

Specification

Edexcel Diplomas

Edexcel Level 1 and Level 2 Principal Learning in Engineering

Issue 4
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Structure and aims of Principal Learning in Engineering

The Edexcel Diplomas in Engineering: Principal Learning

The Edexcel Diplomas in Engineering aim to:

- Develop a broad understanding and knowledge about engineering and related sectors.
- Develop the knowledge, skills and attributes required to work in the engineering sector.
- Encourage learners to learn through experience of applying knowledge and skills to tasks or contexts including those that have many of the characteristics of real work.
- Support equality and diversity by considering the needs of all potential learners, to minimise any later need to make reasonable adjustments for learners who have particular requirements.
- Encourage learners to develop and apply functional skills in mathematics, English and ICT at the appropriate level (Level 1 in Level 1 Diplomas, Level 2 in Level 2 Diplomas and Level 2 in Level 3 Diplomas).
- Encourage learners to develop and apply transferable personal, learning and thinking skills (in independent enquiry, creative thinking, reflective learning, team working, self-managing and effective participation).
- Encourage learners to draw out and articulate lessons learnt (both generalised and specific).
- Encourage learners to plan, review and reflect on their experience.
- Develop learners' understanding of spiritual, moral, ethical, social, legislative, economic and cultural issues, where appropriate to the engineering sector.
- Develop understanding of sustainable development, health and safety considerations and European developments, consistent with international agreements.

Edexcel Level 1 Principal Learning in Engineering

All units are compulsory.

| Unit number | Title | GLH | Assessment |
|-------------|--|-----|------------|
| 1 | Introducing the Engineering World | 30 | External |
| 2 | Practical Engineering and Communication Skills | 60 | Internal |
| 3 | Introduction to Computer Aided Engineering | 30 | Internal |
| 4 | Developing Routine Maintenance Skills | 30 | Internal |
| 5 | Introduction to Engineering Materials | 30 | Internal |
| 6 | Electronic Circuit Construction and Testing | 30 | Internal |
| 7 | Engineering the Future | 30 | Internal |

Edexcel Level 2 Principal Learning in Engineering

All units are compulsory.

| Unit number | Title | GLH | Assessment |
|-------------|---|-----|------------|
| 1 | Exploring the Engineering World | 60 | Internal |
| 2 | Investigating Engineering Design | 60 | Internal |
| 3 | Engineering Applications of Computers | 60 | Internal |
| 4 | Producing Engineering Solutions | 60 | Internal |
| 5 | Electrical and Electronic Circuits and Systems | 30 | Internal |
| 6 | Application of Manufacturing Techniques in Engineering | 60 | Internal |
| 7 | Applications of Maintenance Techniques in Engineering | 30 | Internal |
| 8 | Exploring Engineering Innovation, Enterprise and Technological Advancements | 60 | External |

Unit format

All units in Edexcel Principal Learning qualifications have a standard format which is designed to provide clear guidance on the requirements of the qualification for learners, tutors, assessors and those responsible for monitoring national standards.

Each unit is set out in the following way:

| | |
|-------------------------------------|---|
| Unit title | The unit title is accredited by QDCA and this form of words will appear on the learner's Notification of Performance (NOP). |
| Level | This is the level of study of the qualification. |
| Internal/external assessment | Further details of the mode of assessment are given later in the unit. |
| Guided learning hours (GLH) | <p>In the Principal Learning qualifications each unit consists of 30, 60 or 90 guided learning hours depending on the level.</p> <p>Guided learning hours is 'a notional measure of the substance of a unit'. It includes an estimate of time that might be allocated to direct teaching, instruction and assessment, together with other structured learning time such as directed assignments or supported individual study. It excludes learner-initiated private study.</p> <p>Centres are advised to consider this definition when planning the programme of study associated with this specification.</p> |
| About this unit | <p>This section is designed to give the reader an appreciation of the value of the unit in the vocational setting of the qualification as well as highlighting the focus of the unit.</p> <p>It provides the reader with a snapshot of the aims of the unit and the key knowledge, skills and understanding developed while studying the unit. The unit abstract also emphasises links to the sector by describing what the unit offers the sector.</p> |
| Learning outcomes | Learning outcomes state exactly what a learner should 'know', 'understand' or 'be able to' do as a result of completing the unit. |
| What you need to cover | <p>This section identifies the depth and breadth of knowledge, skills and understanding needed to achieve each of the learning outcomes. This is illustrated by the range of subject material for the programme of learning and specifies the skills, knowledge and understanding required for achievement to the level required to comply with all mark bands.</p> <p>Each learning outcome is stated in full and then expanded with further detail on the right-hand side. Internally assessed units may contain 'egs' within this section. These are used to show indicative lists of content only.</p> |

