topics in this unit involve the use of equations and numbers when problem-solving; lots of the techniques investigated in *Unit 10: Mathematics for Engineering*, for example, graph-plotting, will be put into practice when working on this unit
- explain the use of diagrams to present information before starting on a calculation
- introduce parameters of direct current circuits and magnetic fields using an interactive whiteboard; this could take the form of an activity to match up parameter, description, SI unit
- introduce circuit diagrams, their function, layout, components and the use of circuit symbols; interactive activity to match components to their circuit symbols.

You could then give learners individual activities:

- hand-draw simple circuits which combine resistors in series and parallel configurations; to include a battery, switch, ammeter, voltmeter, lamp and fuse.

You could then continue with further whole-group teaching:

- demonstrate how to calculate the total resistance when resistors are connected in series and in parallel; also as combined series/parallel circuits
- explain how to use Ohm's law when solving circuit problems; calculations could be supported by circuit simulation using a software package which has virtual instruments, or by building circuits with real components and taking measurements with instruments.

Working in pairs learners could then undertake practical activities:

- using breadboards, combine resistors together and measure total resistances
- set up a simple circuit which has a variable resistor, vary the voltage and measure the current, plot out voltage and current to prove Ohm's law (this activity links nicely to *Unit 10: Mathematics for Engineering*)
- using the previously drawn circuits, calculate their parameters – voltages, currents, power
- construct the circuits on breadboards and take measurements of voltage and current, compare measured values with calculated ones
- set up the circuits using simulation software and take readings of voltage and current.

You could then continue with further whole-group teaching:

- introduce electro-magnetic theory and explain how products such as solenoids have their operating principles based upon it
- demonstrate how to calculate the force produced on a current-carrying conductor when it interacts with a magnetic field; then develop this theory to work out the torque produced by a simple DC motor.

**Unit 11: Electrical and Mechanical Science for Engineering**

Learners could then undertake a further practical activity if time allows:

- assemble a small permanent magnet DC electric motor from a kit
- run a small permanent magnet DC motor and measure the current it draws and the torque produced; the torque measuring could be done using a simple band brake
- dismantle the motor and measure the dimensions of the armature; then calculate the torque by referring to given values for the flux density and number of coils on the armature – compare with measured value by calculating the percentage difference, a technique covered in *Unit 10: Mathematics for Engineering*.

**Assignment 1:** Electricity and Magnetism*

**Learning aim B: Know about concepts and principles relating to mechanical science**

You could start with whole-group teaching:

- introduce the parameters of static and dynamic mechanical systems using an interactive whiteboard; this could take the form of an activity to match up parameter, description, SI unit
- explain how forces can be represented by vectors and why graphical methods are a good way to work with them
- demonstrate the use of graphical techniques to solve problems involving static forces, highlight the importance of using correct scale, direction arrows and labels.

You could then give learners individual activities:

- learners construct parallelograms and triangle of forces and from these identify resultant and equilibrant
- they could then go on to investigate a system of four forces by setting them up on a force board and constructing a polygon of forces; there is no requirement at level 1 or level 2 to confirm their results by an analytical (resolving) method.

You could then continue with further whole-group teaching:

- explain the principle of moments and how it is applied when considering the static equilibrium of a body.

You could then give learners an individual activity:

- investigate the static equilibrium of a body by considering the forces acting on it and the turning moments they produce.

**Assignment 2:** Static Mechanical Systems*

**Learning aim B: Know about concepts and principles relating to mechanical science**

You could start with whole-group teaching:

- explain the relationship between time, distance and speed, analytically, graphically and by simple experiment, for example, by timing the movement of an object between reference points
- explore the concepts of displacement and velocity as apposed to distance and speed; you could link back to earlier work done on vectors
- explain the relationship between time, velocity and acceleration
- introduce learners to the concept of limiting the coefficient of friction, work done and power.

You could then give learners individual or small-group activities:

- plot displacement/time and velocity/time graphs, measure gradients and establish parameters such as acceleration and retardation – this links well to topic A3 in *Unit 10: Mathematics for Engineering*

| **Unit 11: Electrical and Mechanical Science for Engineering** |
|---|
| • perform simple work done and power calculations for bodies moving at constant velocity on smooth horizontal surfaces.<br>You could then continue with further whole-group teaching:<br>• explain gauge and absolute pressure; simple demonstration using a pressure gauge which will read zero in the classroom even though all around is atmospheric pressure<br>• show how a simple U-tube manometer can be used to measure pressure – develop the formula for calculating pressure at depth in a liquid<br>• explain that the unit of pressure measurement (Pa) is very small; you could demonstrate this by sprinkling 100 g of salt over a $1m^2$ table top – then explain that because atmospheric pressure is approximately $10^5$ times bigger it is usually expressed in bar or MPa<br>• you could link to *Unit 17: Welding* topic A3 – gas bottles, regulators, gas pressures/flow rates.<br>You could then give learners individual or small-group activities:<br>• in a science laboratory measure the gas pressure using a U-tube and also a pressure gauge, calculate the U-tube pressure and compare with the value indicated on the gauge<br>• read off atmospheric pressure from a barometer and convert the calculated gas pressure to absolute pressure. |
| **Assignment 3:** Dynamic Mechanical Systems and Fluids* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 5: Engineering Materials*
- *Unit 10: Mathematics for Engineering*
- *Unit 13: Engineering Assembly*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Bird, J., *Science for Engineering,* Routledge, 2012 (ISBN 9780415517881)
A practical introduction, it assumes no prior knowledge of engineering.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book (Full edition)*, Pearson Education, 2013 (ISBN 9781446902431)

### Websites

www.yenka.com/en/Yenka_Basic_Circuits
Yenka Basic Circuits is a free product that lets you build and test circuits using basic electrical components.

# Unit 12: Engineering Design

## Delivery guidance

### Approaching the unit

You can deliver this unit using a largely portfolio-based approach which could be built up during the programme of study. In terms of designing assessments a single project, broken down into manageable steps, would allow learners to experience the whole design process from initial customer brief to final design solution. Learners should consider customer briefs and extract information from these briefs, in order to develop a product design specification (PDS). They will then use design techniques to propose designs that satisfy the requirements of the PDS. Finally, these proposals should be evaluated to develop a final design solution. To support this, you should give your learners the opportunity to access a range of resources including typical design specifications and examples of design proposals.

### Delivering the learning aims

Learning aim A focuses on the design process. Learners should be able to describe the internal and external factors that drive the design process and be able to put these factors into context when considering engineering products. The use of case studies, of innovative design products such as the Toyota Prius, will allow learners to demonstrate an understanding of the steps that go into a successful design. Organising a visit or inviting a guest speaker (such as an engineering designer or product engineer) from a local engineering company or manufacturing organisation, could help learners understand the processes involved in the development of new design ideas and/or the redesign of existing products.

Learning aim B allows learners to consider specific customer requirements that could appear in design briefs. Learners will be expected to study design briefs, in order to extract information from them and develop a specification. Typical examples might include case studies such as a small-scale wind-up radio or a solar-powered mobile phone charger. Learners can then produce a PDS for the product, using a template or an exemplar PDS that would be beneficial in guiding learners on the format of this kind of document.

Learning aim C gives learners an opportunity to be creative in the development of design ideas. Exercises on how design sketches and specifications are drawn up would be helpful, in developing the required skills to allow learners to prepare design solutions. Access to CAD systems might also prove beneficial although the use of CAD drawings, to present design proposals or solutions, is not an assessment requirement for this unit. Group work and open discussion will allow learners to develop an awareness of design ideas and alternative approaches. When developing design proposals team exercises will allow the development of alternative design solutions, with the team members then having to justify their individual designs before the final design solution is decided upon. Individual and group research activities also play their part in allowing learners to consider all elements of design and the design process.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 12: Engineering Design**

**Introduction**

You could introduce this unit to your learners with a group discussion on engineering design. This could be followed by a brief outline of the scope of the unit and how it could be linked to other units.

**Learning aim A: Know about the factors that influence the design of a new product**

You could start with whole-group teaching:

- describing, with the use of case studies, such as the Dyson vacuum cleaner or BMW Mini, the processes that take place which inform the design process and result in new designs being developed.

Using individual and small-group practical activities:

- learners could identify and give examples of the key internal factors that drive the design process. Considerations could include market research, or identifying a gap in the market and how this can prompt new designs to be developed. Similarly learners should think about how external factors, for example, changes in manufacturing technologies such as additive machining, can inspire new designs to be developed.

In whole-group teaching, you could then:

- provide an explanation and overview of these factors
- provide an explanation and comparison of how different products evolved, and about how decisions made at the design stage resulted in them being a commercial success or failure.

**Assignment 1:** The Design Process*

**Learning aim B: Be able to develop a product design specification (PDS) from a customer brief**

In whole-group teaching you could:

- outline the different sections of a typical PDS
- present an exemplar PDS
- present a case study of a typical customer brief such as a small-scale wind-up radio or a solar-powered mobile phone charger.

This could be followed by practical activities:

- in small groups, learners could extract the key information from the brief, such as the size requirements, the power generated by the solar cell or wind-up generator or the battery capacity; they could then use this information to develop the requirements for design and manufacture
- individually learners could research information required to allow them to complete the key elements of the PDS for the given product, listing size, shape colour, battery capacity, case materials etc.

You could follow this with group work.

- Small groups of learners could translate information gathered from research and consideration of the brief in order to fill out a given PDS template.

**Unit 12: Engineering Design**

**Learning aim C: Be able to prepare design proposals and design solutions that meet the requirements of a PDS**

Whole-group teaching:

- explain to learners the reason for clear design ideas and design sketches, introduce case studies of designs that have required a large number of design ideas before the final design emerged (e.g. Dyson vacuum cleaner, Apple iPhone, Shimano indexing gears for mountain bikes)
- present an example of an evaluation matrix or checklist that allows designs to be compared, by comparison with the specification requirements. Three different designs of can-opener could be ranked, for example, with grades or scores being based on factors such as ease of use or safety features
- introduce learners to design sketching by hand, drawing isometrically and orthogonally. Use of appropriate standards such as BS8888. Discuss annotation techniques such as balloon referencing and adding notes to sketches to explain principle of operation or design features.

Practical activities for a small group:

- mind-mapping, thought showers and other activities to promote creativity; flow diagrams can be useful, as can techniques such as Design for Manufacture and Assembly (DFMA)
- learners could consider an example PDS and each produce a design sketch that meets the given requirements
- learners could consider previously developed ideas. The individual sketches of each learner could be compared against defined criteria in order to develop a final preferred solution; this solution could be one of the learner's designs or a combination of several designs; once they have decided on a direction, they could develop this further to come up with a drawing or design of the proposed solution
- learners could use CAD software to generate final design solutions.

**Assignment 3:** Developing Design Solutions*

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with BTEC Firsts in Engineering:

- *Unit 1: The Engineered World*
- *Unit 6: Computer-aided Engineering*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produceendorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Mantovani, B. and Weatherill, B., *BTEC Level 2 First Engineering Student Book*, Pearson Education, 2010 (ISBN 9781846907234)
Written to support the previous version of the BTEC First but contains relevant information.

Cross, N., *Engineering Design Methods Strategies For Product Design* (4th edition), John Wiley, 2008 (ISBN 9780470519264)
A useful guide to the overall design process, this would be a useful resource for the teacher but there are practical examples, too, which could be used with learners in whole- or small-group sessions.

### Websites

www.technologystudent.com
This website has a range of useful resources, including explanations of design templates and product design concepts.

# Unit 13: Engineering Assembly

## Delivery guidance

### Approaching the unit

Delivery of this unit can concentrate on specialising in a particular area, such as assembling fluid power components and assemblies. However, a generic approach that covers a range of components and assemblies (mechanical, electrical/electronic, fluid power, pipework etc.) is more likely. You should determine the approach to take with your learners through an analysis of your learners' needs and, in particular, by considering the range of industries that your centre is working with or preparing your learners to work in. However, it is expected that the learners' experience should be sufficiently varied to provide them with the underpinning knowledge and skills needed to work with tools, equipment, measuring instruments, assembly methods and techniques in most industrial settings.

### Delivering the learning aims

The two learning outcomes logically follow one another and it would make sense to deliver them sequentially. The first learning aim will allow learners to begin to recognise a range of specific tools and their function and limits related to specific tasks, components and assemblies. This will also help retain a practical approach rather than spending too much time on theory. For example, a short introduction to a component, the function of the component within the larger assembly, the tools necessary to carry out the assembly task and their limits, together with any safety considerations, followed by practice.

Once learners have the necessary knowledge and skills to work with a sufficient range of tools, they can be introduced to the second learning aim. Learners will have the opportunity to put these new-found skills to the test by assembling a range of engineering equipment. This will include working to instructions, quality checking own/others' work, and checking compliance with given standards and specifications.

Achievement at merit and distinction levels will be demonstrated through the learner's independence when carrying out tasks as well as their use of evaluative skills. Therefore, it is important that development of these skills is encouraged during the delivery/learning phase. Formative assessment will play an important part in the learner's general development but especially their achievement of these higher level abilities. The ability to reflect and evaluate is also required at distinction level, and again formative work in the delivery phase will enable centres to encourage learners to consider how the assembly processes and techniques being applied could be improved. Although group work would not be appropriate for summative assessment, it would be reasonable for tools and equipment to be shared within a group of learners who are undertaking individual tasks.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 13: Engineering Assembly**

**Introduction**

You could introduce this unit with a safety induction that includes a tour of the workshop facilities and a group discussion on health and safety. This could be followed by a brief outline of the scope of the unit and how it links to other units.

**Learning aim A: Be able to check and use tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment**

You should start with whole-group teaching about the engineering equipment:

- introduce your learners to the workshop – for example, tour the workshop examining potential risks and hazards, including PPE, handling and storage of components and parts – identify a range of hand tools, equipment and measuring instruments
- provide your learners with a health and safety briefing relating to relevant assembly processes or electrical/mechanical equipment that is used in the workshop and may require servicing/maintenance
- discuss COSHH regulations
- explain the importance of working to job instructions, specifications and assembly drawings.

Then, in small-group activities with your learners, you could:

- give them the opportunity to demonstrate their knowledge of safety in the workshop
- design a poster to be placed around various parts of the workshop warning of potential hazards
- examine the most appropriate tools, equipment and measuring instruments for some equipment that requires assembling such as a mechanics' vice or parts of a car engine – your learners could devise ways of checking that tools, equipment and measuring instruments are fit for purpose.

Through whole-group teaching and practical workshop exercises, you could:

- introduce and explain the requirements of inspection
- produce a checklist of important inspection procedures
- explain the importance of quality checks – you could examine a range of techniques to check quality from given examples such as a fire extinguisher
- demonstrate the correct and safe procedures for carrying out quality checks such as ensuring the extinguisher is easily accessible, that the pressure is at the correct level, the nozzle is not hindered in any way, the pin and tamper seal are intact and the fire extinguisher is generally in a good state of repair, i.e. no leaks or corrosion
- carry out inspection on selected systems and components
- work in pairs to inspect a range of products/equipment such as fire extinguishers, smoke alarms or computer hardware
- use a range of tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment.

**Assignment 1:** Checking Assembled Engineering Equipment*

**Learning aim B: Be able to assemble components to engineering equipment**

Through whole-group teaching you could:

- identify a range of components that can be connected/fitted to engineering equipment – your learners could produce a chart linking components with appropriate pipework,

| **Unit 13: Engineering Assembly** |
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| electronic/electrical or fluid power engineering equipment<br>• explain the importance of working to set times – your learners could produce a bubble chart exploring this important factor<br>• examine service manuals/assembly instructions for a product such as a brake calliper, to ensure correct procedures are followed – your learners to interpret information and produce a plan to allow the assembly of a product to take place effectively.<br>Through whole-group teaching and practical workshop exercises, you could:<br>• introduce and explain the requirements of assembly, fitting and joining exercises<br>• examine a range of standards relating to specific assembly tasks such as those relating to the fire extinguisher<br>• demonstrate the practical assembly, fitting and joining techniques for a range of engineering equipment such as the assembly of a mechanics' vice<br>• explain specific system requirements<br>• explain the importance of customer feedback and coordinating with line managers and quality control teams – you could discuss the impact of quality and accuracy on production or maintenance of final product.<br>Individual learner activities:<br>• carry out a risk assessment of practical activities and prepare for and carry out assembly, fitting and joining exercise, including component removal/refitting, equipment strip and rebuild<br>• carry out two different assembly tasks on engineering equipment, such as a fire extinguisher and a working model of a wind turbine, using assembly instructions or working drawings<br>• investigate and carry out quality checks during and upon completion of the assembly tasks, with reference to specific standards, assembly instructions or customer requirements, such as ensuring components fit together or align correctly, and that parts and components are the correct size. |
| **Assignment 2:** Using Assembly Methods and Techniques* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 5: Engineering Materials*
- *Unit 7: Machining Techniques*
- *Unit 9: Interpreting and Using Engineering Information*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Tooley, M., *BTEC First Engineering*, Newnes, 2006 (ISBN 9781856176859)

### Websites

www.austinmemories.com/page62/page62.html
Website focusing on assembly and production of early cars.

http://auto.howstuffworks.com/under-the-hood/trends-innovations/car-assembling.htm
How Stuff Works website: assembling kits cars.

wwwme.nchu.edu.tw/~CIM/courses/Manufacturing%20Processes/Ch33-MechanicalAssembly-Tseng.pdf
PDF of a PowerPoint® presentation that examines a range of components and techniques for modern assembly of products.

www.stemnet.org.uk
Science, Technology, Engineering and Mathematics Network: has resources for science, technology, engineering and maths.

### Videos

www.youtube.com/watch?v=usnv9gB6RLU&feature=related
YouTube video showing how small parts and components are put together to make a line-following robot.

www.youtube.com/watch?v=hGRNhmtMAQw&feature=related
YouTube video looking at a combination of automated and manual assembly techniques at Audi.


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# Unit 14: Vehicle Engines and Other Systems

## Delivery guidance

### Approaching the unit

This unit can be delivered using a mix of theoretical and practical approaches. Learners should have access to appropriate resources such as vehicles and vehicle sub-systems; specifically engines, fuel systems, exhaust systems and ignition systems. This will allow them to understand and apply relevant theories and identify specific components, assemblies and configurations.

Learners should be given the opportunity to observe vehicle engines and associated systems in operation. However, in terms of practical investigation, bench work might be more appropriate as it would be beneficial if systems can be inspected whilst removed from vehicles, to both act as a teaching aid and to allow identification and inspection of individual parts.

### Delivering the learning aims

Learning aim A concentrates on engine components and assemblies and how they work together. Practical activities involving the use of components removed from vehicles, along with working models and video presentations will provide learners with the opportunity to understand how engines operate. In addition, workshop activities can be used to show how engine parts can be assembled on the bench. None of these activities need necessarily be carried out on vehicles, nonetheless it is anticipated that teachers will supervise learners closely and provide identification opportunities and simulations where appropriate. It is important that learners are able to indicate how components are assembled, and how sub-assemblies work together in vehicles, to generate power. The opportunity to work with individuals during practical investigation work can be used to good effect to underpin learning. In particular, it can be used to reinforce working principles and system operation.

Learning aim B focuses on vehicle ignition systems as well as engine fuel and exhaust systems. A range of different systems will be considered during the delivery of the unit, and centres should ensure sufficient coverage of the learning aims and content. All elements should be covered for assessment purposes, for example, where alternative fuels are considered, learners should describe all four of the fuel sources listed. This should be considered in the delivery strategy adopted by teachers.

Whilst learners should undertake practical investigations of components used in fuel, exhaust and ignition systems the detailed analysis of complex systems is not always necessary. Use of practical demonstrations of these systems, electronic resources using animations of fuel/ignition systems (incorporating self-assessment), display boards and training rigs will allow learners to gain an understanding of the principles of operation of these systems whilst still maintaining a practical approach.

In terms of assessment most of the evidence presented by learners will require descriptions of the different features of engines and associated systems. The main focus of assessment is therefore an understanding of the principles and parameters rather than the practical skills required to disassemble and assemble engines, fuel systems, ignition systems and exhaust systems.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 14: Vehicle Engines and Other Systems**

**Introduction**

You could introduce this unit to your learners with a whole-group presentation to familiarise learners with the requirements of the learning aims and how to approach each one effectively. An overview of vehicle engines and fuel systems, exhaust systems and ignition systems linked to practical demonstrations of each or video presentations for each could be used to show the part played in vehicle power systems and sub-systems.

**Learning aim A: Know about the fundamental operating principles of petrol and diesel internal combustion engines**

You could start with whole class teaching including:

- an overview of different petrol and diesel engines including exploded views or animations and asking learners to identify the different parts
- a health-and-safety briefing regarding working practices in the motor vehicle workshop.

Using paired or small-group activities:

- identify individual systems/components using artefacts, photographs, models etc. determining operation and function
- examine a study of a model engine and its operation indicating how each of the components operates and interacts with other components.

In whole-group teaching you could then:

- present a demonstration of the working principles of different engines.

**Assignment 1:** Introduction to Engines – Components and Sub-assemblies*

**Learning aim A: Know about the fundamental operating principles of petrol and diesel internal combustion engines**

You could start with whole class teaching including:

- an overview of cylinder layouts using different cylinder blocks, showing the different numbers of cylinders required
- demonstration of engine configuration and orientation using cylinder blocks, cutaway models, video presentations or practical simulations.

Using individual activities, your learners could:

- research the layout of a given petrol or diesel engine using web-based research or the manufacturer's manuals or handbooks. A variety of different engine types could be used with learners tasked to present an annotated illustration of the one they have been given indicating the number of cylinders and their orientation.

In whole-group teaching, you could then:

- present results of individual research activities for different engines comparing and contrasting the engine types and configurations.

**Assignment 2:** Engine Configuration, Orientation and Layout*

**Learning aim A: Know about the fundamental operating principles of petrol and diesel internal combustion engines**

You could start teaching with the whole group, using:

- animations of engine cycles using video or PowerPoint® presentations
- a model engine to facilitate a practical demonstration of engine parameters during the

| **Unit 14: Vehicle Engines and Other Systems** |
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| engine cycle.<br>Using paired or small-group activities, the learners could:<br>• identify the different engine operating cycles using a set of diagrams. These should then be placed in the correct order and labelled/annotated to indicate the stages of the cycle.<br>An individual activity for learners could:<br>• investigate operating cycles with the use of interactive software packages and incorporating self-assessment exercises. |
| **Assignment 3:** Engine Cycles* |
| **Learning aim B: Know about the function and operation of vehicle engine fuel, exhaust and ignition systems** |
| You could start with whole-group teaching and get learners to:<br>• review the fire triangle and show how fuel, air and ignition are supplied to an engine.<br>• outline the principle of operation of an exhaust system using a cutaway of an exhaust system (artefact or diagram) to demonstrate.<br>Using paired or small-group activities, each pair/group could:<br>• identify components of an exhaust system in a practical workshop activity.In an individual activity, learners could:<br>• using interactive software packages investigate fuel systems and incorporate self-assessment exercises.<br>Whole-group plenary:<br>• using PowerPoint® slides or animations, compare and contrast different fuel systems identified by learners from software tutorials. |
| **Assignment 4:** Fuel Systems* |
| **Learning aim B: Know about the function and operation of vehicle engine fuel, exhaust and ignition systems** |
| You could start with whole-group teaching and outline:<br>• the spark ignition combustion process using an animation/video clip<br>• the compression ignition process using an animation/video clip.<br>Using a small-group activity, each group should either:<br>• produce a poster/presentation showing the stages of the spark ignition process<br>• prepare a presentation showing the phases of combustion or<br>• prepare a presentation showing a typical ignition control system.<br>Whole-group plenary:<br>• compare and contrast the three different ignition systems presented by the different groups of learners. |
| **Assignment 5:** Spark and Control Systems and Combustion* |
| **Learning aim B: Know about the function and operation of vehicle engine fuel, exhaust and ignition systems** |
| You could start with whole-group teaching:<br>• outline the use of alternative fuel in modern engines, for example, the Nissan Leaf, Toyota Prius and/or Honda Clarity.<br>Using a small-group activity, each group should produce a poster explaining the use of:<br>• electricity as an alternative energy source for vehicles |

| **Unit 14: Vehicle Engines and Other Systems** |
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| • gas as an alternative energy source for vehicles<br>• hydrogen as an alternative energy source for vehicles<br>• biodiesel as an alternative energy source for vehicles.<br>Whole-group plenary:<br>• compare and contrast the four different fuel sources presented in the groups' posters. |
| **Assignment 6:** Alternative Fuels* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with BTEC Firsts in Engineering:

- *Unit 11: Electrical and Mechanical Science for Engineering*
- *Unit 13: Engineering Assembly*
- *Unit 20: Sustainable Vehicle Power and Structure Design*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Hammond, R., *Car Science,* Dorling Kindersley, 2008 (ISBN 9781405332002)
This book provides a light-hearted approach to complex theories in an easily accessible way. Includes lots of useful illustrations.