| | |
|--|--|
| Learning outcomes and assessment criteria | This section contains learning outcomes and assessment criteria for the externally assessed units. Learning outcomes and assessment criteria for internally assessed units can be found in <i>Annexe F</i> . |
| How you will be assessed | This section gives information about the assessment activities required for this unit. |
| Marking grid | Internally assessed units have a marking grid which contains a list of assessment foci, with statements ordered into three mark bands. When work is marked it is judged against these statements and an appropriate mark awarded. |
| Guidance for teaching this unit | <p>This section is designed to give tutors additional guidance and amplification on the unit in order to provide a coherence of understanding and a consistency of delivery and assessment. This section includes guidance on:</p> <ul style="list-style-type: none"> • <i>Delivery</i> – this could, for example, explain the relationship between the content and the learning outcomes or guidance about possible approaches to delivery. • <i>Assessment</i> – this could provide amplification about the nature and type of evidence that learners need to produce in order to pass the unit or achieve the higher marks. This section should be read in conjunction with the marking grid. <p><i>Personal, learning and thinking skills (PLTS)</i> – this section identifies where there may be opportunities within the unit for the generation of evidence to meet the requirements of PLTS.</p> <p>Assessors should take care to become familiar with PLTS and not to rely on the contents of this section when presenting evidence for moderation. The full PLTS framework is included in this document as <i>Annexe B</i>, but centres should refer to the QCDA website (www.qcda.gov.uk) for the latest version of the PLTS framework.</p> <p><i>Functional skills</i> – this section identifies where there may be opportunities within the unit for the generation of evidence to meet the functional skill requirements.</p> <p>This section will also provide guidance relating to <i>Work experience, Specialist resources</i> and <i>Reference materials</i>.</p> |

Assessment and grading of the Principal Learning

The purpose of assessment is to ensure that effective learning of each unit has taken place. Principal Learning units are assessed either internally by tutors or externally by Edexcel. Each unit is labelled clearly as internally or externally assessed.

It is essential that tutors familiarise themselves with and follow the guidelines set out in the document *Internal Assessment of Principal Learning Units: Controls for Task Setting, Task Taking and Task Marking — for Principal Learning in Construction and the Built Environment, Creative and Media, Engineering, Information Technology and Society, Health and Development* (see *Annexe E*) when developing assignments for internally assessed units.

Internal assessment

Internal assessment will be used to facilitate assessment of generic and practical skills. It will be quality assured through internal and external moderation. It will be supervised and completed under controlled conditions.

Each unit is assessed through a single **assignment** which has an overall purpose that reflects the aim of the unit, and is described in the *How you will be assessed* section. An **assignment** may be broken down into a few separate **tasks**. Tasks may be further broken down into smaller activities. The *Internal Assessment of Principal Learning Units: Controls for Task Setting, Task Taking and Task Marking — for Principal Learning in Construction and the Built Environment, Creative and Media, Engineering, Information Technology and Society, Health and Development* document details the nature of the controls that need to be applied to each type of task/activity and its outcome.

Where a unit is internally assessed, centres can use the sample assignments provided by Edexcel, or can design and quality assure suitable assignments. When designing assignments, centres are required to be aware of the following design principles (see relevant Tutor Support Materials for further guidance).