Parker, S., *How it Works: Cars, Trucks and Bikes,* Miles Kelly Publishing Ltd., 2009 (ISBN 978-1848101296)
Straightforward style with lots of cutaway drawings and useful illustrations. Although covering a range of topics there is useful content on engines and fuel, exhaust and ignition systems.

### Websites

www.howstuffworks.com
This website has a range of useful resources, including explanations and demonstrations of vehicle engine and related systems and components.

### Software

LJCreate

Autoinsight

These are software packages that incorporate onscreen assignments and self-assessment exercises. These are widely used in the engineering and automotive sectors to support underpinning knowledge in the classroom. There are many other software tools available and centres are encouraged to explore the range of options available.

### Training rigs

Block automotive – Engine Rigs
Typical of a range of commercially available training rigs which allow safe hands-on opportunities for fault finding and testing.

Haynes Combustion Engine
Model that learners can build, helping them understand how the engine and its components go together and how ignition timing works.

# Unit 15: Operating an Efficient Workplace

## Delivery guidance

### Approaching the unit

This unit could be delivered using a largely practical approach. It is likely that learners will have come across some of the principles outlined in this unit in their daily lives and being able to put this into an engineering/manufacturing context should be the initial focus. Learners will need access to an engineering workshop to carry out some of the activities and give context to the unit content.

The unit could be delivered though a combination of lectures, case studies, practical activities and group work. Learners should be given the opportunity to work together in groups, as many of the principles that underpin this unit such as 5S (Sort/Set/Shine/Standardise/Sustain) or 5C (Clear out/Configure/Clean and Check/Conformity/Custom and Practice) and standard operating procedures (SOPs) require teamwork and cooperation.

During the delivery of the unit, centres should ensure sufficient coverage of the learning aims and content. Examples are given in the content to give centres an idea of the typical range of applications that might be covered. For example, in the section on visual management, a range of problems with traditional reporting systems is indicated. For assessment purposes only two of these would need to be considered. However, it would be anticipated that learners will have the opportunity to consider more than two examples whilst being introduced to the principles.

### Delivering the learning aims

Learning aim A concentrates on 5S or 5C. Learners should be able to describe and carry out a 5S or 5C activity. When delivering this unit it is important that learners understand that these are two expressions used for the same principle and this should be initially explained. It is anticipated that, to avoid undue repetition and confusion, only one of the expressions, either 5S or 5C, is used thereafter.

Group work and open discussion will allow learners to develop an awareness of key principles. Visits to local manufacturing companies, along with videos will help learners understand how 5S or 5C is the cornerstone of workplace organisation and is used to aid efficiency and make for a more productive working environment. Group work is a key element of this unit, as learners will be working together to plan a 5S or 5C activity. This activity should be in a workshop environment and may require some preparation, by teachers, to ensure that learners can demonstrate all of the techniques required. Health and safety is of course a prime consideration and a risk assessment should be undertaken prior to any workshop-based practical activities taking place.

Learning aim B requires learners to develop an understanding of visual management and visual display. It would be useful to arrange a company visit where examples of visual management can be observed. Discussions with guest speakers from the company outlining why traditional methods do not work as well as the visual display systems in place could support this visit.

Learning aim C could be supported, in a similar way to learning aim B, with a company visit, allowing learners to see the benefits of standardised working practices and getting valuable input from representatives of the company on how efficiency is increased with the use of standardised jobs, line-balancing, PDCA etc.

Although the assessment of this unit could be facilitated using a series of discrete assignments the design of the unit lends itself to consideration of one working area. Consequently one project, broken down into individual elements, could be considered. Learners could describe and undertake a 5S or 5C activity for a given, or simulated, engineering/manufacturing procedure. This could be followed by a visual management display being prepared for the same procedure, supported by examples from a workplace visit or research activity. Finally, learners could produce a standard operating procedure (SOP) for the same engineering/manufacturing procedure describing the benefits of the SOP.

## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments in the specification.**

| **Unit 15: Operating an Efficient Workplace** |
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| **Introduction**<br>You could introduce this unit to your learners with a group discussion on the requirements for engineering and manufacture to demonstrate efficient operation in a competitive market place. This could be followed by a brief outline of the scope of the unit and how it could be linked to other units. |
| **Learning aim A: Know about the principles of the 5S or 5C process** |
| **Learning aim B: Plan and carry out a 5S or 5C activity** |
| **Learning aim C: Know about how methods of visual control are used and prepare a visual management display** |
| For learning aim A, you could start with a discussion of the principles of 5S or 5C and follow this with a workplace visit, with a company representative explaining the benefits of workplace organisation. Alternatively, use a presentation or case studydemonstrating the principles of 5S or 5C and indicating the effects on workplace organisation, reflecting on the efficiency before and after the 5S or 5C activity has taken place.<br>For learning aim B, using small-group practical activities, learners could:<br>• complete a class-based activity simulating the production of a simple assembly, such as a 3-pin plug, computer mouse or toy car, including preparing the work area with due consideration of health and safety and carrying out a 5S or 5C activity to improve efficiency.<br>In whole-group teaching you could then:<br>• evaluate the improvements made during the 5S or 5C activities and discuss how these improvements can be maintained.<br>For learning aim C, in whole-group teaching you could:<br>• introduce the principles of visual management, identifying examples of visual control and the process involved in preparing visual management displays.<br>Using paired and small-group activities, learners can:<br>• read a case study where traditional reporting systems have led to issues with the quality, efficiency and effective manufacture of engineering products, such as when learners simulate building 3-pin plugs or toy cars and the final quality check reveals issues<br>• collect data in order to prepare a visual display system.<br>*continued* |

| **Unit 15: Operating an Efficient Workplace** |
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| In whole-group teaching you could then:<br>• reflect on a previous workplace visit and input from company representatives, or use workplace or video evidence of examples of visual management to illustrate the importance of visual display and outline the types of planning methods used and techniques applied<br>• link visual management to 5S or 5C activities, and develop examples of how visual control is used in the workplace.<br>Using paired and small-group activities:<br>• prepare visual management displays using given data. Examples could include shadow boards for tools and equipment, colour coding maintenance activities based on urgency etc. |
| **Assignment 1:** Workplace audit* |
| **Learning aim D: Be able to produce a standard operating procedure (SOP)** |
| In whole-group teaching you could:<br>• outline the principles of standardising operations<br>• present an exemplar SOP such as assembling a model car, making a cup of tea or replacing a fuse in a plug.<br>This could be followed by practical activities:<br>• in small groups, learners could simulate manufacture of simple assemblies and develop SOPs to allow other learners to complete the same manufacturing operations. Examples such as assembling a computer mouse or a model car could be used.<br>You could follow this with whole-group teaching outlining:<br>• PDCA<br>• the use of standard operations sheets and work charts<br>• continuous improvement. |
| **Assignment 2:** New Standard Operating Procedures* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with BTEC Firsts in Engineering:

- *Unit 1: The Engineered World*
- *Unit 6: Computer-aided Engineering*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Mantovani, B. and Weatherhill, B., *BTEC Level 2 First Engineering Student Book*, Pearson Education, 2010 (ISBN 9781846907234)
Written to support the previous BTEC First but contains relevant information.

Plant, G., *Business Improvement Techniques: Level 2 NVQ Diploma* (1st edition), Benchmark Media UK Ltd, 2010 (ISBN 97809566-08505)
A useful overview of the key techniques designed for level 2 learners.

Peterson, J. and Smith, R., *The 5S Pocket Guide* (1st edition) Productivity Press, 1998 (ISBN 9780-527763381)
Although a little dated, this guide provides a valuable overview for teachers to gain an understanding of the key principles.

### Websites

www.graphicproducts.com/tutorials/five-s/index.php
Although a commercial website, the free tutorials provide a useful overview of the principles of 5S and lean manufacturing.

# Unit 16: Vehicle Electrical Systems

## Delivery guidance

### Approaching the unit

This unit could be delivered using a largely practical approach. Learners should have access to vehicle electrical systems in order to carry out tests and check performance. These systems can be demonstrated using purpose-built rigs and simulations. However, it is expected that learners will investigate real electrical systems on vehicles in order to fulfil the practical assessment evidence required.

### Delivering the learning aims

Learning aim A focuses on lighting and auxiliary electrical systems and their respective components. Practical activities involving the checking and testing of electrical systems and components should form the majority of delivery and it is anticipated that the majority of learning can take place using electrical training and simulation boards and/or utilising specific software. Although providing demonstrations will be useful, it is important that learners develop the ability to independently test and check electrical systems and components.

You should provide your learners with the opportunity to observe real vehicle lighting systems in operation. They should be allowed to activate and check all of the systems and categorise them appropriately. Visits to local garages that are vehicle auto electrical specialists could be used to help learners understand the use of diagnostic techniques when checking the performance of specific vehicle electrical systems.

You will need to supervise your learners closely when working in workshops or on vehicles, ensuring that appropriate risk assessments and health and safety procedures are in place.

In a similar manner to lighting systems, the opportunity to observe and activate auxiliary systems should be facilitated whether using an actual vehicle or purpose-built training rig. In the section on general systems, examples of electrical systems are identified. Whilst learners should be able to describe general systems, for assessment purposes, there is no requirement to cover all of the elements specified by the range.

For learners to be able to check the performance of a vehicle's lighting and auxiliary systems, it is important that they have access to the manufacturer's specifications in order to perform appropriate calculations. This may require assessors to simulate faults in the systems. If learners will be accessing the same vehicle, it would be useful to have a variety of different faults to ensure enough valid evidence can be generated.

Learning aim B requires learners to demonstrate an understanding of the working principles of lead acid batteries, alternators and starter motors. In addition, learners will undertake practical investigations of these components using bench-work activities that allow them to identify clearly the component parts and disassemble, assemble and test components. In order to facilitate these activities there needs to be safe removal of the components from vehicles and safe replacement as well as testing. These activities should be undertaken under close supervision with a focus on using appropriate personal protective equipment (PPE) and ensuring that appropriate risk assessments and health and safety procedures are in place. For

learners to carry out performance tests will require competence in the use of tools and measuring equipment such as test meters and analysers.

The opportunity to work with individuals during the delivery of this practical work can be actively used to underpin learning. In particular, it can be used to reinforce working practices and skills, help learners to deal with problems with the use of tools or equipment or support them when they need to work with others more effectively in order to achieve the task.


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## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 16: Vehicle Electrical Systems**

**Introduction**

You could introduce this unit to your learners with a whole-group presentation to familiarise learners with the requirements of the learning aims and how to approach each one effectively. An overview of vehicle electrical systems linked to a practical demonstration of the operation of each system using a demonstration vehicle or video presentation could be used to show the purpose of different electrical systems and components.

**Learning aim A: Be able to identify, describe and check the performance of vehicle lighting and auxiliary electrical systems and components**

You could start with whole-class teaching, including:

- an overview of the different statutory and non-statutory lighting systems and components
- a health and safety briefing regarding working practices in the motor vehicle workshop.

Using paired or small-group activities:

- research individual systems/components determining operation and whether they are statutory or non-statutory. For example, where is a reverse lamp located, what colour is it, how many are required, is it a statutory requirement to have one, how does it operate and how can it be checked
- each pair/group could feedback to the whole class the use of the lighting system and whether it is statutory or non-statutory.

In whole-group teaching you could then:

- present an overview of auxiliary electrical systems and components using artefacts, video clips and animations.

Individual activity:

- use of interactive software packages investigating electrical systems and incorporating self-assessment exercises.

**Assignment 1:** Vehicle Lighting and Auxiliary Electrical System and Components Understanding*

**Learning aim A: Be able to identify, describe and check the performance of vehicle lighting and auxiliary electrical systems and components**

You could start with whole-class teaching including:

- introduction to statutory requirements including levels of performance
- demonstrate the use of calculations and compare results with the manufacturer's specifications.

Using paired or small-group activities:

- use a simulator to identify and correct faults in lighting and auxiliary circuits
- learners could then use test equipment to carry out given tests, of lighting and auxiliary systems, on a vehicle. This activity should only be carried out under close supervision
- perform calculations based on test data collated, from the tests carried out on the vehicle, and compare results against expected values as specified by manufacturers data.

**Unit 16: Vehicle Electrical Systems**

**Assignment 2:** Vehicle Lighting and Auxiliary Electrical System and Components Testing*

**Learning aim B: Be able to confirm the correct function and operating principles of a vehicle's lead acid battery, alternator and starter motor safely**

You could start with the whole group:

- presenting an outline of electrical principles and units of measurement
- demonstrating the construction and operation of lead acid batteries using cutaway models, PowerPoint® slides etc.
- giving a health and safety briefing on the safe handling and testing of lead acid batteries.

In paired or small-group activities, each pair/group could:

- identify components of a lead acid battery using interactive software or annotating diagrams from directed research
- prepare a checklist for the safe handling of a lead acid battery
- remove and replace lead acid batteries from a vehicle in the workshop. This activity must take place under close supervision with appropriate use of PPE.

**Assignment 3:** Vehicle Charge and Start Systems – Batteries and Starter Motors*

**Learning aim B: Be able to confirm the correct function and operating principles of a vehicle's lead acid battery, alternator and starter motor safely**

You could start with the whole group:

- demonstrate the construction and operation of an alternator using, for example, animations, video simulations, cutaway models
- outline the operating principle and control procedures required for safe use of an alternator and issues surrounding faulty rectification
- give a health and safety briefing on the safe handling and testing of alternators.

Using paired or small-group activities, each pair/group could:

- identify components of an alternator using interactive software or annotate diagrams from directed research
- prepare a checklist for the safe handling of an alternator
- remove and replace an alternator from a vehicle in the workshop. This activity must take place under close supervision with appropriate use of PPE.

Each learner could:

- research issues surrounding alternator operation.

**Assignment 4:** Vehicle Charge and Start Systems – Alternators*

**Learning aim B: Be able to confirm the correct function and operating principles of a vehicle's lead acid battery, alternator and starter motor safely**

You could start with the whole group:

- demonstrating the construction and operation of a starter motor using animations, video simulations, cutaway models etc.
- giving a health and safety briefing on the handling and testing of starter motors.

Using paired or small-group activities, each pair/group could:

- identify components of a starter motor using interactive software or annotating diagrams from directed research

| **Unit 16: Vehicle Electrical Systems** |
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| • prepare a checklist for the safe handling of a starter motor<br>• remove and replace a starter motor from a vehicle. |
| **Assignment 5:** Vehicle Charge and Start Systems – Starter Motors* |
| **Learning aim B: Be able to confirm the correct function and operating principles of a vehicle's lead acid battery, alternator and starter motor safely** |
| You could start with whole-group teaching activities:<br>• demonstrating the test procedure used to check the functioning of batteries, starter motors and alternators<br>• health and safety briefing on the safe handling and testing/checking of batteries, starter motors and alternators<br>• demonstrating how test data from tests is interpreted in terms of fitness for purpose or necessity of repair or replacement.<br>You could then give learners individual activities:<br>• carry out tests on batteries, starter motors and alternators<br>• interpret results of tests in terms of fitness for purpose, necessity of repair/replacement. |
| **Assignment 6:** Vehicle Charge and Start Systems – Testing Vehicle Batteries, Alternators and Starter Systems* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with BTEC Firsts in Engineering:

- *Unit 8: Electronic Circuit Design and Construction*
- *Unit 11: Electrical and Mechanical Science for Engineering*
- *Unit 14: Vehicle Engines and Other Systems*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Martyn, R., *The Haynes Car Electrical Systems Manual*, J H Haynes & Co Ltd., 2006 (ISBN 978184425251-0)
A useful guide to the functioning of electrical systems on vehicles, whilst this would be a useful resource for the teacher there are practical examples which could be used with learners in whole- or small-group sessions.

Tracy, M., *How to Diagnose and Repair Automotive Electrical Systems (Motorbooks Workshop)*, Motorbooks International, 2005 (ISBN 9780760320990)
A useful guide to the diagnosis and repair of electrical systems on vehicles, whilst this would be a useful resource for the teacher there are practical examples for use with learners in whole- or small-group sessions.

### Software

LJCreate

Autoinsight

These are software packages that incorporate on screen assignments and self-assessment exercises. These are widely used in Engineering and Automotive to support underpinning knowledge in the classroom. There are many other software tools available and centres are encouraged to explore the range of options available.

### Training rigs

Block automotive – Self-wiring Auto Electrical Trainer SWET-001
Typical of a range of commercially available training rigs which allow safe hands-on opportunities for fault finding and testing.

### Websites

www.howstuffworks.com
This website has a range of useful resources, including explanations and demonstrations of vehicle electrical systems and components.

# Unit 17: Welding

## Delivery guidance

### Approaching the unit

This unit should be delivered using a largely practical approach and will require a significant amount of teaching time to be carried out in a workshop environment. In the time allocated to deliver the unit, it is not expected that your learners will become 'expert' welders. However, to meet the requirements of the assessment and grading criteria, they will be expected to show a reasonable degree of competence.

When delivering this unit there are health and safety implications and the level of supervision provided when your learners are carrying out practical tasks needs to be fully thought through. It is very important that where there are possible restrictions on physical resources, delivery is managed in a way that allows your learners to have full access to the practical tasks. Many of the assignment tasks that you set will require learner evidence to be supported by annotated photographs and observation records; learners should also be encouraged to keep logbook records of time spent in the workshop.

### Delivering the learning aims

To achieve learning aim A, your learners must be able to detail the main categories of the welding process and understand how they are carried out. When discussing processes it is important to have plenty of examples of welded joints to show them; these could be hardware samples or images. Most of this section of the unit can be delivered through discussion and its assessment should be done using tasks which require written evidence to be submitted. For the assessment and grading criteria which require your learners to select tools, equipment, information and consumables, they should present own writing rather than simply completing checklists.

For learning aim B, your learners will be based in a welding workshop where they can see demonstrations of welding techniques before putting them into practice themselves. It may be useful to show them video clips of the various techniques but the intention here is that they should be learning in a 'hands on' environment. Before performing the welding tasks for assessment purposes, learners will have carried out basic welding exercises in order to learn and improve their technique. It is not necessary for this formative work to be presented as evidence. Some of the criteria for this learning aim require welds to be produced to a required quality standard. As this standard is not detailed in the unit specification you can use your professional judgement to set your own. Typically, it will cover things like correct positioning, distortion, weld profile, burning of parent metal, spatter – perhaps issue your learners with an inspection checklist.

For learning aim C, learners need to know about and be able to carry out non-destructive and destructive tests on welded joints; ones that they have produced or joints which you have prepared with designed-in specific, identifiable faults. Your learners need to know about the range of tests available but for assessment purposes one from each category is all that is needed.

Activities should be planned to ensure that your learners are working safely and identifying risks and associated hazards as they prepare for assessment activities. These activities should allow them to work individually and in groups in order to build confidence.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 17: Welding**

**Introduction**

You could introduce this unit to learners with a discussion about why joining metals using heat fusion is an important and widely used fabrication process. You could explain the three basic steps to making a welded joint; preparation of materials and equipment, making the joint and inspecting the joint. Perhaps explain that although a lot of welding is done using automated systems, for example, fabricating car bodies, the basic principle is the same as that for manual welding – align, heat, fuse and cool.

**Learning aim A: Be able to prepare for work in a welding environment**

You could start with whole-group teaching:

- explain that a lot of the unit is assessed through practical activities that involve the use of procedures that are hazardous and that appropriate procedures must be followed in order to minimise risk
- identify the links between this unit and *Unit 3: Health and Safety in Engineering*
- overview the two process groups for welding metals – gas welding and electric welding.

You could then give learners an individual or small-group activity:

- investigate the main hazards and risks when welding metals and propose control measures; present findings as a short PowerPoint® to rest of group or produce a leaflet which could be given to someone starting work in a welding environment.

You could then continue with further whole-group teaching:

- describe the procedures to be followed when preparing for and setting up a gas welding process and an electric welding process; preparation of materials to be joined, consumables, equipment
- using exemplars (images or hardware), discuss why particular welding processes were chosen.

You could then give learners an activity to work in pairs or small groups:

- produce checklists of consumables, tools and equipment requirements for given fabrications using a gas welded joint (one learner does this) and an electric welded joint (another learner does this), pool findings.

You could then continue with a teacher-led whole-group discussion about the paired activities looking at:

- reasons for choosing the welding process, consumables, tools and equipment.

**Assignment 1:** Welding Processes*

**Learning aim B: Be able to safely produce welded joints to quality standards**

You could start with whole-group teaching/discussion:

- review the safety issues relating to working in a welding environment.

You could follow up with workshop based demonstrations:

- obtain and put on appropriate personal protective equipment (PPE)
- working from technical drawings prepare materials for welding; contamination check, cut to size, edge prepare
- safety check tools and equipment and then set up for a welding process; your learners should be shown gas welding and one type of electric welding

**Unit 17: Welding**

- position and restrain materials to be welded; consider differences for one-off and small batch production – fixtures rather than simple clamping
- weld materials – butt and fillet joints produced using different weld positions; your learners will watch the demonstration given by yourself or a technician, it will help if they are given checklists showing good and bad practice
- visually inspect welded joints and assess conformity; dimensional aspects, correct fusion and quality of finished product.

You could then give learners a paired practical activity.

- The starting point could be a drawing of the components to be fabricated; learners decide which is the best process to use, source PPE, materials and equipment, set up equipment, confirm with you that they understand the safety issues involved, edge prepare, make their welds and inspect the finished product.
- Your learners should not be expected to spend too much time preparing materials. It is probably best if they are given raw materials that are the right size and just require edge preparation. However, if they are involved with other practical activities, for example, manufacturing a toolbox, then welding might well be one of the fabrication processes they choose to use.

You could follow up with a whole-class discussion about the features which affect the quality of welded joints:

- present exemplars of 'good' and 'bad' joints; dimensional conformity and degree of fusion
- examine some of the joints which your learners have produced.

**Assignment 2:** Positional Welding and Visual Examination of Welds*

**Learning aim C: Be able to safely perform non-destructive and destructive tests on welded joints**

You could start with a whole-group discussion:

- covering the reasons why it is important to test welded joints
- review documented examples of welded joints which have failed in service and the consequences of this.

You could follow this up with a practical demonstration:

- a non-destructive test (for example, dye penetrant) and a destructive test (for example, a fracture test).

You could then give learners a paired practical activity:

- visual examination of joints; these could be the ones that your learners have produced but it may make the exercise more controlled if they are given ones which have easy-to-spot surface or internal defects designed into them
- for destructive testing carry out preparation such as cutting samples and surface preparation
- carry out non-destructive and destructive tests on welded joints and record the findings; annotated images would be a good way to do this.

**Assignment 3:** Testing Welded Joints*

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 1: The Engineered World*
- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Timings, R., *Fabrication and Welding Engineering,* Newnes, 2008 (ISBN 9780750666916)

### Websites

www.millerwelds.com/resources/video_library
The Miller video library contains short video clips of welding procedures.

www.youtube.com
There are a number of step-by-step welding videos on YouTube.

# Unit 18: Computer Numerical Control Programming

## Delivery guidance

### Approaching the unit

This unit could be delivered using a largely practical approach. Learners should have access to computers with appropriate CNC software and CNC machining facilities in order to run programs and produce workpieces. As it is likely that learners will have access to an engineering workshop to carry out some of the CNC activities, appropriate risk assessments and health and safety considerations should be considered.

Learners should be given the opportunity to observe CNC machines in operation and visits to local industry to observe the process, from programming to workpiece production, would provide a useful introduction. Video evidence and workshop demonstrations would also allow learners to develop an understanding of the principles.

### Delivering the learning aims

For learning aim A, learners should be able to outline and compare the use of different CNC machines. Learners should have access to CNC machines, however additional research activities may be required to cover the range in the specification. It is important that learners should understand the capabilities of CNC machines for a range of production processes.

For learning aim B practical activities involving the use of designs, drawings, specifications and components should allow learners to develop an understanding of the material and tooling requirements as well as the appropriate CNC machine to use in developing a workpiece. By producing plans for production of given components, an understanding of the whole production process can be developed in learners.

Learning aim C can be supported by activities that allow learners to write and develop simple and then increasingly more complex part-programs. Access to an appropriate CNC set-up, with a computer system using software that allows CNC code to be generated and edited for drawings/instructions/specifications, will be required and this or other software/hardware should be used to simulate part production prior to actual production. In the section on working safely, a range of examples of risks and control measures is identified. Whilst this consideration is required for assessment purposes, in terms of safe use of CNC machines, there is no requirement to cover all of the elements specified by the range.

Before learners are allowed to use machines independently, health-and-safety briefings and risk assessments should be carried out to ensure that they can load and run programs safely. Learners should be able to demonstrate appropriate use of personal protective equipment (PPE) and that they can undertake appropriate audits that include identifying hazards, control measures and those at risk.