Assignments should be:

| | |
|-----------------|--|
| Fit for purpose | <i>They should consist of tasks which are related to the subject matter and content of the unit. For example, where a unit is centred on IT, the assessment will use IT at the core of the task.</i> |
| Manageable | <i>They should be designed to be manageable for both the learner and for the centre.</i> |
| Secure | <i>They should be delivered under controlled conditions, where centres can guarantee the work produced is truly that of the individual learner.</i> |
| Reliable | <i>They should produce judgements of a similar standard from occasion to occasion and between different assessors.</i> |
| Valid | <i>They should assess what they are intended to assess in terms of the learning outcomes.</i> |
| Transparent | <i>They should be expressed in ways that can be readily understood by learners, tutors and assessors.</i> |
| Balanced | <i>They should fairly reflect the content and associated learning outcomes, avoiding confusing learning with assessment and not adversely affecting teaching and learning.</i> |
| Flexible | <i>They should provide opportunities for learners to produce a variety of different forms of evidence.</i> |

Centres are encouraged to use a variety of assessment methods, which might include, for example, the use of case studies, work-based assessments, projects, performance observation and time-constrained assessments. Centres are encouraged to place emphasis on practical application, providing a realistic scenario for learners to adopt, and making maximum use of practical activities and work experience.

The creation of assignments that are **fit for purpose** is vital to learners' achievement and its importance cannot be over emphasised.

When reading the marking grids and designing assignments, centres should note the following.

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

External assessment

There is a requirement that some units in the Principal Learning will be externally assessed. These external assessments will be made available by Edexcel on agreed, published dates during the year.

For the Principal Learning in Engineering the following units will be externally assessed:

| Level | Unit number(s) | Unit title(s) |
|------------|----------------|---|
| Foundation | Unit 1 | Introducing the Engineering World |
| Higher | Unit 8 | Exploring Engineering Innovation, Enterprise and Technological Advancements |

Calculation of the Principal Learning grade

Performance in each unit of Principal Learning will be assessed against criteria given in the marking grid, giving rise to unit **marks**.

Unit marks will be allocated according to marking criteria that do not bear a direct relationship to grading mark bands; that is, assessors will be clear that they are allocating **marks** and are not grading learners directly.

There will be no pre-published unit grade boundaries.

Once units have been completed by learners and marked, they will be graded by Edexcel through a separate process involving professional judgement of performance and of technical and statistical data. This will produce unit grade boundaries and hence unit grades which will be reported.

To permit the calculation of a Principal Learning qualification grade, Principal Learning unit marks will be converted to **points**. Points for all Principal Learning units will be added together to devise a Principal Learning score. Using published thresholds the Principal Learning score will be converted to a Principal Learning grade.

Calculation of the Diploma grade

The overall grade for the Diploma will be based only on grades obtained from Principal Learning and the project. However, achievement of **all** components within the Diploma will be required in order to gain the Diploma qualification.

Points for Principal Learning units (weighted as appropriate) will be added to points for the project to derive a Diploma **score**. Using published thresholds the Diploma score will be converted into a Diploma grade.

Programme design and delivery

These Principal Learning qualifications consist of units of assessment. Each unit is 30, 60, or 90 guided learning hours in length depending on the level. The definition of guided learning hours is 'a notional measure of the substance of a qualification'. It includes an estimate of time that might be allocated to direct teaching, instruction and assessment, together with other structured learning time such as directed assignments or supported individual study. It excludes learner-initiated private study. Centres are advised to consider this definition when planning the programme of study associated with this specification.

Mode of study

Edexcel does not define the mode of study for the Principal Learning of Diplomas but there is an explicit requirement that for at least 50 per cent of the time learners will be engaged in applied learning.

Applied learning

Acquiring and applying knowledge, skills and understanding through tasks set in sector contexts that have many of the characteristics of real work, or are set within the workplace. Most importantly, the purpose of the task in which learners apply their knowledge, skills and understanding must be relevant to real work in the sector.

Reference: *The Diploma* (Qualifications and Curriculum Authority, 2007)

Centres are free to offer the qualifications using any mode of delivery that meets the needs of their learners and the requirements of applied learning. For example this may be through a combination of traditional classroom teaching, open learning and distance learning. Whatever mode of delivery is used, centres must ensure that learners have appropriate access to the required resources (see individual units) and to the subject specialists delivering the units.

Assignments based on the work environment should be encouraged. Those planning the programme should aim to enhance the vocational nature of the Diploma by:

- liaising with employers to ensure a course relevant to the specific needs of the learners
- accessing and using non-confidential data and documents from workplaces
- including sponsoring employers in the delivery of the programme and, where appropriate, in the assessment
- linking with company-based/workplace training programmes
- making full use of the variety of experience of work and life that learners bring to the programme.

Delivery of applied learning

It is important that centres develop an approach to teaching and learning that supports the applied learning requirement of the Diploma. The Principal Learning specifications contain a balance of practical skill development and knowledge requirements, some of which can be theoretical in nature. Tutors and assessors need to ensure that appropriate links are made between theory and practice and that the knowledge base is applied to the sector. This will require the development of relevant and up-to-date teaching materials that allow learners to apply their learning to actual events and activity within the sector.

Tutors are reminded that **experiential learning** techniques are required and that the opportunities for formative assessment where learners benefit from regular and structured feedback are a necessary requirement of a Diploma programme.

Where learners are performing an activity by practically applying their knowledge and skills, they are essentially behaving in the required applied nature of the Diploma. By then reviewing that learning and considering how improvements can be made and implemented, experiential learning will take place (see *Figure 1*).

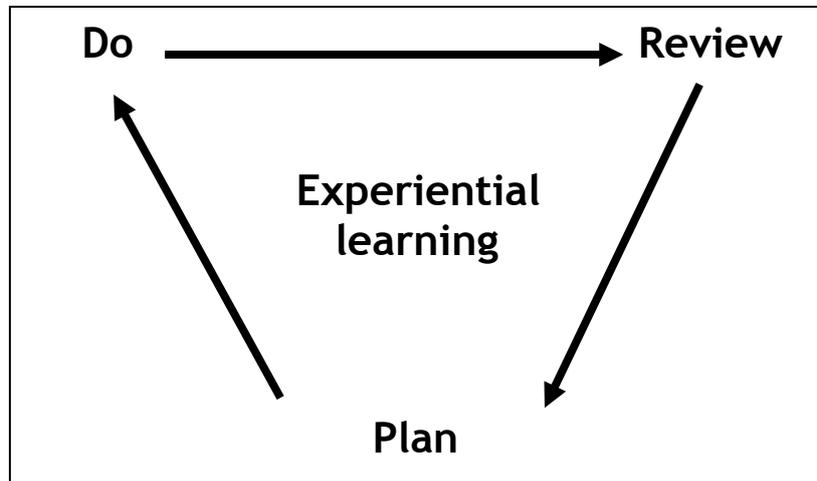


Figure 1: Experiential learning cycle

Resources

One aim of Diplomas is to prepare learners to progress to employment in specific sectors. Physical resources need to support the delivery of the programme and the proper assessment of the learning outcomes and therefore should normally be of industry standard.

Staff delivering programmes and conducting the assessments should be fully familiar with current practice and standards in the sector concerned.

Centres will need to meet any specialist resource requirements when they seek approval from Edexcel.

Assessment and learning

Summative assessment

Summative assessment serves to inform an overall judgement of achievement, which may be needed for reporting and review, perhaps on transfer between years in a school or on transfer between schools, perhaps for providing certificates at the end of schooling.

Although learners are working to satisfy a summative assessment (the marking grids reflect a final overall judgement) the benefit of formative assessment should be strongly emphasised throughout the learning.