Once learners have produced, edited and checked programs, they should then be given the opportunity to access CNC machines to produce components. Demonstrations of sample parts being manufactured, from given instructions and programs, allows learners to understand the process and could support learning. Similarly learners should understand that programs can be used in a variety of ways

with different techniques to transfer, save, load and run them in engineering environments depending upon the machines available.

Learning aim D requires that learners should have the opportunity to use proofreading procedures for CNC programs. This might best be achieved by demonstration and close supervision, allowing learners to practice on given CNC programs with known errors, for example. Before, during and after production of workpieces, learners should be given the opportunity to use appropriate measuring techniques and instruments to allow them to check the conformity of parts against a given specification or drawing. Example parts and specifications/drawings, along with individual instruction on the use of measuring devices, would be helpful in building confidence in learners that they are using the correct techniques.


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## Getting started

**This provides you with a starting place for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 18: Computer Numerical Control Programming**

**Introduction**

You could introduce this unit to your learners with a whole-group presentation to familiarise learners with the requirements of the learning aims and how to approach each one effectively. An overview of CNC linked to a visit or video presentation could be used to show the process from design to production.

**Learning aim A: Know about the types of CNC machines and their uses**

**Learning aim B: Be able to create a production plan for a CNC machine using a product specification**

**Learning aim C: Be able to write a part program and safely demonstrate its use for the manufacture of a product or component on a CNC machine**

For learning aim A, you could start with a presentation or workshop demonstration to your learners:

- outlining the operation of two typical CNC machines, for example, the use of a machining centre and a 2-axis CNC lathe to produce a hollow screwdriver handle
- comparing them with more traditional machines in the workshop such as a capstan lathe, pillar drill or vertical milling machine.

If limited workshop facilities are available visits to local companies or video presentation could be substituted.

Using paired or small-group activities, each pair/group could:

- research a CNC machine from the range of machines given in the specification using web-based resources
- feedback to the whole class the use of the machine they have researched, comparing it with a traditional machine that performs the same function.

For learning aim B, in whole-group teaching you could then demonstrate:

- how a product specification is used to identify key criteria for the production of given components such as a plumb bob or nut and bolt
- how a production plan is generated from a product specification.

Using paired and small-group activities, each pair/group could:

- complete production plans for the manufacture of components from a given product specification.

For learning aim C's topic C1, in whole-group teaching you could demonstrate:

- how a straightforward part program is generated from a production plan
- how additional elements are added to a straightforward part program increasing its complexity.

Using paired and small-group activities:

- generate straightforward and complex part programs from given specifications for example, a key fob incorporating a simple logo or a nut (and then a bolt).

**Assignment 1:** Using Product Specifications to Write Part Programs

**Learning aim C: Be able to write a part program and safely demonstrate its use for the manufacture of a product or component on a CNC machine**

**For learning aim C's** topics C2/C3, in whole-group teaching you could demonstrate:

| **Unit 18: Computer Numerical Control Programming** |
|---|
| • how part programs are loaded, stored, retrieved, transferred<br>• the running of a CNC part program to produce a given part.<br>This could be followed by appropriate health and safety training and activities followed by individual practical activities:<br>• individually learners could risk assess their work area then load, transfer, store and retrieve part programs and use them to safely manufacture a given part under supervision, using part programs they have created – for example, a key fob incorporating a simple logo. |
| **Assignment 2:** Safely Running Part Programs on a CNC Machine* |
| **Learning aim D: Be able to carry out a proofreading procedure for a CNC program and check conformity of a manufactured product or component to its specification** |
| In whole-group teaching you could:<br>• demonstrate the use of simulation graphing software using an exemplar part program<br>• demonstrate how proofreading CNC part programs can identify errors, (such as where the tool will break through the side of a part) or omissions (such as missing holes or threads).<br>This could be followed by practical activities:<br>• in small groups, learners check given part programs identifying errors, faults or omissions<br>• use simulation/graphing software to simulate part production.<br>You could follow this with whole-group teaching to:demonstrate the use of measuring equipment to check finished components meet specification.<br>This could be followed by practical activities:<br>• using given objects (such as a plumb bob or valve guide) and engineering drawings, learners can use a range of measuring equipment taking direct measurements to check for conformity to specification. |
| **Assignment 3:** Checking Conformity and Proofreading CNC Program* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Engineering maintenance is essential to all engineering activities. This unit links with BTEC Firsts in Engineering:

- *Unit 6: Computer-aided Engineering*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 7: Machining Techniques*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Evans, K., *Programming of CNC Machines Student Workbook* (3rd edition), Industrial Press Inc., 2007 (ISBN 9780831133160)
A useful guide for teachers, with guidance on CNC theory and practice.

### Websites

www.technologystudent.com
This website has a range of useful resources including comprehensive CNC resources.

# Unit 19: Bicycle Servicing and Maintenance

## Delivery guidance

### Approaching the unit

This is a practical unit where learners will gain hands-on experience of maintaining a range of different types of bicycle, gain knowledge of the components and systems that are used in bicycles, and apply systems which will ensure that the bicycles are safe to use.

It would assist learners in their understanding of the different types of bicycle available if they were able to have access to a range of bicycles, such as off-road, touring, children's and BMX. Where possible, it may be a good idea to investigate the types of bicycle which learners are more familiar with in the first instance.

It would be beneficial to learners if they could experience at first-hand the activities performed by specialist bicycle technicians. To address this, a partnership with a local specialist bicycle shop or manufacturer would be appropriate.

### Delivering the learning aims

For learning aim A, learners should be able to demonstrate knowledge of, and be able to classify and understand the purpose of a range of different types of bicycle including: road bicycles, off-road and mountain bicycles, freestyle bicycles and city bicycles. It is important that learners know about typical examples of each of these groups, such as racing, cyclocross and touring bikes as examples of road bicycles. You could ask learners to investigate the types of bicycles which they themselves use, or are used by members of their family. This would allow them to become familiar with the typical uses of these. Learners should also know about the parts which combine to make a bicycle including the frameset, the drivetrain, the saddle and seatpost, the steering and braking mechanisms, the wheelsets and also the suspension systems in mountain bikes. To address this, learners could perform a practical task to disassemble a bicycle, logging the different tools and equipment used to complete the task. To further develop this understanding, learners could watch videos of the production of bicycles such as the folding cycles produced by Brompton Bikes.

Learners need to be aware of a range of key features associated with the parts of the bicycle, as detailed in the specification. They should know about the materials used and the durability of these materials. The cost implications and physical characteristics of components available in high street shops compared to specialist suppliers should also be considered. This could take the form of comparisons of materials used for bicycles sold in shops such as Halfords, Toys R Us and Decathlon, to those available from specialists such as Evans Cycles. Learners will need to think about the target user for the cycles, and how this influences materials, processes and costs. They could consider these with respect to carbon fibre and steel frames. Learners should be able to compare the similarities of the products, but also identify the features that set the high end products apart from those on sale in supermarkets.

To address learning aim B, learners will need to have access to a range of different types of bicycles with differing maintenance needs. This should include at least one road bicycle and one mountain bicycle. To introduce the topic, the use of a 'Tour de France' roadside wheel change or other service activity could be used to explain to learners that maintenance does not necessarily need to take place in a workshop environment.

To complete this learning aim, learners will need to be able to show that they are able to follow procedures and work safely to perform pre-ride checks and also full safety checks. Learners should be able to demonstrate the practical skills required in order to complete a range of checks on the bicycles, and be able to identify and make any adjustment in order that the user can ride the bicycle safely. Learners will also have to show that they are able to check that all aspects of a bicycle are safe to use and in good working order, such as ensuring that tyres have a good tread, are free from cracks and holes, and that they are inflated to the correct pressure. This could be done initially by providing learners with a checklist of the various parts of the bicycle (as listed in the specification) that need to be inspected for a full bicycle safety check. They could then inspect the cycle before discussing each part in turn.

For learning aim B, learners also need to prove that they are able to work safely while carrying out bicycle servicing and maintenance procedures. To do this they will be expected to devise their own risk assessments, using the Health and Safety Executive guidance, for the process they are to follow. They should use the document 'Five Steps to Risk Assessment' to do this. Learners will need to record their findings and be prepared to share them with others in the group.

In addition, learners will need to have a good understanding of the tools and equipment needed to service a range of different types of bicycle. Learners will need to have access to specialist tools, including tyre levers, lockring wrenches and sprocket removal tools. (A comprehensive list of tools is included in the specification.) In addition, they should be able to use more general workshop tools such as torque wrenches and hex keys. To meet the requirements of this learning aim, learners will need to complete a range of basic servicing and maintenance procedures on bicycles. They should have experience of tyre removal and installation, chain installation and brake servicing. This should take the form of teacher demonstrations initially, followed by practical activities performed by learners servicing the various aspects of the bicycle. Learners will need to be able to adjust the derailleur systems on the transmission system, and be able to remove and reinstall the cassette and freewheel. Learners should be given the opportunity to perform advanced servicing procedures which address problems associated with the chainline such as gear-shift problems, excessive noise and loose cranks. Learners will also need to be able to demonstrate that they can service a threadless headset.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 19: Bicycle Servicing and Maintenance**

**Introduction**

You could introduce this unit by providing learners with the opportunity to gain experience of working with a range of different types of bicycle. This can be done by using video clips of racing cycles, off-road cycles and other types in use, and also by inspection of actual bicycles, as well as the tools and equipment required to make sure that maintenance is completed safely.

**Learning aim A: Know about different types, component parts and key features of bicycles**

With your learners, you will need to look at a range of different bicycles:

- to examine and investigate road, off-road, freestyle and city bicycles
- discuss with the group the different purposes these bicycles have been designed for.

Ask learners to select one bicycle from each of the groups (road, off-road, freestyle and city). Discuss as a group the general features which are common to these groups of bicycles (e.g. chunky tyres for off-road bicycles).

- Develop a range of criteria within the group which learners can use to compare and contrast the typical use, purposes and users of bicycles from the four general classifications.

Allow learners to select one bicycle from two of the different classifications of bicycle. Using these bicycles, they should investigate the different systems present on each one:

- explain the key features, such as the cost of the item, the materials used for the manufacture, the functional properties such as weight, and the durability of the item
- evaluate the components from the two bicycles which they studied, considering whether they are fit for purpose for the bicycle to which they are fitted.

**Assignment 1:** Introduction to Bicycles*

**Learning aim B: Be able to carry out checking, servicing and maintenance procedures on bicycles safely**

To complete learning aim B learners will need to have access to two different bicycles, one for the pre-ride check and another for the full safety check activity. To prepare for these activities, learners will need to perform risk assessments of the operations they are going to perform. Learners should be able to:

- draw on their prior experience of identifying health and safety issues from Unit 1 and Unit 3
- undertake practical work in order to perform a detailed risk assessment which should include control measures, advice on the use of PPE, persons at risk and reviews following completion of the activity
- perform safety checks on at least one road bicycle and one all-terrain bicycle
- demonstrate the skills required to safely complete checks on the wheels, brakes, saddle, handlebars and transmission for the pre-ride 'M check'. It is appropriate to introduce some faults such as misaligned brakes or loose saddle in order for learners to obtain the evidence which they need.

**Unit 19: Bicycle Servicing and Maintenance**

For learners to complete the full bicycle safety check they will need to:

- ensure that the handlebars are correctly adjusted and safe to use
- check the steering system performs correctly without wobbles
- check brake and gear levers are secure and in good condition
- check that wheel hubs do not wobble, and turn smoothly
- ensure that both the front and rear derailleur systems are properly adjusted, lubricated and fitted securely
- check the frame and wheels are true and undamaged
- test that the brake system performs correctly and any wear is not excessive
- check that wheels are true, with no missing or broken spokes
- make sure tyres have a good tread and no signs of cracking
- check the condition and height of the saddle
- make sure the bottom bracket has no wobble and turns smoothly, that the pedal cranks are straight, and that pedals are fixed firmly, undamaged and turn freely
- ensure the chain is not too worn, slack or rusty, and is lightly oiled
- check the chainwheel has no worn teeth and is not bent
- check that all peripherals such as lights, racks and mudguards are fixed securely.

In order to correct faults and make adjustments, learners will need to have access to bicycles that you have 'rigged' by introducing faults for them to identify and rectify. It would be appropriate for the faults to be of varying degrees of severity, requiring a range of different tools to be used to complete the task. Appropriate faults include misalignment of brake blocks, a loose headset or seat, and repairing a puncture.

**Learning aim B: Be able to carry out checking, servicing and maintenance procedures on bicycles safely**

Learners should be given the opportunity to carry out two basic servicing and maintenance procedures, such as:

- removing and installing tyres and inner tubes
- replacing the chain
- servicing the brakes on the bicycle, including side-pull systems, V-brake systems, cantilever systems and hydraulic systems on mountain bicycles.

These activities would generally be undertaken using main tools and non-specialist tools.

Once learners have achieved these servicing activities safely and to an acceptable degree of accuracy, they should be able to perform procedures such as:

- adjusting the derailleur systems (both front and rear)
- removing and replacing the cassette and freewheel.

Further advanced maintenance and servicing procedures include:

- troubleshooting a noisy or creaky drivetrain, taking into account loose components in the drivetrain (such as cranks, chainwheel and/or bottom bracket), dry chain/derailleur, creaking wheels and spokes and other component parts of the bicycle
- chainline and shifting issues to make sure the chainline is effective from the rear cogs to the front rings, the position of the front chainring, and length of bottom bracket along with the chainline from the rear hub
- servicing a threadless headset, including removal, reinstallation and reassembly.

These activities would generally be undertaken using a range of specialist tools and equipment, which should be available for them to use.

| **Unit 19: Bicycle Servicing and Maintenance** |
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| To do this, learners will need to have access to a range of specialist tools and bicycles which have some safety faults. Learners will need to show that they are able to perform these checks thoroughly and safely, and be able to identify and rectify faults which occur in bicycles, such as misalignment of the derailleur gear system. Learners will need to:<br>● demonstrate that they are able to work safely, especially while performing maintenance activities using solvents and lubricants<br>● demonstrate they can use personal protective equipment correctly and appropriately as identified in their own risk assessments<br>● maintain their work area to make sure it is clean and tidy<br>● keep a record of changes which they think may improve their working procedures.<br>Evidence for this learning aim should be provided in the form of both witness statements and observation records, although these are instances where a formal assessment could be more appropriate. |
| **Assignment 2:** Bicycle Safety Checking, Servicing and Maintenance* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Unit 19 has direct links to units in the BTEC Firsts in Engineering where maintenance activities and risk assessments are studied:

- *Unit 2: Investigating an Engineered Product*
- *Unit 4: Engineering Maintenance.*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C., Watkins, N., *BTEC Level 2 First Engineering Student Book*, Pearson Education, 2012 (ISBN 9781446902431) (units 2 and 4)

Storey, M., *The Bike Book – Complete Bicycle Maintenance,* Haynes, 2012 (ISBN 9780857331182)
Includes step-by-step guides for maintenance procedures and methods to select bicycles for users.

### Journals

HSE *Five Steps to Risk Assessment* INDG163
Guidance on how to perform risk assessments.

### Websites

www.bikeradar.com
Information about different types of bicycles.

www.ctc.org.uk
Cycle touring club, information about bicycles and maintenance.

# Unit 20: Sustainable Vehicle Power and Structure Design

## Delivery guidance

### Approaching the unit

This unit is designed to allow learners to become more aware of the various new technologies which have been developed for use in motor vehicles, and gives them the opportunity to complete work which is both theoretical and also practical. When delivering this unit, you could use a wide range of activities, including group activities, to design and make a model racing car, group discussions concerning the merits of environmentally friendly cars, and individual learner work researching and presenting ideas and information.

This unit offers a lot of scope for learners to investigate aspects of vehicle design and then apply this knowledge in the design of their own electrically powered cars.

### Delivering the learning aims

For learning aim A you could initially divide learners into smaller groups to investigate different power sources used in modern vehicles, perhaps allocating one type of sustainable power supply to each group, then getting them to present their findings back to the whole group. Learners should be encouraged to investigate and evaluate the use of these alternative power supplies in actual vehicles, perhaps comparing the performance of an electrically powered city car to that of a fuel cell powered city car.

Learners will need to investigate the advantages and disadvantages of a range of methods of control for electric motors. This could be done through practical tasks where the traditional switch controllers are compared to alternative methods using field effect transistors (FETs), pulse width modulation (PWM) or computer control software. Encourage your learners to consider the viability of these options for use in vehicles.

For the final part of learning aim A, learners should be encouraged to investigate the different methods of storing electricity in batteries, as well as the methods in which electricity can be generated from hydrogen fuel cells and other alternative sources. The investigation should also consider the environmental benefits of these power sources and their effectiveness as methods of providing energy for vehicles. This could consist of a short report which considers the range, emissions, refuelling time and number of passengers which can be carried for battery-powered cars, fuel-cell-powered cars, diesel or petrol-electric hybrids, eco-diesel and eco-petrol cars, and conventional petrol cars.

To address learning aim B, learners need to be able to gain a good understanding of the three main types of vehicle construction, chassis and body, monocoque and space frame. In order to do this, they should have access to reference books, the internet and video clips. They should be able to identify the typical characteristics of each type of construction, and the typical applications of each. A starting point could be to show learners examples of coach-built vehicles such as a Morgan sports car which has an aluminium chassis and ash-framed body, a typical city car and a car with a space frame such as an Aerial Atom.

Learners should be guided as to where to research for the materials which are used in vehicle construction, including the uses of a range of polymers, metals and composites. Learners will need to show that they are able to identify the

manufacturing processes used to produce various aspects of the vehicles, and justify why these materials and processes are used in a range of different types of vehicle.

For learning aim C, learners are expected to work in small groups to design and manufacture a model of a car with a chassis and body construction. The car should be designed to run on a self-assembly vehicle track and be powered by electricity.

You could provide learners with an unlimited range of materials, although in reality the materials made available to the learners should be appropriate for the manufacturing processes available in the centre. Typically materials for the construction of the chassis could be aluminium or mild steel sections, with bodywork being constructed from GRP or sheet material such as HIPS or aluminium. It would be good practice to limit the time available to learners to complete the manufacture of their chassis and body in order to make sure that the cars they design continue to be realistic designs. Learners may need to use a range of methods to construct their vehicles, such as welding to construct the chassis and laying-up of GRP to produce the body. At all times learners should work safely and work to risk assessments which they have undertaken.

On completion of their vehicles, learners should consider the effectiveness of their design, not only in terms of its functionality, but also with regard to the materials used, areas of improvement and the cost implications which may be incurred if they were to make several of their designs.

When delivering learning aim D, it may be appropriate to combine this with learning aim B. To introduce the topic it would be useful to show learners a video of crash testing being completed on cars which meet current safety standards, and also ones that fail. From these videos the concepts of compression, tension, torsion and shear forces can be developed with learners producing their own notes to describe the differences between them. From the understanding of these forces, learners can be introduced to the concepts of crumple zones, roll cages and other safety features incorporated into modern road cars.

It will benefit the understanding of learners if they can have experience of observing a full Euro NCAP safety test, this would be appropriate through the use of video or the Euro NCAP website. This will not only improve their understanding of the types of test which can be carried out on cars, but also the role of crash test dummies in evaluating how passengers are protected by the safety features installed in the cars.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

| **Unit 20: Sustainable Vehicle Power and Structure Design** |
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| **Introduction**<br>To introduce this unit you could show learners a video showing a range of different vehicles powered by alternative sources, such as the Australian Solar Car Race. Following this it would be appropriate to discuss the benefits and disadvantages of using solar power before considering other alternative methods of energy for powering vehicles. |
| **Learning aim A: Know about sustainable vehicle power supply and systems aligned to their benefits and environmental impact** |
| Using whole-group teaching, learners can be:<br>• introduced to the different types of environmentally sustainable vehicles by using video clips and, if appropriate, visits to workplaces or motor shows.<br>Learners should then undertake individual activities:<br>• research the use of the eco-friendly designs for plug-in electric, hybrid electric and fuel cell powered cars using the internet and other appropriate sources<br>• produce a short report to compare these alternative-energy-powered cars with the methods which can be used to modify conventional cars to run on other power sources including biofuel<br>• show the results of the research in the form of a short presentation<br>• compare two different forms of sustainable vehicle power, and evaluate them in terms of the basic operation and the benefits of each type of power supply and system.<br>Through practical investigations, learners could:<br>• compare different control methods which can be used with motors, such as using mechanical switches and Pulse Width Modulation (PWM) for controlling the speed and direction of vehicles<br>• evaluate the performance of each of the different means of controlling a vehicle – ease of use, how intuitive they are to operate and practicality for use with the car should all be considered<br>• produce a short report that describes and compares the advantages and disadvantages of these methods of controlling motor speeds and direction<br>• investigate a range of different battery types, such as alkaline and lithium, in order to compare the advantages and disadvantages of each, suggesting appropriate applications for each.<br>You could get learners to use the internet and appropriate books as sources of information in order to consider the different methods of producing power from alternative sources such as hydrogen or wind power, and consider the appropriateness of these energy sources for use in vehicles. |
| **Assignment 1:** The Green Car Guide* |

**Unit 20: Sustainable Vehicle Power and Structure Design**

**Learning aim B: Know about the principles of vehicle structure design**
**Learning aim D: Know about vehicle safety testing**

Using whole-group teaching, with the group of learners:

- introduce the three categories of vehicle structure – chassis and body, monocoque and space frame
- use appropriate videos to describe each in turn
- review their prior learning of materials and manufacturing methods, concentrating on metals, polymers and composites. This can be done through discussion or investigation
- discuss the need for crash-testing for vehicles, show videos of car accidents and testing situations to encourage learners to thing about the reasons why tests are performed, as well as how they are performed.

Learners should then undertake individual activities, which require them to:

- produce a report which describes the typical uses of the different types of vehicle construction
- describe the characteristics of each type of construction in relation to the use of the vehicle
- investigate the different materials which are used to manufacture vehicles, considering the properties of these materials and why they are suitable for the application
- research and investigation should be carried out to justify why materials are used in specific vehicle types, and the manufacturing processes which are followed in order to construct different types of vehicle
- having considered the different materials and manufacturing techniques, describe how vehicles are designed in order to resist the forces which they will encounter in an accident
- compare two different vehicle structures and how they perform in crash tests, and provide a justification for the development of safe zones within vehicles to protect the driver and passengers
- describe, in a short report, how the various Euro NCAP tests are performed on new cars, and how these tests need to be taken into consideration by car manufacturers
- investigate the use of crash test dummies in the development of new vehicles, and how the data from these tests is used to improve designs to further protect drivers and passengers.

**Assignment 2:** Why Do We 'Crash Test' Vehicles?*

**Learning aim C: Be able to design and manufacture a model chassis and body structure**

Using whole-group teaching:

- introduce the group to their activity of designing and manufacturing a car
- discuss what challenges are likely to lie ahead and how can they best be overcome
- talk about the need for the vehicle to be powered by electricity, and to be able meet safety criteria. Encourage learners to reflect on their prior learning about crash testing, control methods and power source
- demonstrate, either through physical demonstrations in the workshop, or through the use of video clips, techniques which may be needed in the construction of the car, such as welding, brazing, and the laying up of GRP
- discuss the features which need to be included for a vehicle which consists of a chassis and a body, considering where the strength needs to be concentrated

| **Unit 20: Sustainable Vehicle Power and Structure Design** |
|---|
| • consider, in a group discussion, the environmental impacts of manufacturing electric cars, including those from processes and materials.<br>Learners should then undertake group activities, which require them to:<br>• generate a range of ideas for both chassis and body structures in their design groups<br>• produce a design for a chassis and body which has been developed through modelling, by using appropriate criteria<br>• produce a detailed plan for manufacturing which included dimensioned drawings, sequences of manufacturing and information about measurements and tolerances<br>• consider the wheelbase of the car along with methods to ensure tracking is accurate<br>• undertake risk assessments for the processes which they will be undertaking, before starting to manufacture their car, identifying all control measures including PPE, and the environmental impact of their activities<br>• during the making processes, learners should make sure that they are working safely at all times, photographs and observation records will provide evidence of this.<br>The group should construct the chassis and body of their chosen vehicle design using a range of materials and processes, taking into account material availability and sustainability. It is good practice to take photographs of the work at various stages as evidence for the practical activity.<br>On completion of the vehicle, it should be tested to make sure it is fit for purpose. These tests could include:<br>• functional tests to make sure that it moves and steers as expected<br>• safety tests that will show whether the vehicle is safe to use.<br>Evidence for this learning aim will generally be provided in the form of the sketches and design work prior to making, along with photographs and observation records for the manufacturing process. |
| **Assignment 3:** Drag Racer Toy Design Challenge* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

Unit 20 has direct links to units in the BTEC Firsts in Engineering where maintenance activities and risk assessments are studied:

- *Unit 1: The Engineered World*
- *Unit 2: Investigating an Engineered Product*
- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 8: Electronic Circuit Design and Construction*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Askeland, D., Fulay, P. and Wright, W., *The Science and Engineering of Materials* (6th edition), Cengage Learning, 2011 (ISBN 9780495668022)
Includes chapters covering metals, polymers and composite materials, along with production techniques.

Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C., Watkins, N., *BTEC Level 2 First Engineering Student Book*, Pearson, 2012 (ISBN 9781446902431)
Covers content for the units 1, 2, 3, 5 and 8, which this unit links to.

Tooley, M., *BTEC First Engineering: Core Units for BTEC Firsts in Engineering and Common Specialist Units in All Pathways*, Newnes, 2006 (ISBN 9780750680608)
Includes chapters covering scientific principles, materials and health and safety.

### Websites

There are many links to manufacturing processes through a search for 'How things are made'. Stanford University supply a very good range.

www.euroncap.com
Video and information concerning the different tests performed on new cars.

www.Key2study.com and www.matweb.com
Both websites are excellent resources for engineering materials.

www.nissan.co.uk/leaf and www.vauxhall.co.uk/ampera
Electric city cars, including information about charging and range.

www.sustainability.com
There are a range of case studies available that examine sustainable issues within business.

www.towards-sustainability.co.uk
This site takes a closer look at a variety of sustainable issues.

www.toyota.co.uk
Includes information about environmentally friendly cars, production processes and technologies.

### Videos

www.youtube.com/watch?v=8EPXVFhJoUU
Australian solar car race design team discussing the challenge for designing a solar car.

# Unit 21: Introduction to Communications for Engineering

## Delivery guidance

### Approaching the unit

It is important to be able to communicate effectively at all levels when working in the engineering sector. Your learners will be well aware of the huge advances in communication technology made in the last ten years. Perhaps, when starting on the delivery of this unit, you could ask the learners to put down their smart phone or tablet computer and step back a bit.

### Delivering the learning aims

Learning aim A is about developing your learners' skills in using graphics to communicate engineering information. They will investigate how to sketch simple three-dimensional objects using pictorial and orthographic techniques; however, it is not intended that they become expert draftspersons. The requirement here is to be able to communicate information in enough detail to enable someone in a workshop to make a reasonable attempt at producing the component. For this reason your learners' sketches should be in good proportion and carry leading dimensions. To add reality, you could ask a technician to take away a few of the sketches, manufacture the components and bring them back to a future session. Did the products turn out as learners expected?

Learning aim B leads your learners into the world of how to achieve effective communication. Although the context is engineering, your learners will be developing communication skills that are generic and can be applied to any discipline. They will be investigating how to communicate information in written, graphical and spoken formats. To provide interest and validity it is recommended that the engineering activities considered are ones that your learners carry out in other units or when they are on work placement.

The topics covered in learning aim C will help your learners develop the skills of searching for and using information sources; as with learning aim B, these are skills that are transferable. The internet has opened up a huge information resource with Google® and Wikipedia® playing a major part when people are searching for information. One of the things you must do is impress on your learners that not all the information out there is valid or accurate. Learning aim C investigates how to search effectively for accurate, validated data using computer- and non-computer-based sources and how to then use it.

An important facet of an engineer's job is being able to communicate effectively to a whole range of people, for example, colleagues at work, customers, site visitors, sub-contractors, suppliers of materials, compliance organisations such as the Health and Safety Executive; the list is endless. Learning aim D will give your learners the opportunity to develop their communication skills through the preparation and delivery of a technical presentation. The emphasis is on the use of information and communication technology (ICT), but learners will also be encouraged to consider more traditional forms of communication media, such as printed documents.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 21: Introduction to Communications for Engineering**

**Introduction**

You could introduce this unit to your learners by explaining why communication is a key element of everyday life. Then focus in on engineering and think about the steps that are followed when a new product is designed and brought to the marketplace. Your aim would be to produce a flow chart that outlines the various steps followed, for example, market research, design, prototyping, testing. Then overlay it with the communication links taking place, for example, verbal, written, sketching, graphics, numerical. Present a few exemplars of situations that occur in industry and review the best type of communication technique for each, for example, a production engineer giving a machinist a detail drawing of a component to be produced on a lathe or a designer having a face-to-face discussion with a technician about some test results that don't look right.

**Learning aim A: Be able to sketch simple shapes to represent engineering components**

You could start with a whole-group discussion:

- present some situations and for each decide on the best form of communication to use
- why is it important to communicate information accurately? To illustrate this point try playing the party game 'Chinese Whispers'
- another way to demonstrate how things can go wrong is to put an engineering phrase into an online translator (for example, English to French) and then repeat the process going backwards (French to English); do this a couple of times and see what happens to the original meaning of the phrase.

You could follow this up with some whole-class teaching:

- demonstrate the basic techniques of sketching in isometric and orthographic projection, briefly describing the benefits and limitations of each
- demonstrate how to sketch simple regular solids, hollow objects and standard engineering components using isometric and orthographic (multiple view) projection
- discuss the equipment your learners will be using when sketching (please note that for this unit learners can only work with pencil and paper – no CAD is allowed).

You could then give learners individual sketching exercises (isometric and orthographic (multiple view) projection):

- regular solids, such as cube, block, cylinder
- hollow objects, such as circular and square section tube
- nuts, bolts, screws
- complex shapes, such as a casting or welded structure

You could follow this up with a whole-group discussion about the value of pictorial sketching:

- its importance, such as the future link to 3D modelling
- its benefits, such as speed of production
- its limitations, such as lengths not true, ambiguity of dimensions.

You could then review a selection of work produced by your learners and comment on its clarity of presentation, accuracy, getting the message across, etc.

**Unit 21: Introduction to Communications for Engineering**

**Assignment 1:** The Use, Benefits and Limitations of Sketching in Engineering*

**Learning aim B: Be able to use communication methods in engineering contexts**

You could start with a whole-group discussion based on an exemplar of a simple engineering activity, for example, organising the assembly and testing of an electronic circuit by a technician based in the school/college project room.

- Establish what information will be needed to carry out the job, for example, circuit diagram, parts list, tests to be carried on the circuit, completion date.
- Discuss the most appropriate ways of communicating this information to the technician, for example, handwritten notes, circuit sketch, verbal instruction.
- Discuss how the technician will feed back information when the job is finished, for example, test results.

You could follow this with a small-group exercise based on an engineering activity, to be undertaken elsewhere within the programme of study or during a work placement. It should be something that has clearly defined objectives and a set timeframe, for example, a maintenance routine, machining a component, fabricating a component, electronic circuit design and construction, planning a project, identifying and controlling hazards in a workshop.

- The group nominates one member to take notes.
- The group discusses the activity and then, with the aid of mind mapping and flow diagrams, prepare, in note form, an overview of the activity and a proposal for its implementation.
- One member of the group is nominated spokesperson and they discuss the viability of the proposal with you (role playing a senior manager in an engineering company).
- The spokesperson gives verbal feedback to the group.
- The group produces a formal proposal for implementing the activity, to include text, diagrams and graphics. This can be linked to learning aim D (using ICT).
- The group then presents the proposal to an audience, which is linked to learning aim D (PowerPoint®, interactive white board).

After each group's presentation you could lead a brief discussion about its effectiveness, for example, did they get the message across, did they use appropriate ICT, are there improvements or alternatives for future presentations?

When all the groups have presented you could have a discussion about presenting technical information to an audience, such as effective use of body language, listening to other people and answering their questions, respecting another person's point of view if it conflicts.

**Assignment 2:** Communicating Well in Engineering*

**Learning aim C: Be able to select and use engineering information to solve engineering problems**

You could start with whole-group teaching:

- describe the public information resources (free and paid for) available to engineers, such as manufacturers' catalogues, data sheets, technical reports, trade journals, British and European Standards, analytical software, databases
- describe the additional in-house information resources available to engineers, such as test/experimental results data, company data sheets
- discuss strategies for the effective selection and use of information sources

**Unit 21: Introduction to Communications for Engineering**

- review the pros and cons of working with non-computer- and computer-based formats when presenting information
- demonstrate how to find and use information when solving an engineering problem, for example, designing a structural component or a circuit diagram. If you opt for the structural component, for example, you could mark up a drawing (using an interactive white board) with the information needed, such as screw thread data, material properties, manufacturing processes etc. Then identify sources of information and extract relevant detail.

You could follow this up with small-group or individual working to solve a given engineering problem; a simple design exercise or maintenance procedure are good ones to do:

- identify relevant information sources, extract data and use it
- establish the accuracy of the data found by looking to more than one source.

You could finish off with a whole-class review of how each learner or group got on:

- was time wasted trawling through the huge amounts of information available on the internet?
- were strategies for effective searching used?
- how valid was the data found?

**Assignment 3:** Finding and Using Information*

**Learning aim D: Be able to select and use information and communication technology (ICT) to present information in engineering contexts**

You could start with whole-class teaching:

- using checklists and images, review the hardware devices and software packages commonly used by engineers when preparing and making presentations
- explain why computer systems are just one element of an information and communication (ICT) system
- explain why, when making presentations, engineers very often support computer-based presentations with paper-based information (handouts), such as documents containing text and numerical data
- make a brief exemplar engineering presentation to your group and follow up with a discussion about why it was fit for purpose.

You could follow this up with a paired activity:

- using ICT prepare a presentation relating to a simple engineering activity
- deliver the presentation to the whole group.

After each presentation follow this up with a whole group discussion:

- did the presentation get the message across?
- had ICT been used appropriately?
- are there any suggestions for improving the presentation?

You could then follow this with an individual activity:

- based on comments from the group discussion make alterations/improvements to the presentation
- repeat carrying out the presentation, but this time to an audience or individual unfamiliar to the learner.

Some learners will be nervous and this last activity may need to be carried out under sympathetic conditions. There is no requirement with this learning aim for the learner to be questioned by the audience.

| **Unit 21: Introduction to Communications for Engineering** |
| --- |
| **Assignment 4:** Using ICT to Present Information* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

- Pearson Level 2 NVQ Diploma in Performing Engineering Operations (QCF):
- *Unit 3: Using and communicating technical information*

### Resources

#### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Boyce, A., Clarke, S., Darbyshire, A., Mantovani, B. and Weatherill, B., *BTEC Level 2 First Engineering Student Book*, Pearson Education, 2010 (ISBN 9781846907234)

Simmons, D., Maguire, D. and Phelps N., *Manual of Engineering Drawing*, Butterworth-Heinemann, 2012 (ISBN 9780080966526)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

#### Websites

www.hse.gov.uk
Health and Safety Executive

# Unit 22: Continuous Improvement and Problem-Solving

## Delivery guidance

### Approaching the unit

You should approach this unit in such a way as to encourage learners to think about why it is important for engineers in all sectors to be able to refine and improve upon designs to create the highest possible quality of outcome. This could, for example, involve the improvement of either a design, to make it more effective, or the manufacturing process, to improve the efficiency of the process. You should encourage learners to consider their own experiences of practical engineering tasks during which they have refined their outcomes either at design or manufacturing stage.

This unit is designed to be both taught and assessed by combining traditional paper-based activities with both presentations and practical activities. As such, it is important that you encourage learners to produce notes for their presentations and to use these for their assessment. In addition, as tutor, you will need to produce witness statements and observation records for the practical activities that learners participate in. You should also encourage learners to take photographs of their work, which they can then annotate to explain their tasks.

### Delivering the learning aims

Learning aim A introduces learners to the concept of 'quality gurus' and their philosophies for continuous improvement techniques. The aim of the unit is to encourage learners to think about the different approaches that can be taken to continuous improvement, and that there are a range of different methods that can be used to meet the desired aims. Learners will need to investigate three key quality gurus using a range of sources including the internet and reference books. You should encourage learners to consider at least three 'quality gurus' who have differing approaches to their philosophies as this will enable learners to demonstrate deeper understanding and produce a more detailed comparison of the philosophies of each guru.

Learners should also gain a sound understanding of the principles employed in order to achieve continuous improvement. Many of these principles are intrinsic to the philosophies of the quality gurus, therefore you should encourage learners to read deeper and research these as appropriate.

Learning aim B is best approached by providing learners with a scenario that would benefit from the introduction of quality tools to solve a manufacturing problem. To encourage the engagement of learners, it would be a good idea to provide them with a range of manufacturing problems that will stimulate their interest. One example could be an electronics manufacturer where overproduction of mobile phone components has caused them to be stock-piled. Learners could then be encouraged to consider methods to reduce overproduction and how to ensure that such a situation would not occur again.

Learning aim C allows learners to gain practical experience of implementing a continuous improvement activity in small groups. It would benefit learners to have a workshop-based scenario with which they have some familiarity in order to be able to design their improvement techniques. You should encourage learners to record their

activities in the form of a log, which they can make reference to, as it is likely that, in their work, they will find that some techniques lead to greater improvements than others, and recording these will assist in their evaluation work.

It is important for each of the learning aims that learners have the freedom to investigate the philosophies and techniques used during continuous improvement activities. However, there may be times when learners need to be guided towards more appropriate solutions.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 22: Continuous Improvement and Problem-Solving**

**Introduction**

You could introduce this unit by discussing with the group the reasons why engineers need to produce products which are of a high quality, and develop this by discussing the methods by which world-class manufacturing techniques can be achieved. This could be done by considering the philosophy behind the design and manufacture of a Formula 1 racing car, where design details are continually refined until they achieve the optimum performance.

**Learning aim A: Know about quality gurus' philosophies and continuous improvement principles**

You could start with whole-group teaching:

- introduce the concepts of continuous improvement being used in engineering to ensure that products are of the highest standard possible
- introduce the ideals and philosophies used by quality gurus to try to make sure that what is produced is the best that it can be.

You could then give learners individual activities:

- using the internet and reference books, learners could research the philosophies of one quality guru, such as Feigenbaum and the philosophies of total quality control.
- each learner could research a different quality guru and report back to the group with facts they have found out.

You could then continue with further whole-group teaching:

- introduce learners to the various principles employed to develop continuous improvement in engineering, such as lean manufacturing and kaizen; encourage learners to discuss how they think these could lead to improvements in engineering projects
- explain the impact of the various 'wastes' on an engineering project and how many of these have links between them
- discuss with learners the connection between the principles of the quality gurus and the various principles that can be employed for improving quality during production
- discuss with learners the different approaches taken by the various gurus by considering the 14-point improvement plan of Crosby against the 14-point quality management plan of Deming. Discuss the similarities and differences between them.

**Assignment 1:** Quality Gurus*

**Learning aim B: Be able to use quality tools to solve a manufacturing problem**

You could start with whole-group teaching:

- introduce the quality tools that are used in the identification and measurement of manufacturing problems.
- discuss with learners the use of some of the tools with which they may already be familiar, such as tally charts, histograms and scatter diagrams; encourage learners to suggest typical uses of each in an engineering context.

Learners should then begin to work on individual tasks:

- using the internet and reference books, learners research the typical uses of a range of quality tools as used in engineering

**Unit 22: Continuous Improvement and Problem-Solving**

- learners should develop this further to consider the ways in which these tools can be used to improve an engineering activity with which they have some familiarity.

You could then develop this understanding further with whole-group teaching:

- introduce learners to the typical types of problem that can be experienced during engineering activities
- explain that in many cases these problems can be related to production issues or poor planning
- discuss with learners how many problems can be linked together, such as overproduction leading to poor-quality products or that there will be significant wait time for employees if the machinery is not running to capacity.

You could then give learners an individual activity:

- for a given engineering activity, learners should select and use three different quality tools to identify and solve manufacturing problems
- learners should also explain how the use of quality tools has allowed them to solve these manufacturing problems, and then evaluate the effectiveness of the tools which they selected.

**Assignment 2:** Using Quality Improvement Tools*

**Learning aim C: Be able to use continuous improvement techniques**

You could start with whole-group teaching:

- review the concepts of continuous improvement as used in engineering, making reference to the philosophies of the quality gurus and the tools that may be used in order to make improvements
- introduce the process of implementing an improvement plan – use a video if appropriate (http://www.youtube.com/watch?v=KHxi4T_DboU)
- discuss with learners what is meant by the terms 'key performance indicators' and 'objectives and targets'.

You could then give learners a research task to complete:

- learners use appropriate sources to research the range of key performance indicators which are related to engineering, and consider how each can be measured
- learners produce a brief report on the health and safety requirements of the work area in which the engineering activity is to take place.

You could then continue with further whole-group teaching:

- introduce learners to the task of identification of an area where a continuous improvement activity will be beneficial; discuss typical situations with learners
- explain that the selected activity should have the scope to show a measurable improvement and be appropriate for a team activity.

You could then give learners the task activities to complete:

- learners identify and record an engineering activity within a given workshop scenario where there is a need for a continuous improvement activity; they need to discuss the reasons for their choice in their groups and record these in their work
- in their groups, learners identify the specific areas where improvement activities are required, and decide upon the methods that they will use
- learners will then need to plan their work by drawing conclusions from their previous experience and identifying the steps they will need to take during the implementation of their plans
- on competition of the plan, learners evaluate the performance of their problem solving techniques and explain how each of the techniques was used as a part of their plan


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| Unit 22: Continuous Improvement and Problem-Solving |
|---|
| • as a conclusion, learners will need to be able to discuss and evaluate the issues and problems that they encountered during the implementation of their plans. |
| **Assignment 3:** Continuous Improvement* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

- BTEC First Diploma in Engineering
- *Unit 1: The Engineered World*
- *Unit 3: Health and Safety in Engineering*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 10: Mathematics for Engineers*
- *Unit 15: Operating an Efficient Workplace*
- *Unit 31: Production Planning for Engineering*
- *Unit 35: Application of Quality Control and Measurement in Engineering*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Videos

http://www.youtube.com/watch?v=KHxi4T_DboU – implementing a continuous improvement plan

### Websites

www.qualitygurus.com
Information about the lives and works of quality gurus

www.totalqualitymanagement.wordpress.com/2008/12/19/quality-gurus
About the work of Deming, includes some video clips

www.dhutton.com/tqm/gurus.html
Brief biographies of some of the quality gurus

# Unit 23: Electronic Devices and Communication Applications

## Delivery guidance

### Approaching the unit

To help your learners get to grips with the learning aims of this unit it is essential to give them plenty of opportunities for practical investigation and circuit building. This unit should be very much a hands-on experience for your learners. The aim of this unit is to introduce learners to the basics of electronic communications and applications through practical activities.

Initially your learners need to understand signals and units of measurement used in electronic communications. This will include digital and analogue signals, dc and ac signals and measurement of various typical waveforms. Alongside the practical work, you should introduce the correct units of measurement to your learners so that a good knowledge base is established. You should then look at components and devices used in typical electronic communication circuits and give your learners the opportunity to build typical circuits using a variety of techniques, before moving on to look at communication systems and data transmission.

Delivery of this unit should be as practical as possible so as to excite and motivate young learners. All sessions should ideally contain some practical work and should lead learners to achieve the assessment criteria by completing a range of varied practical assignments.

### Delivering the learning aims

Learning aim A gives a certain amount of initial knowledge about signals, which can be demonstrated practically by you and then experimentally through hands-on activities to look at and measure signals and waveforms. Initially, you will need to introduce learners to basic measuring devices, such as a multimeter, and then to more complex measuring instruments, such as an oscilloscope. Again this can be done with practical tasks as much as possible. You can introduce units of measurement using various activities, including 'definition matching', 'dominoes', 'hangman' etc., backed up by practical measurement and feedback.

Learning aim B looks at the function of components and devices used in electronic communication circuits. Learners will initially need to be able to match a physical component to its BS symbol and then be able to describe its function. You can do this in a practical session using real components and perhaps match cards depicting symbols and descriptions, all of which have to be matched by your learners. You will ultimately need to allow your learners time to practise using the symbols they are now familiar with in producing circuit diagrams. You could use one of the many computer software simulation packages to achieve this. Learners could benefit from plenary sessions such as team quizzes, mystery bag, blockbusters or any game where knowledge and recall is assessed.

Learning aim C is very much hands on. You will need to introduce your learners to electronic circuit building techniques. Your learners will need to be able to use two different techniques, such as protoboard, veroboard or PCB. The circuits built will cover passive, analogue and digital circuits. You can address this aim through interactive teaching approaches, exploring and establishing links between subject matter are through appropriate practical activities and assignments that assess the criteria. Your learners will appreciate that the process of building circuits involves trial

and error. When a circuit doesn't work the first time, your learners will need to inspect connections, check for defective components, and consider how to effect repairs.

Learning aim D is not as practical as previous learning aims and concentrates on learners being able to describe, explain and analyse different communication systems and data transfer work. You could achieve this by introducing case studies and research activities to meet the assessment criteria. This learning aim is also suitable for industrial visits to see systems in action.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

| **Unit 23: Electronic Devices and Communication Applications** |
|---|
| **Introduction**<br>You could run a paired activity to draw out what learners already know about electronic devices and communications. This knowledge could be shared to the group and would introduce some peer assessment. |
| **Learning aim A: Know the types of signals and units of measurement used in electronic systems** |
| You could start with whole-group teaching:<br>• introduce learners to the multimeter by use of practical measuring activities. This activity should be on sample circuits so that different voltage and current ranges can be used<br>• you could use a quiz to test learning. Timed quizzes with teams would allow learning discussion and a sharing of knowledge between teams<br>• you can introduce the oscilloscope to learners within practical sessions by demonstrating it and then allowing learners to use oscilloscopes to measure amplitude, frequency and bits per second.<br>You could then give learners individual activities:<br>• one activity could take the form of a workbook for learners to complete as they work independently through various experiments to measure ac/dc signals and waveforms using the knowledge gained from previous practice sessions. |
| **Assignment 1:** Signals and Units of Measurement* |
| **Learning aim B: Know the function of electronic components and devices** |
| • Introduce the scenario and use short starter activities to draw out previous knowledge of stores, parts, stock etc.<br>• Learners can match physical components and symbols to cards with descriptions.<br>• Learners can undertake further research activities using a variety of ICT aids to develop the matching of components and devices to symbols and then descriptions of function.<br>• Ask learners to complete a table of five components and five devices, chosen from the unit content, showing a picture of the physical component, a BS circuit symbol and a description of its function.<br>• Supply learners with simple physical circuits containing a combination of at least eight components and devices. Ask them to draw circuit diagrams using BS circuit symbols.<br>• Ask learners to justify their selections – this can introduce learners to the use of catalogue and manufacturers' data sheets. |
| **Assignment 2:** Function of Electronic Components and Devices* |

| **Unit 23: Electronic Devices and Communication Applications** |
|---|
| **Learning aim C: Be able to construct simple passive circuits and construct and test analogue and digital electronic circuits** |
| • Introduce each construction method – you could pair learners working on different practice methods, such as protoboards, veroboard and pcb, until proficient at that method.<br>• Swap learner pairings and ask each learner to instruct their colleague in a different technique – this will reinforce learning and introduce differentiation, co-operative learning and peer assessment.<br>• You can show learners how to use test equipment and then they can undertake circuit testing, for example, completing pro-forma tables of results works well. |
| **Assignment 3:** Construct and Test Electronic Circuits* |
| **Learning aim D: Understand electronic communication systems and data transmission** |
| • Introduce concepts behind electronic communications systems and data transfer. You could also show video clips of working systems.<br>• Introduce case studies where learners have to research a particular sub-system and present back to their colleagues for open discussion.<br>• Learners can take part in activities where sub-systems have to be matched to applications.<br>• This learning aim lends itself to input from local industries that provide or use communications equipment. Sessions could be built around visiting speakers or work-based visits. |
| **Assignment 4:** Communications and Data Transmission* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts in Engineering:

- *Unit 8: Electronic Circuit Design and Construction*
- *Unit 25: Operation and Maintenance of Electronic Systems and Components*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Bishop, O., *Electronics – Circuits and Systems,* Fourth Edition, Newnes, 2011 (ISBN 9780080966342). Covers the basics of communications and data transfer.

Deacon, M., O'Dwyer, N. and Tooley, M., *Edexcel Diploma Engineering Level 2 Higher Diploma*, Pearson Education, 2008 (ISBN 9780435756208)

Floyd, T.L., Buchla, D.L., *Electronics Fundamentals: Circuits, Devices and Applications*, 8th edition, Pearson, 2009 (ISBN 9780135096833)
Comprehensive yet practical exploration of basic electrical and electronic concepts, hands-on applications, and troubleshooting

Platt C., *Make: Electronics: Learning Through Discovery*, O'Reilly, 2009 (ISBN 9780596153748)
Teaches the fundamentals of electronics in a hands-on way; components and essential principles are covered through a series of experiments; circuit building and theory.