Formative assessment

Formative assessment is concerned with the short-term collection and use of evidence as guidance of learning, mainly in day-to-day classroom practice.

In order for formative assessment to occur, the learner must understand what they have learned, what they have yet to learn and what they need to do to learn it. The responsibility of helping learners through a process of planning and reviewing their learning lies with the tutor.

Personal, learning and thinking skills (PLTS)

Personal, learning and thinking skills are necessary for work and for general learning. Learners will have opportunities to develop, apply and assess all the personal, learning and thinking skills within Principal Learning. Personal, learning and thinking skills consist of the following six skills:

- independent enquiry
- creative thinking
- reflective learning
- team working
- self-management
- effective participation.

Annexe B contains detailed information relating to each of the six personal, learning and thinking skills.

Each unit requires learners to demonstrate personal, learning and thinking skills, which are a mandatory requirement and a key feature of the Diplomas. Personal, learning and thinking skills are to be used as both a guide on the delivery of each unit and also as a motivating formative indicator for the learner.

Coverage

All personal, learning and thinking skills are required to be covered and assessed during the delivery and assessment of the whole Diploma and provide the context for the delivery and assessment of the programme of learning. A final summary of the coverage is also provided in *Annexe B* which collates the coverage of personal, learning and thinking skills throughout the programme.

Personal, learning and thinking skills are an essential, embedded feature of the delivery and assessment of the Principal Learning. Learners may also develop and apply personal, learning and thinking skills within the other components of the Diploma.

Centres should design the programme of study so that approximately 60 GLH will be allowed to enable learners to develop, plan and review the application of their personal, learning and thinking skills across their learning programme. Personal, learning and thinking skills will not be separately assessed as part of the Diploma but all six personal, learning and thinking skills will be integrated into the assessment criteria for Principal Learning. Each learner's achievement of personal, learning and thinking skills will be recorded in the Diploma transcript.

How personal, learning and thinking skills are used to support formative feedback

Personal, learning and thinking skills provide an excellent structural guide for the tutor when providing formative feedback to the learner. Tutors will be able to structure assessment and learning opportunities around personal, learning and thinking skills and should use a pro forma sheet to indicate to the learner where progress has been made and where the learner needs to focus further development. A suggested sheet ('PLTS Performance Indicator') for this activity is provided in *Annexe B*.

The 'PLTS Performance Indicator' can be used by the assessor to feed back on work to the learner showing the level of success that has been demonstrated during each assignment. The indicator is filled in by the assessor or supervisor to record the learner's performance at regular intervals during the course and ideally after every assignment. This informs the learner of their strengths and weaknesses and illustrates graphically where the learner should concentrate their efforts in the future.

Access and recruitment

Edexcel's policy regarding access to its qualifications is that:

- the qualifications should be available to everyone who is capable of reaching the required standards
- the qualifications should be free from any barriers that restrict access and progression
- there should be equal opportunities for all wishing to access the qualifications.

Centres are required to recruit learners to Edexcel qualifications with integrity. This will include ensuring that applicants have appropriate information and advice about the qualifications and that the qualification will meet their needs.

Centres should take appropriate steps to assess each applicant's potential and make a professional judgement about their ability to successfully complete the programme of study and achieve the qualification. This assessment will need to take account of the support available to the learner within the centre during their programme of study and any specific support that might be necessary to allow the learner to access the assessment for the qualification. Centres should also show regard for Edexcel's policy on learners with particular requirements.

Access arrangements and special considerations

Edexcel's policy on access arrangements and special considerations aims to enhance access to the qualifications for learners with disabilities and other difficulties (as defined by the Disability Discrimination Act 1995 and the amendments to the Act) without compromising the assessment of skills, knowledge, understanding or competence.

Further information

For further information please call Customer Services on 0844 576 0028 (calls may be recorded for training purposes) or visit our website at www.edexcel.com.