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Websites

www.bbc.co.uk/schools/gcsebitesize/design/electronics/
Many useful activities based around electronics

www.technologystudent.com/index.htm
Covers components and symbols, measurement, electronic circuits and communications; lots of suggested activities and worksheets

# Unit 24: Operation and Maintenance of Mechanical Systems and Components

## Delivery guidance

### Approaching the unit

You should give your learners the opportunity to investigate a variety of mechanical systems and components. They must be made aware of the benefits of maintaining equipment in good working order and the procedures to be followed if breakdown occurs. The unit can be delivered as a mix of formal teaching input and individual and small-group investigative activities. There needs to be a significant amount of 'hands on' and to do this effectively will require the provision of suitable mechanical systems and components. The systems need not be overly complicated; your learners are expected to carry out fault-finding routines and it is important that any faults that you design into a system are straightforward to identify and rectify. You should impress upon your learners the importance of working safely and accurately recording actions taken during maintenance and fault rectification activities.

### Delivering the learning aims

Learning aim A is about investigating the function and operation of mechanical systems and their components. To do this effectively requires learners to have access to a range of systems and the components found within them. Your learners should be provided with diagrammatic representations of the systems that they are looking at; the use of block/system/circuit diagrams should be encouraged when investigating the function of a particular system.

Learning aim B introduces your learners to the process of working with system and component reference data so that they can correctly select components to be used in proposed maintenance procedures. This will involve them looking at different types of reference materials, for example, assembly drawing, block diagram, maintenance procedure, catalogue, repair manual. Learners will need to be given focused data to work with to avoid the danger of them spending inappropriate amounts of time trawling for information.

Learning aim C leads your learners into the interesting world of fault-finding and rectification. Many of them will have had experience of products developing faults and the frustrations experienced when trying to put things right. The importance of following prescribed procedures should be emphasised; also the keeping of accurate records and post-rectification testing. You should deliver this learning aim in a very practical context and you will need to give thought to setting up system faults that are straightforward for your learners to identify.

Learning aim D gives your learners the opportunity to develop their skills in safely carrying out routine maintenance on mechanical equipment. The second topic of this learning aim investigates safety issues that relate specifically to working in a maintenance environment. It will be useful to remind them of the generic health and safety requirements covered in mandatory *Unit 3: Health and Safety in Engineering*.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 24: Operation and Maintenance of Mechanical Systems and Components**

**Introduction**

You could introduce the unit to learners by discussing, as a group, reasons why mechanical systems should be maintained in good condition. Then focus in on the consequences if a mechanical system breaks down or develops a partial fault. You could then go on to discuss why it is important to have well-managed fault-finding and rectification procedures which can be brought into play if a system goes faulty. You could then go on to overview why it is necessary to keep accurate records of rectification work and routine maintenance carried out on systems. You could finish your introduction by reminding learners of the need for safety awareness when carrying out practical activities.

**Learning aim A: Know about the operation of mechanical systems and the function and operation of components used in them**

You could start with whole-group teaching:

- introduce the concept of function and operation as applied to mechanical systems
- review the types of mechanical system that learners will come across
- introduce the concept of representing systems as block or circuit diagrams.

You could then give learners individual or small-group activities:

- learners look at an assembly drawing of a simple mechanical system, identify how it operates, represent it as a block or circuit diagram and write descriptions for its function and operation.

You could then continue with further whole-group teaching:

- review the range of system components as listed in the unit content
- explain the implications for the operation of a system if components within it develop faults.

You could then give learners small-group activities:

- for a given selection of components, learners investigate and make a record of their function and operation. You could use images of components but it will make this topic much more meaningful if learners are able to handle actual components
- learners look at a system diagram and investigate the effect on it if components become faulty or fail completely, before preparing a short report.

**Assignment 1:** Mechanical Systems and Components*

**Learning aim B: Be able to select components used in mechanical systems when carrying out maintenance procedures**

You could start with whole-group teaching:

- discuss why it is important to have access to system and component data before starting work on fault-finding and maintenance procedures
- discuss the pros and cons of sourcing replacement components from an original equipment manufacture (OEM) as opposed to a third-party generic supplier
- present a small number of examples, in digital and hard-copy form, of catalogues, data sheets, repair manuals and parts lists.

**Unit 24: Operation and Maintenance of Mechanical Systems and Components**

You could then give learners small-group activities:

- learners look at an assembly drawing or block diagram of a mechanical system, identify components within it and pick out the part numbers of replacement items from a catalogue or data sheet
- learners make reference to system and component data (e.g. circuit diagram, assembly drawing, parts schedule, block diagram, catalogue, data sheets, repair manual) to identify the components needed to carry out a given maintenance procedure on a given mechanical system; they then tabulate their findings, providing an image for each component, system reference number, supplier's part number for ordering purposes and its cost. To add realism this data could be entered into a dummy online order form.

**Assignment 2:** Selecting Components used in Mechanical Systems*

**Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault rectification on mechanical systems and their components**

You could start with whole-group teaching:

- demonstrate or describe the impact of intermittent, partial failure and complete breakdown of a mechanical system
- overview how reference data can be used as an aid to determining a fault in a system
- describe and demonstrate fault-finding techniques and identify faulty components.

You could then give learners a small-group activity:

- learners investigate a system that is not operating to specification, diagnose the fault(s) in it, identify components that need to be replaced and produce a fault report.

You could then continue with further whole-group teaching:

- overview the equipment to be used when carrying out fault rectification on a system
- demonstrate how to safely replace faulty components, carry out post-rectification checks and record actions taken
- explain why it is important to ensure that a system operates to specification after rectification work has been carried out on it.

You could then give learners a small-group activity:

- give learners a piece of equipment that has clearly identifiable faults and provide them with relevant reference data e.g. data sheets, repair manual
- learners carry out fault-finding on the system and identify components that need to be replaced, repaired or adjusted; implement safe working procedures for this activity
- learners identify and source the equipment needed to effect fault rectification
- learners replace faulty components, test the system and record actions in hard copy or digital form and make a verbal report back to you.

**Assignment 3:** System Fault-finding and Rectification*

**Learning aim D: Be able to prepare for and safely carry out maintenance procedures on mechanical systems and their components**

You could start with whole-group teaching:

- review, in generic terms, how to keep safe when working in an engineering environment
- use a group discussion to draw up a definition for routine maintenance
- discuss particular hazards and risks involved when carrying out routine maintenance on mechanical systems

| **Unit 24: Operation and Maintenance of Mechanical Systems and Components** |
|---|
| • discuss the different types of inspection check/test that can be used when carrying out routine maintenance on mechanical systems and their components<br>• demonstrate routine maintenance procedures, and explain why it is important to have access to correct tools, test equipment, reference data and reporting documentation.<br>You could then give learners an individual or small-group activity:<br>• learners investigate the workplace hazards relating to a small number of given maintenance procedures; they mark up printed copies of the procedures with reference to where particular hazards have been identified and the control measures that should be implemented<br>• learners carry out routine maintenance on a given mechanical system; before starting work learners should identify hazards, risks, control measures and how to keep safe<br>• learners record actions taken and make a verbal report back to you. |
| **Assignment 4:** Routine Maintenance* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.


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## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC First in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 4: Engineering Maintenance*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 13: Engineering Assembly*
- *Unit 27: Operation and Maintenance of Fluid Power Systems and Components*
- *Unit 30: Vehicle Maintenance Techniques*

Pearson Level 2 NVQ Diploma in Engineering Maintenance and Installation (QCF):

- *Unit 5: Carrying out fault location on mechanical equipment*
- *Unit 6: Carrying out maintenance activities on mechanical equipment*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Byrne P., Darbyshire A., Freeman, L., Meredith, S. and Prodgers, A., *Edexcel Diploma Engineering Level 1 Foundation Diploma*, Pearson Education, 2008 (ISBN 9780435756253)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2012 (ISBN 9781446902431)

Deacon, M., O'Dwyer, N. and Tooley, M., *Edexcel Diploma Engineering Level 2 Higher Diploma*, Pearson Education, 2008 (ISBN 9780435756208)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Websites

www.hse.gov.uk
Health and Safety Executive

# Unit 25: Operation and Maintenance of Electronic Systems and Components

## Delivery guidance

### Approaching the unit

You should give your learners the opportunity to investigate a variety of electronic systems and components. They must be made aware of the benefits of maintaining equipment in good working order and the procedures to be followed if breakdown occurs. The unit can be delivered as a mix of formal teaching input and individual and small-group investigative activities. There needs to be a significant amount of 'hands on' and to do this effectively will require the provision of suitable electronic systems and components. The systems need not be overly complicated; your learners are expected to carry out fault-finding routines and it is important that any faults that you design into a system are straightforward to identify and rectify. You should impress upon your learners the importance of working safely and accurately recording actions taken during maintenance and fault rectification activities.

### Delivering the learning aims

Learning aim A is about investigating the function and operation of electronic systems and their components. To do this effectively requires learners to have access to a range of systems and the components found within them. Your learners should be provided with diagrammatic representations of the systems that they are looking at; the use of block/system/circuit diagrams should be encouraged when investigating the function of a particular system.

Learning aim B introduces your learners to the process of working with system and component reference data so that they can correctly select components to be used in proposed maintenance procedures. This will involve them looking at different types of reference materials, for example, assembly drawing, block diagram, maintenance procedure, catalogue, repair manual. Learners will need to be given focused data to work with to avoid the danger of them spending inappropriate amounts of time trawling for information.

Learning aim C leads your learners into the interesting world of fault-finding and rectification. Many of them will have had experience of products developing faults and the frustrations experienced when trying to put things right. The importance of following prescribed procedures should be emphasised; also the keeping of accurate records and post-rectification testing. You should deliver this learning aim in a very practical context and you will need to give thought to setting up system faults that are straightforward for your learners to identify.

Learning aim D gives your learners the opportunity to develop their skills in safely carrying out routine maintenance on electronic equipment. The second topic of this learning aim investigates safety issues that relate specifically to working in a maintenance environment. It will be useful to remind them of the generic health and safety requirements covered in mandatory *Unit 3: Health and Safety in Engineering*.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 25: Operation and Maintenance of Electronic Systems and Components**

**Introduction**

You could introduce the unit to learners by discussing, as a group, reasons why electronic systems should be maintained in good condition. Then focus in on the consequences if an electronic system breaks down or develops a partial fault. You could then go on to discuss why it is important to have well-managed fault-finding and rectification procedures which can be brought into play if a system goes faulty. You could then go on to overview why it is necessary to keep accurate records of rectification work and routine maintenance carried out on systems. You could finish your introduction by reminding learners of the need for safety awareness when carrying out practical activities.

**Learning aim A: Know about the operation of electronic systems and the function and operation of components used in them**

You could start with whole-group teaching:

- introduce the concept of function and operation as applied to electronic systems
- review the types of electronic system that learners will come across
- introduce the concept of representing systems as block or circuit diagrams.

You could then give learners individual or small-group activities:

- learners look at a diagram of a simple electronic system, identify how it operates and write descriptions for its function and operation.

You could then continue with further whole-group teaching:

- review the range of system components as listed in the unit content
- explain the implications for the operation of a system if components within it develop faults.

You could then give learners small-group activities:

- for a given selection of components, learners investigate and make a record of their function and operation; you could use images of components but it will make this topic much more meaningful if learners are able to handle actual components
- learners look at a system diagram and investigate the effect on it if components become faulty or fail completely, before preparing a short report.

**Assignment 1:** Electronic Systems and Components*

**Learning aim B: Be able to select components used in electronic systems when carrying out maintenance procedures**

You could start with whole-group teaching:

- discuss why it is important to have access to system and component data before starting work on fault-finding and maintenance procedures
- discuss the pros and cons of sourcing replacement components from an original equipment manufacture (OEM) as opposed to a third-party generic supplier
- present a small number of examples, in digital and hard-copy form, of catalogues, data sheets, repair manuals and parts lists.

**Unit 25: Operation and Maintenance of Electronic Systems and Components**

You could then give learners small-group activities:

- learners look at an assembly drawing or block diagram of an electronic system, identify components within it and pick out the part numbers of replacement items from a catalogue or data sheet
- learners make reference to system and component data (e.g. circuit diagram, assembly drawing, parts schedule, block diagram, catalogue, data sheets, repair manual) to identify the components needed to carry out a given maintenance procedure on a given electronic system; they then tabulate their findings, providing an image for each component, system reference number, supplier's part number for ordering purposes and its cost. To add realism this data could be entered into a dummy online order form.

**Assignment 2:** Selecting Components used in Electronic Systems*

**Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault rectification on electronic systems and their components**

You could start with whole-group teaching:

- demonstrate or describe the impact of intermittent, partial failure and complete breakdown of an electronic system
- overview how reference data can be used as an aid to determining a fault in a system
- describe and demonstrate fault-finding techniques and identify faulty components.

You could then give learners a small-group activity:

- learners investigate a system that is not operating to specification, diagnose the fault(s) in it, identify components that need to be replaced and produce a fault report.

You could then continue with further whole-group teaching:

- overview the equipment to be used when carrying out fault-rectification on a system
- demonstrate how to safely replace faulty components, carry out post-rectification checks and record actions taken
- explain why it is important to ensure that a system operates to specification after rectification work has been carried out on it.

You could then give learners a small-group activity:

- give learners a piece of equipment that has clearly identifiable faults and provide them with relevant reference data, e.g. data sheets, repair manual
- learners carry out fault-finding on the system and identify components that need to be replaced, repaired or adjusted; implement safe working procedures for this activity
- learners identify and source the equipment needed to effect fault rectification
- learners replace faulty components, test the system and record actions in hard copy or digital form and make a verbal report back to you.

**Assignment 3:** System Fault-finding and Rectification*

**Learning aim D: Be able to prepare for and safely carry out maintenance procedures on electronic systems and their components**

You could start with whole-group teaching:

- review, in generic terms, how to keep safe when working in an engineering environment
- use a group discussion to draw up a definition for routine maintenance
- discuss particular hazards and risks involved when carrying out routine maintenance on electronic systems
- discuss the different types of inspection check/test that can be used when carrying out routine maintenance on electronic systems and their components

| **Unit 25: Operation and Maintenance of Electronic Systems and Components** |
|---|
| • demonstrate routine maintenance procedures, and explain why it is important to have access to correct tools, test equipment, reference data and reporting documentation.<br>You could then give learners an individual or small-group activity:<br>• learners investigate the workplace hazards relating to a small number of given maintenance procedures; they mark up printed copies of the procedures with reference to where particular hazards have been identified and the control measures that should be implemented<br>• learners carry out routine maintenance on a given electronic system; before starting work, learners should identify hazards, risks, control measures and how to keep safe<br>• learners record actions taken and make a verbal report back to you. |
| **Assignment 4:** Routine Maintenance* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC First in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 4: Engineering Maintenance*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 13: Engineering Assembly*
- *Unit 26: Operation and Maintenance of Electrical Systems and Components*
- *Unit 30: Vehicle Maintenance Techniques*

Pearson Level 2 NVQ Diploma in Engineering Maintenance and Installation (QCF):

- *Unit 13: Carrying out fault location on electronic equipment and circuits*
- *Unit 14: Carrying out tests on electronic equipment and circuits*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Bishop, O., *Electronics – Circuits and Systems*, Fourth Edition, Newnes, 2011 (ISBN 9780080966342). Covers the basics of communications and data transfer.

Boyce, A., Byrne P., Darbyshire A., Freeman, L., Meredith, S. and Prodgers, A., *Edexcel Diploma Engineering Level 1 Foundation Diploma*, Pearson Education, 2008 (ISBN 9780435756253)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Deacon, M., O'Dwyer, N. and Tooley, M., *Edexcel Diploma Engineering Level 2 Higher Diploma*, Pearson Education, 2008 (ISBN 9780435756208)

Floyd, T.L., Buchla, D.L., *Electronics Fundamentals: Circuits, Devices and Applications*, 8th edition, Pearson, 2009 (ISBN 9780135096833)

Platt C., *Make: Electronics (Learning Through Discovery)*, O'Reilly, 2009 (ISBN 9780596153748)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Websites

www.bbc.co.uk/schools/gcsebitesize/design/electronics
Many useful activities based around electronics

www.technologystudent.com/index.htm
Covers components and symbols, measurement, electronic circuits and communications; lots of suggested activities and worksheets

www.hse.gov.uk
Health and Safety Executive

# Unit 26: Operation and Maintenance of Electrical Systems and Components

## Delivery guidance

### Approaching the unit

You should give your learners the opportunity to investigate a variety of electrical systems and components. Make them aware of the benefits of maintaining equipment in good working order and the procedures to be followed if breakdown occurs. The unit can be delivered as a mix of formal teaching input and individual and small-group investigative activities. There needs to be a significant amount of 'hands on' and to do this effectively will require the provision of suitable electrical systems and components. The systems need not be overly complicated; your learners are expected to carry out fault-finding routines and it is important that any faults that you design into a system are straightforward to identify and rectify. You should impress upon your learners the importance of working safely and accurately recording actions taken during maintenance and fault rectification activities.

### Delivering the learning aims

Learning aim A is about investigating the function and operation of electrical systems and their components. To do this effectively requires learners to have access to a range of systems and the components found within them. Your learners should be provided with diagrammatic representations of the systems that they are looking at; the use of block/system/circuit diagrams should be encouraged when investigating the function of a particular system.

Learning aim B introduces your learners to the process of working with system and component reference data so that they can correctly select components to be used in proposed maintenance procedures. This will involve them looking at different types of reference materials, for example, assembly drawing, block diagram, maintenance procedure, catalogue, repair manual. Learners will need to be given focused data to work with to avoid the danger of them spending inappropriate amounts of time trawling for information.

Learning aim C leads your learners into the interesting world of fault-finding and rectification. Many of them will have had experience of products developing faults and the frustrations experienced when trying to put things right. The importance of following prescribed procedures should be emphasised; also the keeping of accurate records and post-rectification testing. You should deliver this learning aim in a very practical context and you will need to give thought to setting up system faults that are straightforward for your learners to identify.

Learning aim D gives your learners the opportunity to develop their skills in safely carrying out routine maintenance on electrical equipment. The second topic of this learning aim investigates safety issues which relate specifically to working in a maintenance environment. It will be useful to remind them of the generic health and safety requirements covered in mandatory *Unit 3: Health and Safety in Engineering*.

## Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 26: Operation and Maintenance of Electrical Systems and Components**

**Introduction**

You could introduce the unit to learners by discussing, as a group, reasons why electrical systems should be maintained in good condition. Then focus in on the consequences if an electrical system breaks down or develops a partial fault. You could then go on to discuss why it is important to have well managed fault-finding and rectification procedures which can be brought into play if a system goes faulty. You could then go on to overview why it is necessary to keep accurate records of rectification work and routine maintenance carried out on systems. You could finish your introduction by reminding learners of the need for safety awareness when carrying out practical activities.

**Learning aim A: Know about the operation of electrical systems and the function and operation of components used in them**

You could start with whole-group teaching:

- introduce the concept of function and operation as applied to electrical systems
- review the types of electrical system that learners will come across
- introduce the concept of representing systems as block or circuit diagrams.

You could then give learners individual or small-group activities:

- learners look at an assembly drawing of a simple electrical system, identify how it operates, represent it as a block or circuit diagram, write descriptions for its function and operation.

You could then continue with further whole-group teaching:

- review the range of system components as listed in the unit content
- explain the implications for the operation of a system if components within it develop faults.

You could then give learners small-group activities:

- for a given selection of components, learners investigate and make a record of their function and operation; you could use images of components but it will make this topic much more meaningful if learners are able to handle actual components
- learners look at a system diagram and investigate the effect on it if components become faulty or fail completely, before preparing a short report.

**Assignment 1:** Electrical Systems and Components*

**Learning aim B: Be able to select components used in electrical systems when carrying out maintenance procedures**

You could start with whole-group teaching:

- discuss why it is important to have access to system and component data before starting work on fault-finding and maintenance procedures
- discuss the pros and cons of sourcing replacement components from an original equipment manufacture (OEM) as opposed to a third-party generic supplier
- present a small number of examples, in digital and hard-copy form, of catalogues, data sheets, repair manuals and parts lists.


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You could then give learners small-group activities:

- learners look at an assembly drawing or block diagram of an electrical system, identify components within it and pick out the part numbers of replacement items from a catalogue or data sheet.
- learners make reference to system and component data (e.g. circuit diagram, assembly drawing, parts schedule, block diagram, catalogue, data sheets, repair manual) to identify the components needed to carry out a given maintenance procedure on a given electrical system; they then tabulate their findings, providing an image for each component, system reference number, supplier's part number for ordering purposes and its cost. To add realism this data could be entered into a dummy online order form.

**Assignment 2:** Selecting Components Used in Electrical Systems*

**Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault rectification on electrical systems and their components**

You could start with whole-group teaching:

- demonstrate or describe the impact of intermittent, partial failure and complete breakdown of an electrical system
- overview how reference data can be used as an aid to determining a fault in a system
- describe and demonstrate fault-finding techniques and identify faulty components.

You could then give learners a small-group activity:

- learners investigate a system that is not operating to specification, diagnose the fault(s) in it, identify components that need to be replaced and produce a fault report.

You could then continue with further whole-group teaching:

- overview the equipment to be used when carrying out fault rectification on a system
- demonstrate how to safely replace faulty components, carry out post-rectification checks and record actions taken
- explain why it is important to ensure that a system operates to specification after rectification work has been carried out on it.

You could then give learners a small-group activity:

- give learners a piece of equipment that has clearly identifiable faults and provide them with relevant reference data e.g. data sheets, repair manual
- learners carry out fault-finding on the system and identify components that need to be replaced, repaired or adjusted; implement safe working procedures for this activity
- learners identify and source the equipment needed to effect fault rectification
- learners replace faulty components, test the system, record actions in hard copy or digital form and make a verbal report back to you.

**Assignment 3:** System Fault-finding and Rectification*

**Learning aim D: Be able to prepare for and safely carry out maintenance procedures on electrical systems and their components**

You could start with whole-group teaching:

- review, in generic terms, how to keep safe when working in an engineering environment
- use a group discussion to draw up a definition for routine maintenance
- discuss particular hazards and risks involved when carrying out routine maintenance on electrical systems
- discuss the different types of inspection check/test that can be used when carrying out routine maintenance on electrical systems and their components
- demonstrate routine maintenance procedures, and explain why it is important to have access to correct tools, test equipment, reference data and reporting documentation.

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| You could then give learners an individual or small-group activity:<br>• learners investigate the workplace hazards relating to a small number of given maintenance procedures; they mark up printed copies of the procedures with reference to where particular hazards have been identified and the control measures that should be implemented<br>• learners carry out routine maintenance on a given electrical system; before starting work learners should identify hazards, risks, control measures and how to keep safe<br>• learners record actions taken and make a verbal report back to you. |
| **Assignment 4:** Routine Maintenance* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.


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## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 4: Engineering Maintenance*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 25: Operation and Maintenance of Electronic* Systems and Components
- *Unit 30: Vehicle Maintenance Techniques*

Pearson Level 2 NVQ Diploma in Engineering Maintenance and Installation (QCF):

- *Unit 9: Carrying out fault location on electrical equipment and circuits*
- *Unit 10: Carrying out maintenance activities on electrical equipment*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Byrne P., Darbyshire, A., Freeman, L., Meredith S. and Prodgers, A., *Edexcel Diploma Engineering Level 1 Foundation Diploma*, Pearson Education, 2008 (ISBN 9780435756253)

Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2012 (ISBN 9781446902431)

Deacon, M., O'Dwyer, N., Tooley, M., *Edexcel Diploma Engineering Level 2 Higher Diploma*, Pearson Education, 2008 (ISBN 9780435756208)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Websites

www.hse.gov.uk
Health and Safety Executive

# Unit 27: Operation and Maintenance of Fluid Power Systems and Components

## Delivery guidance

### Approaching the unit

You should give your learners the opportunity to investigate a variety of fluid power systems and components. They must be made aware of the benefits of maintaining equipment in good working order and the procedures to be followed if breakdown occurs. The unit can be delivered as a mix of formal teaching input and individual and small-group investigative activities. There needs to be a significant amount of 'hands on' and to do this effectively will require the provision of suitable fluid power systems and components. The systems need not be overly complicated; your learners are expected to carry out fault-finding routines and it is important that any faults that you design into a system are straightforward to identify and rectify. You should impress upon your learners the importance of working safely and accurately recording actions taken during maintenance and fault rectification activities.

### Delivering the learning aims

Learning aim A gives the learners an introduction to fluid power systems and the opportunity to investigate the function and operation of components used in them. The initial introduction to fluid power systems is best delivered in a laboratory and workshop environment using videos and circuit diagrams representing fluid power systems. This will involve learners identifying symbols and interpreting circuit diagrams also gaining an understanding of the function and operation of components such as pumps, valves, actuators, sensors, regulators, compressors, pipes, hoses, and other specific fluid power equipment. The learners can then be transferred to a practical environment to investigate various fluid power systems and the different components found within a fluid power system.

Learning aim B requires learners to be able to select components used in fluid power systems when carrying out maintenance procedures. Initially you will encourage the learners to examine a variety of given system diagrams and component data. Learners should be encouraged to use manufacturers' component and system data supplemented and compared to computer and professionally produced simulation packages. Learners could then be divided into maintenance teams discussing possible maintenance procedures and the required service components selection.

Learning aim C requires the learners to be able to prepare for and safely carry out fault-finding techniques and fault rectification on fluid power systems and their components. You must ensure that each learner has the correct personal protective equipment and that the system is safe for operation. It is also important that the learners work in a safe manner when using equipment or working on fluid power systems. The importance of following prescribed procedures should be emphasised; also the keeping of accurate records and post-rectification testing. You should deliver this learning aim in a very practical context and you will need to give thought to setting up system faults that are straightforward for your learners to identify.

Learning aim D gives the learners the opportunity to prepare for and safely carry out maintenance procedures on fluid power systems and their components. This should be covered primarily through a practical activity requiring learners to prepare for and carry out maintenance activities on fluid power systems in a safe, approved manner.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 27: Operation and Maintenance of Fluid Power Systems and Components**

**Introduction**

You could introduce the unit to learners by discussing, as a group, reasons why fluid power systems should be maintained in good condition. Then focus in on the consequences if a fluid power system breaks down or develops a partial fault. You could then go on to discuss why it is important to have well-managed fault-finding and rectification procedures which can be brought into play if a system goes faulty. You could then go on to overview why it is necessary to keep accurate records of rectification work and routine maintenance carried out on systems. You could finish your introduction by reminding learners of the need for safety awareness when carrying out practical activities.

**Learning aim A: Know about the operation of fluid power systems and the function and operation of components used in them**

You could start with whole-group teaching:

- introduce the concept of function and operation as applied to fluid power systems
- review the types of fluid power system that learners will come across
- introduce the concept of representing systems as block, circuit or system layout diagrams.

You could then give learners individual or small-group activities:

- learners look at drawing diagram of a simple fluid power system, identify how it operates, represent it as a block or circuit diagram and write descriptions for its function and operation.

You could then continue with further whole-group teaching:

- review the range of system components as listed in the unit content
- explain the implications for the operation of a system if components within it develop faults.

You could then give learners small-group activities:

- for a given selection of components, learners investigate and make a record of their function and operation; you could use images of components but it will make this topic much more meaningful if learners are able to handle actual components
- learners look at a system diagram and investigate the effect on it if components become faulty or fail completely, before preparing a short report.

**Assignment 1:** Fluid power systems and components*

**Learning aim B: Be able to select components used in fluid power systems when carrying out maintenance procedures**

You could start with whole-group teaching:

- discuss why it is important to have access to system and component data before starting work on fault-finding and maintenance procedures
- discuss the pros and cons of sourcing replacement components from an original equipment manufacture (OEM) as opposed to a third-party generic supplier
- present a small number of examples, in digital and hard-copy form, of catalogues, data sheets, repair manuals and parts lists.

You could then give learners small-group activities:

**Unit 27: Operation and Maintenance of Fluid Power Systems and Components**

- learners look at an assembly drawing or block diagram of a fluid power system, identify components within it and pick out the part numbers of replacement items from a catalogue or data sheet
- learners make reference to system and component data (e.g. circuit diagram, assembly drawing, parts schedule, block diagram, catalogue, data sheets, repair manual) to identify the components needed to carry out a given maintenance procedure on a given fluid power system; they then tabulate their findings, providing an image for each component, system reference number, supplier's part number for ordering purposes and its cost. To add realism this data could be entered into a dummy online order form.

**Assignment 2:** Selecting Components used in Fluid Power Systems*

**Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault rectification on fluid power systems and their components**

You could start with whole-group teaching:

- demonstrate or describe the impact of intermittent, partial failure and complete breakdown of a fluid power system
- overview how reference data can be used as an aid to determining a fault in a system
- describe and demonstrate fault-finding techniques and identify faulty components.

You could then give learners a small-group activity:

- learners investigate a system that is not operating to specification, diagnose the fault(s) in it, identify components that need to be replaced and produce a fault report.

You could then continue with further whole-group teaching:

- overview the equipment to be used when carrying out fault rectification on a system
- demonstrate how to safely replace faulty components, carry out post-rectification checks and record actions taken
- explain why it is important to ensure that a system operates to specification after rectification work has been carried out on it.

You could then give learners a small-group activity:

- give learners a piece of equipment that has clearly identifiable faults and provide them with relevant reference data e.g. data sheets, repair manual
- learners carry out fault-finding on the system and identify components that need to be replaced, repaired or adjusted; implement safe working procedures for this activity
- learners identify and source the equipment needed to effect fault rectification
- learners replace faulty components, test the system and record actions in hard copy or digital form and make a verbal report back to you.

**Assignment 3:** System Fault-finding and Rectification*

**Learning aim D: Be able to prepare for and safely carry out maintenance procedures on fluid power systems and their components**

You could start with whole-group teaching:

- review, in generic terms, how to keep safe when working in an engineering environment
- use a group discussion to draw up a definition for routine maintenance
- discuss particular hazards and risks involved when carrying out routine maintenance on fluid power systems
- discuss the different types of inspection check/test that can be used when carrying out routine maintenance on fluid power systems and their components

| **Unit 27: Operation and Maintenance of Fluid Power Systems and Components** |
|---|
| • demonstrate routine maintenance procedures, and explain why it is important to have access to correct tools, test equipment, reference data and reporting documentation.<br>You could then give learners an individual or small-group activity:<br>• learners investigate the workplace hazards relating to a small number of given maintenance procedures; they mark up printed copies of the procedures with reference to where particular hazards have been identified and the control measures that should be implemented<br>• learners carry out routine maintenance on a given fluid power system; before starting work learners should identify hazards, risks, control measures and how to keep safe<br>• learners record actions taken and make a verbal report back to you. |
| **Assignment 4:** Routine Maintenance* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

BTEC Firsts in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 4: Engineering Maintenance*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 13: Engineering Assembly*
- *Unit 30: Vehicle Maintenance Techniques*

Pearson Level 2 NVQ Diploma in Engineering Maintenance and Installation (QCF):

- *Unit 16: Carrying out fault location on fluid power equipment and circuits*
- *Unit 17: Carrying out maintenance activities on fluid power equipment*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Byrne P., Darbyshire A., Freeman, L., Meredith, S. and Prodgers, A., *Edexcel Diploma Engineering Level 1 Foundation Diploma*, Pearson Education, 2008 (ISBN 9780435756253)

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Deacon, M., O'Dwyer, N. and Tooley, M., *Edexcel Diploma Engineering Level 2 Higher Diploma*, Pearson Education, 2008 (ISBN 9780435756208)

Floyd, T.L., Buchla, D.L., *Fluid powers Fundamentals: Circuits, Devices and Applications*, 8th edition, Pearson, 2009 (ISBN 9780135096-833)

Mitchell, R. and Pippenger, J., *Fluid Power Maintenance Basics and Troubleshooting* (Fluid Power and Control Series), CRC Press, 1997 (ISBN 9780824798338)

Parr A., *Hydraulics and Pneumatics: A Technician's Guide* – 2nd Edition, Butterworth-Heinemann, 1999 (ISBN 9780750644192)

Platt C., *Make: Fluid powers: Learning Through Discovery*, O'Reilly, 2009 (ISBN 9780596153748)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Turner I., *Engineering Applications of Pneumatics and Hydraulics*, Butterworth-Heinemann, 1996 (ISBN 9780340625260)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Websites

www.bbc.co.uk/schools/gcsebitesize/design/fluid powers/
Many useful activities based around fluid powers

www.technologystudent.com/index.htm
Covers components and symbols, measurement, fluid power circuits and communications; lots of suggested activities and worksheets

www.hmso.gov.uk
Relevant British and International standards: ISO 1219 (BS 2917) Fluid power systems and components graphical systems

www.hse.gov.uk or www.hsebooks.co.uk
Health and safety publications


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# Unit 28: Fabrication Techniques

## Delivery guidance

### Approaching the unit

For this unit you should encourage learners to learn through practical experiences. It is important that they become engaged in their practical tasks as this will provide the underpinning for the theory work required to produce their assessments. The activities learners undertake should ideally be tailored to the facilities available in your centre and, where possible, could be in the form of a short-term practical project that will allow learners to produce evidence for each of the learning aims.

It would be appropriate to combine some traditional paper-based activities with practical tasks in order to provide learners with the knowledge required to give them a solid understanding of the various techniques they will use. Learners need to produce a range of different types of evidence to complement their presentations, which are likely to take the form of annotated photographs, sketches and notes, along with detailed observation records.

### Delivering the learning aims

Learning aim A introduces learners to a range of materials and forms of material that they are likely to use during fabrication activities. To make sure that they have a good understanding of these, it would be preferable if learners could gain some hands-on experience of handling a range of materials and their differing forms. To complement this, learners will need to revise their knowledge of health and safety practices in a workshop environment, including the pieces of legislation that have an impact on engineering tasks. This learning aim also introduces learners to the tools and equipment they will use for measuring and marking out, therefore, where practical, learners could use these instruments to measure the material forms that they experience.

When delivering learning aim B, you will find that learners are more engaged by the content if they can undertake practical tasks. As with learning aim A, learners are required to demonstrate that they are able to work safely, and that they have a knowledge of the relevant safety regulations that exist. Learners should be given the opportunity to complete a range of cutting and forming activities using the various tools listed in the specification. Learners should be able to interpret a specification for an engineered product to be able to mark out and then cut and form the materials required to assemble the product.

Again, you should address learning aim C as a practical task, as learners need to demonstrate an ability to use a range of joining methods in order to fabricate a product. Where possible, you should provide the opportunity for learners to use a range of thermal joining methods in addition to the use of mechanical fastenings.

Learners should be able to complete a range of fabrication activities to produce both simple and complex assemblies, while making sure that they meet the quality and accuracy standards as specified. In order to achieve higher levels of learner engagement, it is advisable to design an activity that allows them to produce evidence for each of the learning aims, and also a product that they will find to be of use.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

## Unit 28: Fabrication Techniques

### Introduction

You could introduce this unit by asking learners to consider one of the engineered items in the room. You can question learners as to whether the product is made in one part, whether it is all one material and also how the parts need to be measured and produced accurately in order to be able to fit together well. This can provide the stimulus needed to encourage learners to produce their own accurate and high-quality fabricated product.

## Learning aim A: Be able to safely measure and mark out materials for fabricated structures

You could start with whole-group teaching:

- introduce the various different tools and pieces of equipment that are used for the measuring and marking out of materials
- discuss with learners what each piece of equipment is used for and the typical materials that will be measured and marked using them.

You could then give learners individual activities:

- each learner could research the typical uses of a range of measuring and marking equipment, recording their findings in order to prepare for the production of their presentation
- each learner could then gain practical experience of measuring and marking out a range of materials in differing forms.

You could then continue with further whole-group teaching:

- recap prior learning regarding the forms of supply of a range of engineering materials that are available for a range of metallic and non-metallic materials
- explain that materials are available in a range of different forms which allows for suitable forms of supply for most engineering activities
- discuss with learners the need for fixtures and fittings in fabrication tasks, such as gusset plates and spars to provide additional rigidity to structural members, and seals and gaskets to provide air- or water-tight connections between components
- demonstrate to learners how they should interpret specifications and parts drawings in order to initially select a form of material that is appropriate for the task, and then mark it out using the correct tools, setting an appropriate datum for measurements.

You could then give learners individual activities:

- you should give learners a specification and a set of drawings for a range of component parts that, once assembled, will complete a fabricated product; learners should use these drawings to first select materials that are appropriate, and next to use the appropriate equipment to mark out the component parts accurately
- once learners have completed their marking-out activity, they need to explain how each part was marked out
- in addition, learners will need to produce a short report to explain how and justify why they made the choices of material and equipment used for the marking out activity
- learners should demonstrate that they are capable of working safely throughout.

**Assignment 1:** Safely Measure and Mark Out Materials for Fabricated Structures*

**Unit 28: Fabrication Techniques**

**Learning aim B: Be able to safely cut and form materials in a sheet metal fabrication environment**

You could start with whole-group teaching:

- review the various methods that can be used for cutting a range of materials, discussing with learners the typical tools involved
- discuss with learners the methods in which materials can be formed, and explain why it is important to check that equipment is safe to use prior to using it.

You could then give learners individual activities:

- learners should investigate using appropriate methods with the cutting and forming tools they will be using
- each learner should make notes regarding the use of each tool and the forming operations that they performed using each.

You could then continue with a further group activity:

- review the content of the specification and the drawings that learners have used for marking out materials previously
- discuss with learners the various tools and equipment that is likely to be needed for each cutting and forming operation
- explain to learners the importance of making choices regarding tools and equipment, and recording these decisions in their work.

You could then provide learners with individual activities:

- learners should then begin to cut and form their component parts as described in the drawings and specifications; it is important that learners work safely at all times
- once learners have completed their cutting and forming activity, they need to produce a presentation to explain how each part was cut and formed
- in addition, learners will need to produce a short report to explain how and justify why they made the choices of tools and equipment used for their work.

**Assignment 2:** Safely Cut and Form Materials in a Sheet Metal Fabrication Environment*

**Learning aim C: Be able to safely join and accurately assemble fabricated structures**

You could start with whole-group teaching:

- review the previous activities of marking out, cutting and forming; discuss with learners how they made their choices of tools and equipment for the various processes they have undertaken
- introduce the various methods of joining and connecting components during fabrication; discuss with learners the differences between permanent and temporary fixings.

You could then give learners individual activities:

- using the internet and reference books, learners should research the thermal and mechanical joining methods, recording their findings in preparation for their presentations
- learners should also investigate the differences between thermal and mechanical joining methods.

You could then continue with further whole-group teaching:

- review the content of the specification and the drawings that learners have used previously; discuss with learners the various joining methods they have researched and consider which would be appropriate for the assembly of their fabrication

| **Unit 28: Fabrication Techniques** |
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| • discuss with learners the various methods they can employ to make sure that their fabricated product is completed accurately, and explain the concepts of tolerances and discuss the need to make sure that edges and joins are secure and safe<br>• explain to learners the importance of following health and safety rules and regulations during their fabrication work, emphasising that they will need to produce a report into safe working as part of their assessment.<br>You could then give learners individual activities:<br>• learners should then begin to use their component parts to produce a fabricated product; it is important that they use a selection of both mechanical and thermal joining techniques, as well as permanent and non-permanent methods during this activity<br>• learners should follow all appropriate safety rules and regulations during their fabrication work, and then should produce a report linked to safety legislation which explains the safe working practices they employed<br>• in addition, learners will produce a presentation that explains and justifies their chosen joining methods; there should be a comparison between permanent and non-permanent methods of joining, and learners should justify their decisions fully. |
| **Assignment 3:** Safely Join and Accurately Assemble Fabricated Structures* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts Engineering

- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 13: Engineering Assembly*
- *Unit 17: Welding*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Charles, J., Crane, F., Furness, J., *Selection and Use of Engineering Materials*, Butterworth-Heinemann, 1997 (ISBN 9780750632775)

Timings, R., *Fabrication and Welding Engineering*, Routledge, 2012 (ISBN 9780750666916)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A. *BTEC First Engineering*, Hodder Education, 2010 (9781444110524)

### Websites

www.engineershandbook.com
Information about various engineering materials and fabrication methods

www.steelconstruction.org/resources/technical/technical-fabrication.html
Information about cutting, forming and fabrication using steel

# Unit 29: Casting Processes and Techniques

## Delivery guidance

### Approaching this unit

You should approach this unit using a range of techniques. It would be appropriate to provide learners with the experience of an industrial visit where they can see first-hand the casting process. If this is not possible, you should use appropriate videos of casting processes.

You should use a variety of methods to deliver this unit, whether this involves industrial visits or not. It is expected that you use videos and paper-based activities during the teaching of the unit, with the assessment taking the form of presentations and other paper-based tasks.

Where possible, link the casting process to components and products with which learners may be familiar, such as car engines and model vehicles. This will help learners to understand the versatility of casting as a production method.

### Delivering the learning aims

Learning aim A is about casting techniques and the actual casting processes. The aim is to build up learners' understanding of the processes involved with both sand and investment casting. Where possible, you should do this through demonstrations or an industrial visit, however using video will allow learners to see the various processes in action. It is important that learners have a thorough introduction to the equipment used in casting, and also to the specific safety precautions that need to be followed, including the use of specialist PPE.

The focus of learning aim B is the practical aspects of the casting process, including the methods typically used to produce the molten materials needed to produce the casting. Due to the diversity of these methods, it is appropriate to use video clips to demonstrate these to learners and also to discuss the reasons why each is used. Learners should be able to draw upon their prior experience of machining operations in order to suggest methods in which completed castings can be prepared for use. There will, however, be some aspects that are new to learners and, where this is the case, you should aim to make the processes relevant to their experiences.

Learning aim C considers die-casting techniques as used in an industrial context. Learners should be provided with access to components made using both gravity die-casting and pressure die-casting. Learners need to be aware of the typical applications of each and then be able to describe why each process is used for the manufacture of components.

While this unit is assessed through paper-based activities, where facilities exist within your centre to perform demonstrations of casting processes or for learners to experience some aspects of the processes, this will add to their knowledge and understanding of the subject.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 29: Casting Processes and Techniques**

**Introduction**

You could introduce this unit by showing learners a complex component, such as a car gearbox, and discussing with the class the way in which they think the component has been made. This could then be followed with a short video of sand casting to emphasise the ability of casting to produce complex shapes.

**Learning aim A: Know how sand and investment casting processes, including mould-making, are safely used**

You could start with whole-group teaching:

- introduce both sand casting and investment casting, explaining to learners the fundamental differences between the two processes
- explain to learners, using either a demonstration or video, how the processes have similarities and how they are used.

You could then give learners individual activities:

- learners could investigate one product made using the sand casting process; they should research the purpose of the different pieces of equipment used to make the mould
- learners can then complete a similar activity, this time considering the investment casting process.

You could then continue with further whole-group teaching:

- discuss with learners the differences they have identified between the two casting methods; allow learners to think about why different processes are used
- explain the importance of working safely when casting; learners should be aware of the potential hazards of moulding sands and slurries
- explain why engineers will select a casting process that is appropriate for the nature of the component being manufactured
- discuss with learners that processes are selected depending on their suitability for the application; it may be of use to show further video clips of the two processes.

You could then give learners individual activities:

- learners should work on a presentation that compares the two casting processes; they should explain the processes of making the moulds and also describe the applications each is used for
- learners should evaluate the two casting methods, considering the limitations of each process and their suitability for manufacturing specific components.

**Assignment 1:** How Sand and Investment Casting Mould-Making Processes are Safely Used*

**Learning aim B: Know how material melting processes and component removal processes and techniques are safely used in the casting process**

You could start with whole-group teaching:

- introduce learners to the various methods that can be used to melt metal in order to carry out casting processes
- discuss with learners the specific hazards they think will be associated with the melting of materials.

**Unit 29: Casting Processes and Techniques**

You could then give learners individual activities:

- learners can use appropriate resources to research the different types of furnace used in the melting of materials, and record their typical uses
- learners need to investigate the specific hazards associated with these melting methods and the methods that can be used to ensure the process is safe; this is likely to be in the form of tables and charts, plus annotated photographs where appropriate
- learners should also investigate the requirements of different scales of production and how this will influence the type of melting method employed; in their presentations, they should explain in detail how the scale and the method are directly linked together.

You could then continue with further whole-group teaching:

- discuss with learners that, once a casting has been produced, it needs to be removed from the mould; using appropriate demonstrations, explain how each process can be used
- explain why removal of the mould is not the end of the casting process, and that in the majority of cases there will be a need for some form of further work
- discuss with learners the typical tools and equipment used for these activities, considering the equipment with which learners are familiar and the procedures that should be followed when using them.

You could then give learners a task to continue working on their presentations:

- learners should investigate the methods used for removing casts from moulds and the techniques used when producing a casting; they should also fully explain how these activities are completed safely
- learners should evaluate the two casting methods, considering the limitations of each process and their suitability for manufacturing specific components; they should be able to justify why specific products are produced using each casting method.

**Assignment 2:** Material Melting Processes and Component Removal Processes and Techniques*

**Learning aim C: Know how gravity and pressure die-casting processes are safely used**

You could start with whole-group teaching:

- introduce gravity die-casting to learners, explaining the typical uses of a gravity die-casting process, and explain to learners the purpose of cores and dies in the process and the specific procedures needed to work safely with them
- explain to learners, using either demonstration or video, why gravity die-casting is appropriate for the manufacture of specific components.

You could then give learners an individual activity:

- learners should investigate the safety procedures that need to be followed when carrying out gravity die-casting; this information should be presented in such a way as to demonstrate fully the safe procedure that should be followed.

You could then continue with further whole-group teaching:

- introduce learners to the three types of pressure die-casting; discuss with them the similarities and differences between the methods, and the safety considerations that each demands.

You could then give learners further individual activities:

- learners should investigate the three pressure die-casting techniques and produce a short report that takes into account the health and safety considerations that need to be made, along with a detailed description of the processes

| **Unit 29: Casting Processes and Techniques** |
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| • learners should then complete a research activity to compare the three different types of pressure die-casting; this could be in the form of a written report along with annotated drawings for each process.<br>You could then continue with further whole-group discussion:<br>• discuss with learners why it is often preferable to use die-casting over sand and investment casting techniques; discuss the potential reasons why this is often the case at an industrial scale<br>• further discussion could focus on the effectiveness of each of the die-casting processes for the manufacture of specific components.<br>You could then give learners a further individual activity:<br>• learners should produce a presentation to explain why gravity and pressure die-casting are used for the production of different components. This should be approached by considering the characteristics of specific components and how the processes used are the most appropriate in each case. This evaluation should also consider the effectiveness of each of the procedures<br>• learners could continue by comparing the nature of castings produced using die-casting when compared to sand and investment casting. This comparison could focus upon scales of production, quality of outcome and cost. |
| **Assignment 3:** How Gravity and Pressure Die-Casting Processes are Used* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering

- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 7: Machining Techniques*

## Resources

### Textbooks

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Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Campbell, J., Complete Casting Handbook: Metal Casting Processes, Techniques and Designs, Elsevier, 2011 (ISBN 9781856178099)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Videos

http://www.youtube.com/watch?v=mx1qteRUYwI – sand casting

http://www.youtube.com/watch?v=0nz5zfesaoc – investment casting

http://www.youtube.com/watch?v=Xv5LchR6fnM – pressure die casting

http://www.youtube.com/watch?v=LH8B3i6e8d4 – gravity die casting

### Websites

www.technologystudent.com/equip1/equipex1.htm
Health and safety information, plus processes for casting

www.efunda.com/processes/metal_processing/sand_casting_intro.cfm
Sand casting

www.diecasting.org
North American Die Casting Association – concerns all aspects of die casting

# Unit 30: Vehicle Maintenance Techniques

## Delivery guidance

### Approaching the unit

When delivering this unit it is essential you engage in possible career opportunities as well as the unit content as learners could be taking this unit at the very early stages of their involvement with vehicles and the automotive industry.

The most engaging way of engaging learners is by practical investigation and experiential learning, for example, checking vehicles, removing parts and inspecting different types of vehicles to see where components and systems are located. The unit content and outcomes lend themselves to this method of teaching and learning. You will need access to a workshop environment and suitable vehicle resources and equipment. These will include functioning vehicles, data sources, maintenance equipment and parts and materials. There is also an expectation that appropriate health and safety guidance is in place.

Make it clear to the learners that the theory part of the content is crucial to the practical application.

### Delivering the learning aims

Learning aim A is designed to give learners the opportunity to identify and use a range of documents which are likely to be used during a number of maintenance procedures. Give learners various scenarios in which they will be required to find out specific data in order to complete a maintenance activity. Make sure learners have access to a range of sources of information, both in electronic form and also as paper-based documentation. It would benefit learners if you enable them to visit an appropriate centre such as a VOSA test centre or a vehicle service centre in order to witness how professional technicians use these documents in their tasks. The visit need not necessarily be to a centre which works with cars; both LGV and PCV service centres would provide a similar experience.

To further understand the need to use documentation during maintenance procedures, explain to learners the different reasons why procedures are likely to be needed, and how the depth and range of these will differ depending on both the age of the vehicle and also the nature of the maintenance procedure. You could investigate this by considering the different servicing needs of a car over a number of years/mileages.

Learning aim B introduces learners to the equipment with which they will need to be familiar when completing maintenance activities. Provide opportunities within the centre (or in an appropriate venue) where learners can gain hands-on experience of using the equipment. In many cases the equipment will be related to testing, but learners should be able to identify the most appropriate tool for a job based upon criteria such as cost, quality and performance.

Further to this, learners will need to develop an awareness of the criteria which should be applied when selecting components and parts to be used in maintenance activities. To achieve this, you should enable learners to take part in some scenario-based role play activities, or shadow an experienced technician in their work and discuss why certain components are selected over others. Make learners aware of the quality implications of using a range of different components and how the quality of items such as tyres, belts and lubricants becomes more critical as the performance of

a vehicle increases. To approach learning aim C, once more you will need to give learners hands-on experience of working on a range of different vehicles, each with differing maintenance needs. At all times it is important that you emphasise safety while learners are engaged in practical tasks – this should be demonstrated in all of their activities.

Initially, approach learning aim C by considering the different diagnostic and inspection methods which should be used to determine the extent of work which will be needed. Give learners the opportunity to carry out both manual inspections and use commercially-available diagnostic systems. To progress from this, help learners develop the practical skills to adjust a range of components and systems on a vehicle and the depth of knowledge required to explain their actions to a customer. This will require access to an appropriate workshop, vehicles and components. Engage learners through the extensive amount of hands-on work associated with this learning aim and provide them with tasks and activities which are associated with bodywork, the engine, transmission and other systems in a vehicle. Learners should be able to maintain and adjust these systems and their experiences should be broad enough to allow them to have transferable skills to other vehicle models and types. You must also help learners develop the necessary skills required to complete paperwork for each type of maintenance procedure.


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# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

## Unit 30: Vehicle Maintenance Techniques

### Introduction

As a group watch a video clip of a BTCC touring car crew preparing a car for a race. Ask learners to try and identify how many different servicing activities are taking place in the clip. Discuss with learners how the crew will be working to set criteria to prepare the car to an optimum setting. Explain to learners how both the components chosen and the tools used will impact upon the performance of the vehicle and the efficiency of the servicing activity.

### Learning aim A: Be able to select information and data for vehicle maintenance procedures

You could start by whole-group teaching:

- discuss with learners the types of information which they think are needed to complete maintenance procedures on vehicles
- explain to learners that different tasks will have different demands for information, and this information could either be generic, or specific to a single model of car.

You could then introduce some group activities:

- in small groups, learners should research the information needed for a range of activities such as servicing, replacing batteries and bulbs or changing brakes
- following their research, learners should present their findings back to the group.

This could be followed by further whole-group teaching:

- discuss with learners the use of electronic systems, such as databases, and how these compare to more traditional methods
- ask learners to consider the differences between them and why these may exist.

You could then give learners the opportunity to work in pairs:

- in pairs, compare the typical uses of paper-based and electronic information, looking at similarities in the sources and differences in the uses
- learners could then continue to work in pairs and consider why these different types of information may be needed
- in pairs, learners should be given a scenario to identify the documents which they would need in order to complete a specific maintenance procedure; these could be tailored to the ability of learners.

Further whole-group teaching could then be used:

- discuss with learners the format of a range of specific documents related to maintenance activities
- explain to learners that in many cases these will be similar in format, and each will contain specific pieces of key information.

Learners could then complete an individual activity:

- learners to identify key aspects of information from documents which you have given them, and then report their findings back to the whole group
- learners could then discuss in pairs the ease or difficulty with which they found the information.

A further whole-group activity could follow:

- explain to learners that there are a wide range of sources of information, making comparisons between data on CD-ROM, service manuals, manufacturers' manuals and

**Unit 30: Vehicle Maintenance Techniques**

generic workshop manuals

- discuss with learners how on-board diagnostic systems can be of use during a servicing activity
- introduce learners to the specific requirements of the assignment.

Learners should then work individually:

- learners should work to a scenario for a specific vehicle to identify the documents and information sources which they would need to complete the work; the scenario should include customer requirements, along with the types of activity likely to be needed
- they should then describe in detail how they would complete a range of routine procedures for a specific model of car.

**Assignment 1:** Preparing to Complete Practical Activity*

**Learning aim B: Be able to select appropriate equipment, components and materials for vehicle maintenance**

You could introduce this topic with whole-group teaching:

- introduce learners to equipment which they are likely to encounter either by demonstration in a workshop or using photographs or video
- discuss with learners the typical uses of each piece of equipment; encourage learners to ask questions in order to clarify information
- demonstrate the use of the equipment in a workshop environment.

You could then give learners individual activities to complete:

- provide learners with a range of activities which need to be completed, such as checking brake fluid, antifreeze content or belt tensions; ask them to identify the tools and equipment needed to complete the activity
- learners should then complete a further similar task within a given timescale to give them an experience of working in a pressurised environment.

You could then take learners on a field visit:

- take learners to a 'live' environment, such as a testing centre or a fast-fit centre; this will give learners an insight into how equipment is used for real tasks
- learners will also gain experience of seeing components being replaced on vehicles, and should be encouraged, where possible, to ask questions of the staff.

You could then give learners a group activity:

- learners are given specific maintenance activities and need to research the materials and components which are needed for the task; they should identify the function, the cost and the specification of each
- learners should also identify the tools and equipment which they would use to complete these activities.

This could be followed by further whole-group teaching:

- demonstrate to learners the safe procedures for using and fitting a range of components and materials in a workshop environment
- discuss with learners the importance of safety, and question them about their observations during their visit to a service centre
- explain to learners that in many instances further items, such as wiper blades, may also need to be replaced at the same time.

Learners could then complete further individual activities:

- learners are provided with a scenario which requires them to select materials, components and tools

**Unit 30: Vehicle Maintenance Techniques**

- learners should select the appropriate requirements for their servicing activities, and justify their choices in terms of cost, performance and quality; this should include comparisons between a range of different components available.

**Learning aim C: Be able to safely carry out vehicle maintenance and complete maintenance records**

You could introduce the topic with whole-group teaching:

- discuss with learners the consequences of not working safely, such as damaged components; where appropriate use video clips.
- encourage learners to consider these consequences and ask questions about the possible hazards when working with hybrid systems as well as petrol/diesel
- explain to learners that they will need to listen for warning sounds such as engine note, the sound of failing components and warning buzzers/signals inside vehicles.

Learners could then be given a task to complete in small groups:

- learners to complete an inspection of a vehicle to identify defective lights and other components. These should be recorded on a checklist
- a series of audio clips could be used for learners to identify faults with vehicles, with these results also recorded on a checklist
- learners should then report the results of their inspection back to the group.

This could be followed by further whole-group teaching:

- review with learners how to use specialist measuring equipment. Ask questions to determine understanding of the safe use of each
- discuss with learners how there is likely to be a range of causes which will lead to a need for maintenance and how in many cases these will be linked together
- introduce learners to the concepts of malfunction and condition, encouraging learners to investigate the different causes of malfunction and to discuss these as a group.

Learners could then complete some activities in small groups:

- show video clips of motorsport incidents which are the result of component malfunction (loose wheel nut, oil leaks, etc) to demonstrate the impact of such malfunctions; learners to identify what they consider to be the cause of the malfunction
- learners are given the opportunity to inspect a vehicle to identify areas in which they think a malfunction could be possible; this should be recorded, along with the reasons for their thoughts
- learners could then work in pairs to complete an activity such as adjusting headlights or checking bodywork; they should make notes of the process which they carry out.

Further whole-group demonstration and teaching could be used:

- demonstrate to learners the consequences of a loose drive belt, and demonstrate both the diagnostics and rectification processes
- discuss with learners the wider impacts which can be caused by a faulty component or a loose belt
- discuss with learners their observations from their previous visit to a testing station, specifically regarding brake performance testing; demonstrate and explain to learners the processes involved with the adjustment of a hand brake.

This could be followed by further paired practical work:

- learners should work in pairs to correctly adjust a drive belt based on the data with which they are provided
- learners could also be given the opportunity to develop their skills in the areas in which they have seen demonstrations using either vehicles or jigs.

| **Unit 30: Vehicle Maintenance Techniques** |
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| Follow this up with further whole-group activities:<br>• discuss with learners how a car can be divided into five vehicle areas and the systems and components to be found within them<br>• demonstrate, either personally or using video, the safe and proper methods of carrying out maintenance activities on the five vehicle areas<br>• explain to learners that there are differences between petrol, diesel and hybrid technologies and how these have differing maintenance demands for the engine, transmission and electrical systems<br>• discuss with learners that different models and makes of car will have different requirements and filling points; this will need to be demonstrated to learners.<br>Learners can then complete further practical activities:<br>• learners should be given the opportunity to identify features such as oil and coolant filler points either on actual vehicles or photographs of engine bays<br>• learners could then complete maintenance activities on a range of vehicles, with tasks such as checking and replacing brake pads, fluid levels, and aspects of the electrical system and drive belts<br>• learners could also survey a number of cars in the centre car park to identify and report bodywork defects or areas of attention which are not usually covered in a service.<br>You could then use further whole-group teaching:<br>• explain to learners that it is important to maintain records of activities, either for legal reasons (such as MOT) or warranty purposes; discuss with them the type of information which needs to be recorded<br>• explain the information which should be included on each type of document and how these can be used for future reference for completing work at a later date.<br>Learners could then complete some individual tasks:<br>• give learners the opportunity to inspect a range of different documents both from franchised dealers and other service centres; they could note the similarities and differences between them, and then develop their own documents<br>• learners should then use the notes and checklists which they have completed during previous tasks to complete the appropriate paperwork for each activity undertaken<br>• learners should record why they completed activities on each vehicle, and justify their decision to replace components when this has been done. |
| **Assignment 2:** A Day in the Life of a Trainee* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering:

- *Unit 1: The Engineered World*
- *Unit 2: Investigating an Engineered Product*
- *Unit 3: Health and Safety in Engineering*
- *Unit 14: Vehicle Engines and Other Systems*

The following are units that could be progression opportunities.

Pearson BTEC Level 2 Certificate, Extended Certificate and Diploma in Vehicle Technology (QCF):

- *Unit 1: Essential Working Practices for Vehicle Technology*
- *Unit 9: Routine Vehicle Maintenance Techniques*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Hillier, V., *Hillier's Fundamentals of Motor Vehicle Technology Book 1*, Nelson Thorne, 2012 (ISBN 9781408515181)

Bonnick, A. and Newbold, D., *A Practical Approach to Motor Vehicle Engineering and Maintenance*, Routledge, 2011, (ISBN: 9781136270222)

### Websites

www.motor.org.uk
Institute of the Motor Industry; one of the Sector Skills Councils for the automotive industry with links to both standards, apprenticeship types and qualification opportunities

www.semta.org.uk
The Sector Skills Council for Science, Engineering and Manufacturing Technologies

# Unit 31: Production Planning for Engineering

## Delivery guidance

### Approaching the unit

You could approach this unit by relating some activities to learners' own experiences in addition to real-world scenarios. It is likely that learners will have completed some planning activities as a part of their studies, and as such it is important that they are able to understand the differences between the planning of a one-off bespoke product and an engineered product manufactured on a continuous production line.

This unit is designed to be both taught and assessed using traditional paper-based methods, although it will benefit learners if they are able to experience the different scales of production in a real-world setting, either through industrial visits or through the use of videos. Learners would also benefit from experiencing different types of equipment in action in an industrial context. Again, this could be through the use of video or industrial visits. A small engineering company that produces bespoke products for customers could therefore be contrasted with the automated production lines found in either automotive or consumer appliance manufacturing.

### Delivering the learning aims

Learning aim A introduces learners to the different scales of production associated with engineering activities. It would be appropriate to use mainly paper-based teaching and learning activities in the delivery of this learning aim, encouraging learners to complete their own investigatory work in order to produce their own definitions of the various scales of production associated with engineering.

Learners should be introduced to the use of block diagrams as a planning tool, using activities with which they are familiar to introduce the concept. You can then develop this into a consideration of the key stages of the production process, and how each of these stages should be represented in the block plans.

You could then use further video clips or industrial visits to demonstrate to learners the different types of equipment and machinery used at each of these stages, and how the choice and selection of this tooling is related not only to the stage of the manufacturing process, but also to the scale of production for the product being manufactured.

The best approach for learning aim B is to provide learners with a scenario that would give them the opportunity to produce a production plan for a product that needs to be produced in small quantities, but also has potential to be made in larger numbers. This is important to allow learners to meet the criteria for a merit. It would be appropriate to identify a product with which learners have some familiarity in order to allow them to plan effectively.

Learners need to know how to interpret a product specification in order to produce their plans, therefore the specification should provide sufficient detail to allow for effective planning. It would be appropriate for the specification to contain drawings, a parts list and material requirements, as each of these will influence decisions to be made.

In the delivery of this unit, it is important to give learners the opportunity to consider how production and planning need to take into account the scale of production and

the nature of the manufactured product. This understanding will enable them to then make decisions for the design of production plans more effective.


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# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 31: Production Planning for Engineering**

**Introduction**

You could introduce this unit by showing learners a video clip of an automated production process, asking them to consider the different activities they see taking place. You could then discuss with learners the importance of how these processes are carried out in a particular order and at specific times. You could then encourage learners to consider the variables that need to be considered to ensure the planning for production of a product is a success, and how this planning will be influenced by the nature and scale of production.

**Learning aim A: Know about scales of production and the processes and types of equipment used in manufacturing organisations**

You could introduce the subject using whole-group teaching:

- you could begin by discussing with learners how the method of production for a product is often dependent on the demand
- introduce learners to the features and characteristics of each scale of production.

You could then give learners individual activities:

- learners should research the features, characteristics and typical uses of the different scales of production; this could be done using the internet and reference books
- each learner could then produce either a short report or presentation explaining the characteristics of each scale of production.

You could then continue with further whole-group teaching:

- introduce learners to the use of block diagrams to explain the stages of a project
- explain how each of these blocks represents a specific stage of the production process; discuss with learners the typical activities that take place at each of these stages
- explain to learners that different stages of the production process and different scales of production will influence the equipment used during manufacturing activities.

You could then give learners individual activities:

- learners should produce a block diagram describing the activities that take place at each stage of the production process; learners could then develop this to consider the specific activities at each stage for a given product
- learners should produce a short report or presentation to describe the typical uses of the types of equipment used for engineering activities; they could develop this by providing a justification for the selection of the equipment based upon the scale of production for the product
- learners could then be given a range of products, ranging from items such as suspension bridges, through to components such as washers; for each, learners should justify the scale of production appropriate for the manufacture of the product.

**Assignment 1:** Scales of Production, Processes and Types of Equipment*

**Learning aim B: Be able to produce a production plan and product specification and prepare related information**

You could start with whole-group teaching:

- review with learners the factors that need to be considered when producing a production plan; learners should consider their activities for learning aim A

| **Unit 31: Production Planning for Engineering** |
|---|
| • discuss with learners the information that needs to be contained within a plan in order to make it effective<br>• further discussion could then consider the planning of a simple engineered product; this should be done as a group in order to allow all learners to contribute and also to gain an understanding of the planning process.<br>Learners should then begin to work on individual tasks:<br>• learners should be given a detailed specification for a simple engineered product, where several processes are needed and there will need to be consideration of manufacturing parameters, costings and labour requirements; the product need not be one that the learner could make using the centre's facilities<br>• learners should produce a production plan that considers all of the major factors involved for the manufacture of the product at a jobbing scale; they should select tooling and processes that are appropriate for this scale of production<br>• learners should also produce supporting evidence for their plan, such as why speeds and feeds have been selected for a certain production process or justification for the order in which activities have been completed.<br>You could then develop this understanding further with whole-group teaching:<br>• discuss with learners how production processes and plans may need to be adjusted if the quantity to be produced is increased – a simple example of cutting a bar with a hacksaw for a one-off but using a chop saw to cut 50 would be appropriate<br>• explain that manufacturing processes will often use more machinery as opposed to hand tools as production increases, and it is likely that the order in which some processes are completed will be changed as a result<br>• discuss with learners how factors relating to cost and time will change, in addition to more obvious details such as materials and components, as and when production increases.<br>You could then give learners an individual activity:<br>• learners should be asked to revise their initial plan to take account of an increase in production; this should be an increase for small batches being produced at regular intervals<br>• using their new plan, learners should revise their costings for the manufacturing process, taking into account materials, components, time and labour; learners should also make reference to changes in their production methods, such as tooling and equipment. |
| **Assignment 2:** Production Plans and Product Specifications* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering

- *Unit 1: The Engineered World*
- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 7: Machining Techniques*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 13: Engineering Assembly*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Deacon, M., O'Dwyer, N. and Tooley, M., *Edexcel Diploma Engineering Level 2 Higher Diploma*, Pearson Education, 2008 (ISBN 9780435756208)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Videos

http://www.youtube.com/watch?v=VSDMP8bbnxA – jobbing production

http://www.youtube.com/watch?v=cE104lVfor0 – batch production

http://www.youtube.com/watch?v=r5wwps7BKuU – continuous production

http://www.youtube.com/watch?v=rXG1a6pU5K4 – automated production of a car

### Websites

www.bdc.ca/en/advice_centre/articles/Pages/production_planning_plan.aspx
Advice on producing an effective production plan

www.technologystudent.com/joints/scalep1.htm
Describes scales of production

# Unit 32: Engineering Marking Out

## Delivery guidance

### Approaching the unit

This unit should be approached in such a way as to give learners both the theoretical knowledge required to perform marking-out activities, and also the practical skills required to be able to mark out products with accuracy. As such, this unit lends itself well to a mixture of activities, with a significant amount of practical work expected to be involved.

You may wish to incorporate the delivery and assessment of this unit into a larger project that would cover several different units, which is an appropriate approach to take. This would allow learners to get an understanding of the need for accuracy in marking out by relating this to a tangible product. It is expected that, in order to deliver this unit, centres will have workshop facilities available to them, and the tools, drawings and materials required for the marking-out activities.

### Delivering the learning aims

Learning aim A introduces learners to the principles involved with marking-out activities, such as the need to have reference points from which to take measurements. You should also introduce learners to a range of marking and measuring tools that they will use to carry out procedures on a number of different shapes and forms of material. It would be appropriate to deliver this knowledge through a combination of theoretical sessions and demonstrations followed by learners completing focused tasks to practise and develop their skills in these areas. It is also important to make learners aware of the need to calibrate measuring and marking tools to ensure that marking-out activities are carried out to a high degree of accuracy.

When carrying out the practical marking-out activities, it is important to provide learners with the opportunity to measure and mark out not only regular shaped bars and plates, but also irregular castings and forged components.

Learning aim B introduces learners to the need to be able to produce a work plan that they can use to complete marking-out activities. Learners should have an awareness of working drawings and work plans from their previous studies, and should be able to draw on this understanding, along with their knowledge gained for learning aim A, in order to produce work plans for several marking-out activities.

It is expected that the majority of the teaching and learning for learning aim B will be carried out as practical tasks. As such, it is important that learners have the opportunity to reflect on their previous work when they are required to identify and select appropriate equipment. When designing activities for your learners, in order to meet the requirements of this learning aim, you should ensure that the tasks give learners the opportunity to carry out a range of different marking-out activities, including working with several different forms and profiles of material.

As with other units where practical activities are involved, learners need to show that they are able to work safely, both by performing activities in a safe manner and also by maintaining a safe working environment.

To deliver this unit, it is important that learners have workshop facilities available to them which include a broad range of marking and measuring tools. You will also need

to have appropriate drawings available for learners to use in order to select equipment and carry out marking tasks.


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# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

## Unit 32: Engineering Marking Out

### Introduction

You could introduce this unit by providing a range of materials in their stock form and some completed engineered products made from the same materials, such as steel plate and hinges or other similar, simple products. You could then discuss with the group the process of changing the flat plate into the product, and how a combination of marking-out, cutting and forming activities need to take place – emphasising the importance of accuracy in marking out.

## Learning aim A: Know about marking-out methods and equipment for different applications

You could start with whole-group teaching:

- introduce learners to the key concepts that underpin all measuring and marking-out activities, such as setting a datum and other reference points from which to measure
- discuss with learners why these reference points are needed and also the importance of making sure that the equipment that they will use is well maintained and accurate.

You could then give learners individual activities:

- using the internet and reference books, learners should research the applications and uses of various items of tooling, holding methods and marking out mediums that are used in engineering
- each learner could identify a typical use of each item and the materials with which its use is appropriate.

You could then continue with a demonstration:

- introduce learners to the various methods of marking out materials in different forms; using either video or demonstration, show learners the appropriate methods for marking out square, circular and irregular shapes on materials
- reinforce the importance of having a datum from which to measure, and explain the need to take all measurements from that point
- discuss with learners how different marking-out and measuring equipment is used together in order to have accuracy.

You could then give learners individual practical activities:

- learners should be given three different marking-out activities to complete, which should involve the use of a wide range of marking-out and holding equipment, and may increase in complexity; each activity should be based around a different form of material supply
- learners should first select the tools and equipment that they will need for each activity, and produce a short report explaining how each will be used for the activities
- this should be followed up by a work plan explaining in detail how each marking-out activity will be completed
- on completion of their plan, learners should use their plan to safely and accurately mark out each material; it is important to record these stages using photographs and observation records.

**Assignment 1:** Methods and Equipment Marking Out*

| **Unit 32: Engineering Marking Out** |
|---|
| **Learning aim B: Be able to mark out engineering workpieces to specification using safe working practices** |
| You could start with whole-group teaching:<br>• review with learners the activities they have completed using marking-out and measuring tools<br>• discuss with learners the implications of not having equipment correctly calibrated, such as components not being correct, parts not being in tolerance, etc<br>Learners should then begin to work on individual tasks:<br>• learners should consider the tasks they have completed and explain why it was important that each tool was correctly adjusted and calibrated for the task; this should be recorded in the form of a report<br>• learners will then develop this further by considering the datum and reference points they used for their marking-out tasks; they should produce a written justification of their choices<br>• learners will also need to justify their selection of tools and equipment for marking-out, measuring and holding as a part of this report.<br>You could then develop learners' understanding with whole-group teaching:<br>• discuss with learners the parameters that influence the accuracy of marking out, such as accuracy of tooling and the method of work holding<br>• with the group, discuss how the correct holding methods allowed accurate marking<br>• discuss with learners the process of evaluating a work plan; emphasise to learners that this is not an evaluation of their outcomes but rather the processes involved to reach the outcomes.<br>You could then give learners further individual tasks:<br>• Learners should review the activities they have completed and produce a report to explain the importance of setting workpieces correctly in order to ensure accuracy. |
| **Assignment 2:** The Importance of Getting it Right When Marking Out* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering

- *Unit 1: The Engineered World*
- *Unit 3: Health and Safety in Engineering*
- *Unit 5: Engineering Materials*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 31: Production Planning for Engineering*
- *Unit 35: Application of Quality Control and Measurement in Engineering*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Timings, R., *Engineering Fundamentals*, Routledge 2012 (ISBN 9780750656092)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 978-1-444110-52-4)

### Videos

www.youtube.com/watch?v=pirr21PjYNc
Using and calibrating a vernier height gauge

www.youtube.com/watch?v=2PWnE6V0PGA
Marking out steel plate

### Websites

www.technologystudent.com/equip1/equipex1.htm
Measuring and marking-out tools explained

www.clag.org.uk/workshoppart02.html
Simple description of marking out

# Unit 33: Preparing and Controlling Engineering Manufacturing Operations

## Delivery guidance

### Approaching the unit

The majority of products manufactured by engineering businesses go for sale on the open market. This marketplace is very competitive and for a company to stay in business any products that it produces have to be fit for purpose, of the correct quality, be delivered on time, and be at the correct price point. The message that you should be getting across to your learners is that there is much more to producing a product than just the straightforward physical activities of cutting metal and assembling components. Perhaps remind learners that key factors to achieving success in any walk of life are excellent preparation and robust control of the actions that follow.

### Delivering the learning aims

Learning aim A is about investigating how to prepare work areas so that efficient manufacturing of engineered products can take place. Learners will become aware that carrying out a mechanical process, such as cutting metal or fabricating a component by welding, is only part of a much larger structured process. When delivering the learning aim your learners will benefit if you support your presentations with exemplars of good and not so good practice. If you can link up with a local engineering company that has good manufacturing systems in place this would be ideal. Basing all your teaching input on what happens in a school/college workshop is less than ideal because this is not a real business environment. In delivering this learning aim, learners will benefit from a visit to an engineering company to see how batch manufacturing of products is organised. Alternatively, a presentation from a guest speaker (manufacturing engineer) would be useful. Both these activities would need to be carefully structured and involve a company that has robust manufacturing systems in place.

Learning aim B investigates how manufacturing procedures are controlled so that when products are being produced they meet quality standards and production targets. The efficient use of materials and equipment resources is also covered, as is the implementation of appropriate safe working practices. The emphasis of this learning aim is about the control of manufacturing operations, not the actual 'hands on' implementation of processes. However, it will make sense to link investigations to other 'making' units in the programme. Providing your learners with exemplars of good, and not so good, control of operating procedures will benefit them.

For both learning aims the gathering of some information for formative and summative purposes will require your learners to be operating in workshop environments. It is important that they are fully aware of how to keep safe and the possible implications of not adhering to relevant health and safety regulations and working practices.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 33: Preparing and Controlling Engineering Manufacturing Operations**

**Introduction**

You could start by showing learners two images: one of a workshop that appears to be in total chaos (e.g. raw materials piled up, workers not wearing PPE, machine tools dripping oil, cables lying around, emergency exits blocked); the other of a workshop that is well organised and working efficiently. These images would support the focus of the first part of the unit, which is to convince your learners that it is very difficult to carry out a job effectively unless things are organised, correct resources are in place and ground rules are laid down. Perhaps talk to your learners about car assembly and the logistics of bringing together components that have been produced at different sites.

**Learning aim A: Be able to prepare a work area for a manufacturing operation in a safe manner according to defined procedures**

You could start with a whole-group discussion:

- identify the benefits to an engineering business of maintaining its manufacturing areas in good order
- give an overview of the procedures followed when raw materials arrive at a factory and when waste is removed at the end of machining operations
- give an overview of the systems in place to manage the storage, issue and hand-back of tools and equipment.

You could support this with input from a guest speaker or a visit to a company. If using a guest presenter do be careful to fully brief them about the level at which to pitch their input and the attention span of your learners.

You could follow this up with a small group role-play activity based on an exemplar of a small engineering business. Provide your learners with a factory layout, product details, job titles and any other relevant information (this could be a fictitious company, but better if it were a local business that was able to help with the delivery of this unit).

- Learners role-play the people involved with product manufacturing.
- A small group of students are to visit the factory to gather information about how products are made.
- With the aid of block/system diagrams, prepare a presentation that shows how preparation of work areas is organised and the procedures followed when manufacturing is carried out.

You could follow this with whole-group teaching:

- discuss problems that may need to be overcome when preparing a work area
- review how to maintain a safe working environment in work areas.

The previous small group activity could now be expanded:

- add to the presentation information about problems that might occur in relation to raw materials, equipment, tooling, the condition of the work area and safe working; outline strategies for resolving them
- if time allows, each group could deliver their presentation to an audience.

**Assignment 1:** Preparing the Work Area*

**Learning aim B: Be able to control a manufacturing operation in a safe manner according to defined operating procedures**

You could start with a whole-group discussion:

- explain that this learning aim is about investigating the techniques used in industry to effectively control manufacturing operations involving machine tools
- explain that, to achieve the learning aim, learners do not necessarily have to carry out a manufacturing operation themselves; they can base their investigations on how they control manufacturing being carried out by another person
- review the operating procedures and potential problems when manufacturing components, and discuss strategies for resolving them.

You could follow this with an individual or small group activity:

- produce a report about operating procedures and control of the manufacturing operation.

You could then follow up with whole-group teaching:

- discuss the adjustments that might have to be made to a manufacturing process to achieve compliance with the product specification and operating in a safe manner
- discuss how collected data (for example, dimensional), is used to influence decisions about adjustments made during a manufacturing operation.

You could follow this with an individual or small group activity:

- learners prepare a report that reviews the effectiveness of the operating procedures followed, problems encountered and how they were overcome
- learners add another section that reports back on how data collected was used to influence the manufacturing operation – for example, machine adjustments based on dimensional measurements
- learners add another section to the report that details how data collected was used to assess the quality of the finished product and the use of resources (raw materials, consumables and equipment)
- learners discuss the effectiveness of the systems in place to provide a safe working environment.

**Assignment 2:** Controlling Manufacturing Operation*

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering:

- *Unit 3: Health and Safety in Engineering*
- *Unit 6: Computer-aided Engineering*
- *Unit 7: Machining Techniques*

Pearson Level 2 NVQ Diploma in Performing Manufacturing Operations (QCF):

- *Unit 5: Preparing for manufacturing operations*
- *Unit 6: Controlling manufacturing operations*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Boyce, A., Clarke, S., Darbyshire, A., Mantovani, B. and Weatherill, B., *BTEC Level 2 First Engineering Student Book*, Pearson Education, 2010 (ISBN 9781846907234)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

# Unit 34: PC Software and Hardware in Engineering

## Delivery guidance

### Approaching the unit

This unit should be approached by combining theoretical studies with a range of practical activities. As such, learners should find this unit to be enjoyable and engaging, and relevant to their daily lives. Learners will generally have some understanding of how computer systems operate, but are likely to have misconceptions that will need to be addressed.

This unit is designed to be taught and assessed using both traditional paper-based activities for learning aim A, and then practical tasks for learning aims B and C. As such, it is important that centres have a range of components and peripherals that can be installed into PCs. As the unit requires software and operating systems to be installed, centres may consider it appropriate to identify a small number of computers that can be used for this purpose.

### Delivering the learning aims

Learning aim A introduces learners to the basic operation of a PC system, including the input and output devices that are commonly used with PC systems. Learners should develop their understanding of how a computer system operates by considering the building blocks of the system – the inputs, processes and outputs. In many cases, due to their use of these systems, learners will be familiar with some of these but others will be new to them. Learners need to understand what happens inside 'the box' of the computer, considering the processors, memory and storage methods. They will also need to know about the language the computer uses.

Learners should become familiar with a wide range of input and output devices, again some of which will be familiar and others new. You could approach this by combining class teaching activities and individual research tasks to investigate image processing and hand-input devices alongside a range of output devices.

For learning aim B it is useful to employ a variety of teaching and assessment styles. It is intended that learners will complete a number of practical activities to generate the evidence required for completion of this learning aim. It would be appropriate therefore for learners to observe demonstrations of the installation of hardware, to research the purpose of different pieces of hardware and to attempt their own practical activities to add devices to a computer system.

Learners will need to show that they understand the methods used to describe a system, such as block diagrams. They will also need to demonstrate their ability to install and configure hardware following recognised procedures and using appropriate equipment.

Learning aim C gives learners further opportunities to carry out practical work. It is expected that the delivery of this learning aim will involve a combination of paper-based activities and demonstrations. Learners will need to understand the processes involved and be able to plan the installation of software. They will need to be able to set up an operating system and configure it for the needs of the user, considering and evaluating the different options that are available during the set-up process. The evidence for the successful completion of these set-up activities should take the form of screenshots and observations.

Due to the practical nature of this unit, learner evidence is most likely to take the form of log books, notes and practical outcomes. As such, annotated photographs of their work, along with detailed observation records will be required in order to provide evidence of the successful completion of this unit.

# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

## Unit 34: PC Software and Hardware in Engineering

### Introduction

You could introduce this unit by asking the group about computer systems and how they think they work. You could discuss with them that no matter how complex the system is, be it for controlling a CNC machine or tracking satellites, the system can be designed as a block model and is made from building blocks of peripherals and software.

## Learning aim A: Know the basic operation of standard PC systems

You could start with whole-group teaching:

- introduce learners to the concept of inputs and outputs with regards to computer systems – this could be related to Unit 8
- discuss with learners the use of block diagrams to describe the make-up of a computer system.

You could then give learners individual activities:

- using the internet and reference books, learners should attempt to identify a wide range of input and output devices used in computer systems; these should be recorded in a log book or report
- learners could then proceed to use the internet to research the specification for a computer system, making particular note of the components which are used in the base or tower unit.

You could then continue with further whole-group teaching:

- discuss with learners the results of their investigations, considering the purpose of each of the component parts identified
- introduce learners to the various languages and coding methods which are used within computer systems, the differences between them and the applications of each.

You could then give learners further individual work:

- learners can use a range of resources to identify the function and purpose of the component parts which form the base unit for a PC, recording these appropriately
- learners can then compare the coding systems which are used within computers, giving examples of the applications of each.

You could then continue with a further whole class discussion:

- discuss with the group the requirement to have input and output devices in a system
- explain that inputs can be classified as either being image processing such as scanners or hand devices such as keyboards and touch pads
- discuss with learners how output devices can also be classified into a number of groups, and that it is important to select both input and output devices as appropriate for an application.

You could then give learners individual activities:

- give learners two scenarios where a range of different input and output devices are needed; they should select the appropriate input and output devices explaining and justifying their choices
- produce a presentation which explains how a computer system operates, and the reasons for their selection of input and output devices for their given scenarios.

**Assignment 1:** PC Systems*

**Unit 34: PC Software and Hardware in Engineering**

**Learning aim B: Be able to safely install and configure standard PC hardware components**

Using whole-group teaching:

- you could review the knowledge gained from learning aim A, considering the simple building blocks that have been used to represent the computer system
- explain to learners that there is a wide range of different types of hardware component that need to be installed into a system in order for it to function correctly.

Learners should then begin to work on individual tasks:

- learners can then investigate the purpose of a range of hardware components, including motherboards, processors, memory, displays, interfaces and power supply units
- for each of these hardware types, learners need to explain what it is used for in the system and to identify its key features and applications.

You could then develop this understanding further through demonstrations and discussion:

- either using demonstration or video, show learners the correct procedures to follow when installing hardware components
- explain that hardware components are likely to need to be installed in a given order, and this could influence the performance of component parts
- discuss with learners the precautions that should be taken when working on electrical equipment, such as using an electrostatic strap, and the dangers of working with mains voltages.

You could then give learners an individual activity:

- learners should install three different hardware devices; these should include at least one peripheral and at least one hardware device and should be installed following the correct safety procedures
- following the installation of devices, learners will need to justify their selection of hardware, with reference to the intended end user
- learners will also need to produce a comparison between the features and operation of bus systems, interfaces and controllers; this could either be written or verbal, supported by observation records.

**Assignment 2:** Hardware Installation*

**Learning aim C: Be able to safely install standard software packages and operating systems, configure and test complete PC systems**

You could start with whole-group teaching:

- review with learners the processes they have been through to install hardware devices on their computers; discuss with them that the hardware alone will not provide a useful computer and that there needs to be software to allow the computer to function
- discuss with learners the types of software with which they are familiar, considering the differences between applications and operating systems.

You could then give learners a practical activity to complete:

- you could give learners a range of software applications from which to select two; these could be in the form of CD/DVD or downloaded files.
- learners should produce a log book to describe the processes they followed to complete the installation of these software packages, noting down issues they encountered and also the options they selected in order to customise the software setup.

You could then continue with further whole-group teaching:

**Unit 34: PC Software and Hardware in Engineering**

- introduce learners to the different requirements for installing an operating system, when compared to an application; discuss with them how the installation may need to be customised depending on the needs of the user
- demonstrate, or use an appropriate video to show, how to install an operating system onto a computer.

You could then give learners the task activities to complete:

- learners should produce a plan for the installation of an operating system onto a computer; this may consider the needs of the end user, the software they need and the order in which the installations should be completed
- learners should then install an operating system onto a computer system; as with the application installation, they should note down how and why they were able to customise the system for the end user.
- as with the installation of the software, learners should complete a logbook to record the decisions made and the processes they went through to install the operating system
- on completion of the installation of the operating system, learners should evaluate the suitability of the completed installation compared to the stated needs of the end user.

You could then continue with further whole-class teaching:

- discuss with learners the scope for producing bespoke computer systems, either for individuals or for commercial clients
- explain that in most instances, the customer will state the requirements of a system rather than the discrete components and applications they would like to be installed; as a result, it is important to be able to interpret these specifications in order to select the most appropriate hardware and software for the task.

You could then give learners a further practical activity:

- you could provide learners with the specification for a computer system, which would include generic requirements such as memory size, hard disk capacity, etc, along with the types of application the customer would like installed
- learners should then interpret this information to produce a detailed specification for the system, including supplier data and technical information
- using this specification, and their prior knowledge of both software and hardware installation, learners should build a customised system that meets the needs of their customer
- on completion of the installation, the system should be tested to ensure that it functions correctly, and that it fully meets the requirements of the customer.

**Assignment 3:** Software Installation and PC Assembly*

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units/qualifications

BTEC Firsts in Engineering

- *Unit 2: Investigating an Engineered Product*
- *Unit 3: Health and Safety in Engineering*
- *Unit 8: Electronic Circuit Design and Construction*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 21: Introduction to Communications for Engineering*
- *Unit 23: Electronic Devices and Communication Applications*
- *Unit 26: Operation and Maintenance of Electrical Systems and Components*

## Resources

### Textbooks

In addition to the resources listed below, publishers are likely to produce endorsed textbooks that support this unit of the BTEC Firsts in Engineering. Check the website (www.edexcel.com/resources) for more information as titles achieve endorsement.

Allman, E., Jarvis, A., Kaye, A., McGill, R., Richardson, D., Soomary, N., Elson, B. and Winser, P., *BTEC First Information and Creative Technology Student Book*, Pearson Education, 2012 (ISBN 9781446901878). Units 2, 14 and 15.

Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Chambers, M., *PCs All-in-One Desk Reference For Dummies*, 4th Edition, John Wiley & Sons, 2011 (ISBN 9781118052204)
Has chapters on both hardware and software.

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 9781444110524)

### Videos

www.youtube.com/watch?v=YzvNMlOa1vw
Guide to installing Windows 7 (student friendly)

www.youtube.com/watch?v=NbYnaRRZlVA
Guide to installing MacOS Mountain Lion on an iMac [free text]

http://www.youtube.com/watch?v=SlAJUtZekAA
Guide to the hardware components in a computer (one of a series which explains installations)

### Websites

www.computerhope.com/issues/chadd.htm
Tips for installing hardware devices

http://jamesl.hubpages.com/hub/How-to-install-computer-hardware
Guides for installing hardware onto a computer system

# Unit 35: Application of Quality Control and Measurement in Engineering

## Delivery guidance

### Approaching the unit

This unit should be approached by relating theoretic concepts to the everyday experiences that learners are likely to encounter. Learners are more likely to understand the need for quality control and accuracy for products such as mobile phones and cars, rather than items they will be aware of but unlikely to ever get first-hand experience of, such as satellites and similar, although these will be suitable for a 'wow factor' to introduce the unit.

This unit is designed to be both taught and assessed using a combination of traditional paper-based activities alongside both presentations and practical activities, which will enable them to gain the knowledge and skills needed to inspect engineered products for quality. Learners will need to carry out a number of independent tasks, including the inspection of simple engineered products. You should select these to be relevant to learners but also give them opportunities to gauge the items against the given requirements.

### Delivering the learning aims

Learning aim A introduces learners to the concept of quality and the parameters associated with quality control. The aim of the unit is to give learners the background knowledge required to understand how quality can be impacted upon by both internal and external influences. You can do this by giving learners case studies and scenarios to investigate. These should be based around mass-produced, commercially available products, rather than bespoke high-end items or craft-made products.

Learners should have the opportunity to conduct some individual work in order to gain a thorough understanding of the requirements of testing for quality checking. This will allow them to understand more fully the reasoning for performing tests on samples for mass-produced products as opposed to 100% testing for bespoke products.

Learning aim B introduces learners to the concept of tolerances and fits. Learners should be given the opportunity to investigate the three types of fit – interference, transition and clearance, and how each of these is relevant to the assembly of components in engineering. Where possible, give learners the opportunity to investigate assemblies where all three are present. This allows them to compare them and determine how and why each is relevant and useful for assemblies. Learners should also consider the various standards related to tolerances, and be prepared to consider how these are used for real-world applications when studying learning aim C.

Learning aim C is intended to give learners the opportunity to develop the practical skills necessary for judging the quality of components with regards to tolerance and fit. You should make sure that there is a range of measuring equipment available to them, in addition to a range of products, each with some defect. The defects could be minor or major, and it would be of use to learners if the products also ranged in complexity.

Learners will need to determine whether the products are within acceptable levels of tolerance, therefore will need appropriately detailed engineering drawings and specifications to judge against.

It is important for learning aim C that learners are able to select their own measuring and comparator tools, therefore guidance may be given, but should be kept to the minimum that each individual learner will need to complete their work.


Delivery Guide – Pearson BTEC Firsts in Engineering –
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# Getting started

**This provides you with a starting point for one way of delivering the unit, based around the suggested assignments in the specification.**

**Unit 35: Application of Quality Control and Measurement in Engineering**

**Introduction**

You could introduce this unit by discussing with the group the need to make sure that complicated products, such as cars or aeroplanes work correctly and reliably. Extend this by thinking about the sheer number of components that need to be brought together to make these products, and how it is vital that each is produced to a specified level of accuracy – the tolerance.

**Learning aim A: Know about quality and quality control in engineering**

You could start with whole-group teaching:

- introduce the concepts of quality costs in engineering, and ask learners to suggest what these could be
- discuss with learners what 'fitness for purpose' and 'safe to use' are, and how these differ when considering engineered products
- introduce learners to the ISO9000 quality standards, and discuss how these standards can influence the requirements of a customer.

You could then give learners individual activities:

- using the internet and reference books, learners should produce a short report that explains the different meanings of quality
- learners could also investigate three products and report on their fitness-for-purpose; one product could be poorly manufactured, one over-engineered and a third one of a suitable quality for use.

You could then continue with further whole-group teaching:

- introduce learners to the five essential parameters of quality control, giving them an overview of the purpose of each
- discuss with learners the appropriate use of the parameters of quality control and the appropriate applications for each
- explain to learners the appropriateness of different approaches to quality control depending on the level of production for the product in question.

You could then give learners individual activities:

- learners should research and report on the five essential parameters of quality control, providing a description for each
- learners should develop, using particular examples, their report to consider specific examples for each of the five parameters, depending on the nature of the product and the quantity in which it is manufactured.

**Assignment 1:** Quality in Engineering*

**Learning aim B: Know about dimensional tolerances and types of fit for simple components**

You could start with whole-group teaching:

- review the concepts of quality control and discuss with learners the need to have some form of flexibility when producing components, as 100% accuracy is not often achieved in all products
- discuss with learners the principles of tolerances and how these relate to engineered products.

**Unit 35: Application of Quality Control and Measurement in Engineering**

Learners should then begin to work on individual tasks:

- using appropriate sources, learners should research the main principles of tolerances and record these in order to assist with the production of the information leaflet
- learners should develop this by considering why there needs to be a number of different principles involved by selecting and explaining a suitable principle of tolerance for a product.

You could then extend learners' understanding with further whole-group teaching:

- introduce learners to the concepts of fit, including clearance, transition and interference
- explain that there will be situations when all three types of fit may be required for the same component, and discuss the consequences of non-compliance with requirements
- discuss with learners how drawings can be interpreted in order to identify the nature of the fit between two or more component parts.

You could then give learners an individual activity:

- using appropriate sources, learners should research the main different types of fit, and explain the importance of each for engineered products
- learners should then use information presented to them in drawings to identify the nature of the fit between parts and also the allowed manufacturing tolerances
- learners should consider why different types of fit, and allowances for tolerance are required, and justify these for the assembly of mated parts
- learners could then consider the consequences of failing to meet the given requirements, and how this will impact on the assembled product; where appropriate, this could take the form of annotated sketches and drawings.

**Assignment 2:** Tolerances and Grades of Fit*

**Learning aim C: Use quality control equipment to monitor the quality of simple engineered products**

You could start with whole-group teaching:

- review prior learning regarding measurements, explaining and discussing the differences between geometric and dimensional features
- discuss with learners how further features can be judged, including surface texture and finish.

You could then allow learners to investigate independently:

- using appropriate sources, learners should investigate the nature of the dimensional and geometric features that engineered products display
- learners should then consider how these features can be shown on engineering drawings, and how features such as tolerance and fit are interpreted.

You could then continue with further whole-group teaching:

- discuss with learners the typical uses of a range of measuring tools, relating these to quality-control activities
- introduce learners to comparator equipment used for quality-control purposes, discussing the use of each.

You could then give learners the task activities to complete:

- learners should be given a range of simple engineered products, along with drawings, which they should inspect using measuring and comparator equipment
- for each activity, learners should describe how the equipment has been used; they should also describe how these simple products have been inspected for surface texture features
- learners should justify their choices of equipment for completing their checks, relating this to the measurements that needed to be taken and the nature of the product

| **Unit 35: Application of Quality Control and Measurement in Engineering** |
|---|
| • in addition, learners should use drawings to evaluate the quality of three engineered products, based on the dimensions, tolerances and fits; as a result, learners should be able to judge the fitness for purpose of each<br>• learners should have a range of non-compliance issues to identify, varying in severity; they should record their work using photographs, with appropriate annotation. |
| **Assignment 3:** Using Quality Control Equipment* |

*Full details for the assignment and scenario can be found in the relevant qualification specification.

## Details on links to other BTEC units, BTEC qualifications and links to other relevant units / qualifications

BTEC Firsts in Engineering

- *Unit 1: The Engineered World*
- *Unit 3: Health and Safety in Engineering*
- *Unit 9: Interpreting and Using Engineering Information*
- *Unit 10: Mathematics for Engineering*
- *Unit 15: Operating an Efficient Workplace*
- *Unit 22: Continuous Improvement and Problem-Solving*
- *Unit 31: Production Planning for Engineering*

## Resources

### Textbooks

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Boyce, A., Clarke, S., Darbyshire, A., Goulden, S., Hallgarth, C. and Watkins, N., *BTEC First Engineering Student Book*, Pearson Education, 2013 (ISBN 9781446902431)

Morris, S., *Measurement and Instrumentation: Theory and Application*, Academic Press, 2011 (ISBN 9780123819604)

Tooley, M., *BTEC First Engineering: Mandatory and Selected Optional Units for BTEC Firsts in Engineering*, Newnes, 2010 (ISBN 9781856176859)

Wallis, S., Godfrey, N., Carey, A., Casey, M., King, A., *BTEC First Engineering*, Hodder Education, 2010 (ISBN 978144411052-4)

### Websites

www.isixsigma.com/implementation/financial-analysis/cost-quality-not-only-failure-costs/
Quality costs

www.technologystudent.com/equip1/equipex1.htm
Measuring equipment

# Annexe

## Definitions of terms used in assessment criteria grids

Most assessment criteria start with a command word – 'describe', 'explain', 'evaluate' etc. These words relate to how complex a learner's answer should be.

Learners will need to provide evidence that meets the command-word requirements of a criterion. Some terms in the assessment criteria grids have particular meanings in the I&CT sector. For clarification, definitions are given below for each of the terms used.

You can use this glossary with your learners to:

- help them understand what the language used in the criteria means
- what they will need to do to attain a specific grade
- to give further clarification on how their work has been assessed.

You may also find it useful as a means of providing further guidance when you are assessing learner work against the assessment criteria.

| Assessment word | Definition |
|---|---|
| Analyse | Use ideas or concepts to explore something carefully, breaking it down into factors and giving comments on which are most important or relevant. |
| Assemble | To put together the parts, usually in a required way. |
| Assess | Give careful consideration to all the factors or events that apply, and reach a conclusion about which are the most important or relevant. |
| Calculate | Determine the answer using mathematical methods. |
| Carry out | Complete task using a structured approach. |
| Comment on | Put forward thoughts. |
| Communicate | Make sure other people are aware of what is being shown/discussed/communicated by an exchange of thoughts. |
| Compare and contrast | Identify the main factors relating to two or more items/situations, explain the similarities and differences, and in some cases say which is best and why. |
| Construct | To put together the parts in a systematic manner. |
| Contribute | To supply ideas or opinions; or to be partly responsible. |
| Create | Use techniques to create a product or system. |
| Demonstrate | Complete a practical task effectively, showing expected skills.<br>**or**<br>Show knowledge by providing relevant examples or application. |
| Describe | Give a clear description that includes all the relevant features – think of it as 'painting a picture with words'. |

| | |
|---|---|
| Develop | Use techniques to develop a product or system. |
| Design | Develop and structure a plan that can be executed within a given situation. |
| Discuss | Consider different aspects of a topic, how they interrelate, and the extent to which they are important. |
| Edit | Review and correct. |
| Evaluate | Bring together all information and review it to form a conclusion. Give evidence for each view or statement. |
| Explain | Provide details and give reasons and/or evidence to support the arguments being made. Start by introducing the topic, then give the 'how?' or 'why?'. |
| Gather | Bring together the appropriate information. |
| Identify | Indicate the main features or purpose of something. |
| Install and maintain | Put in and keep up to date. |
| Justify | Give reasons or evidence to support an opinion. |
| Measure | To determine the size, amount, voltage, pressure or other parameters, etc; or to specify with appropriate units in extent, amount etc. |
| Modify | To change or alter; or slightly compromise. |
| Optimise | Make the best of. |
| Outline | Give a simple account or summary. |
| Plan | Think ahead and document the requirements so a task or activity can be carried out. Consider the 'who', 'what', 'where', 'why', 'when' and 'how'. |
| Prepare | Gather together and organise. |
| Produce | To create, develop, construct or make. |
| Record Audio | Evidence in audio format. |
| Refine | Improve initial work taking into account feedback and aims. |
| Review | Look at again or reconsider. |
| Select | Choose the best or most suitable option. |
| State | Write clearly, listing facts. |
| Test | Check and trial. |

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# Delivery Guide

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