Useful publications

Further copies of this document and related publications can be obtained from:

Edexcel Publications
Adamsway
Mansfield
Nottinghamshire NG18 4FN

Telephone: 01623 467 467
Fax: 01623 450 481
Email: publication.orders@edexcel.com

Related information and publications include:

- *Accreditation of Prior Learning* available on our website: www.edexcel.com
- *Guidance for Centres Offering Edexcel/BTEC NQF Accredited Programmes* (Edexcel, distributed to centres annually)
- *Operating Rules for Component and Diploma Awarding Bodies* (QCA, 2007)
- *The Diploma Structure and Standards, Version 2* (QCA, 2007)
- *Regulatory Arrangements for the Qualification and Credit Framework* (Ofqual, August 2008)
- *What is a Diploma?* (DfES and QCA, 2007)
- the ASL catalogue on the National Database of Accredited Qualifications (NDAQ) website: www.ndaq.org.uk
- the current Edexcel publications catalogue and update catalogue
- the latest news on the Diploma from QCDA available on their website: www.qcda.gov.uk/diploma
- the latest news on Edexcel Diplomas available on our website: www.edexcel.com/quals/diploma

NB: Most of our publications are priced. There is also a charge for postage and packing. Please check the cost when you order.

Professional development and training

Edexcel supports UK and international customers with training related to our qualifications. This support is available through a choice of training options offered in our published training directory or through customised training at your centre.

The support we offer focuses on a range of issues including:

- planning for the delivery of a new programme
- planning for assessment and grading
- developing effective assignments
- building your team and teamwork skills
- developing student-centred learning and teaching approaches
- building key skills into your programme
- building in effective and efficient quality assurance systems.

The national programme of training we offer can be viewed on our website (www.edexcel.com/training). You can request customised training through the website or by contacting one of our advisers in the Professional Development and Training team via Customer Services to discuss your training needs.

Our customer service numbers are:

| | |
|-------------------------------|---------------|
| The Diploma | 0844 576 0028 |
| BTEC and NVQ | 0844 576 0026 |
| GCSE | 0844 576 0027 |
| GCE | 0844 576 0025 |
| DIDA and other qualifications | 0844 576 0031 |

Calls may be recorded for training purposes.

The training we provide:

- is active – ideas are developed and applied
- is designed to be supportive and thought provoking
- builds on best practice.

Level 1 units

Unit 1: Introducing the Engineering World

Principal Learning unit

Level 1

Guided Learning Hours: 30

Externally assessed

(29 hours learning time and 1 hour for assessment)

About this unit

Have you ever wondered what your home would be like without running water, gas central heating or mains electricity? Have you ever considered how the clothes you are wearing are manufactured or how medicine is mass produced?

The world of engineering affects all aspects of our lives, from the everyday time-saving appliances we use in the home to nano-technology used in space exploration.

In this unit you will gain an understanding of how engineering has contributed to the social and economic development of our world. You will find out about the many different careers available by looking at some of the exciting sectors within engineering and the role and responsibilities of some engineering jobs.

Some of the time you will be working in a team and will have opportunities to present what you find out about the contribution engineering makes to the social and economic aspects of our world.

You will also investigate green issues from an engineering perspective, discovering how engineers can help control and reduce environmental damage.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about different engineering sectors and employment opportunities
 - LO.2. Know about presentation methods, the benefits of working in a team, and the contribution engineering makes to the world we live in
 - LO.3. Know how environmental factors influence the engineering world.
-

What you need to cover

- | | |
|--|---|
| LO.1 Know about different engineering sectors and employment opportunities | <p>Learners will need to be aware of the variety of sectors within the engineering and manufacturing industries, including an understanding of specialist areas, eg aerospace, automotive, railway, bio-engineering, building services, civil, chemical, oil industry, communications, control, electrical, electronic, energy sources and systems, nuclear technologies, marine, manufacturing, mechanical engineering, passenger transport engineering, water management.</p> <p>Learners will also need to know about types of jobs and responsibilities – operative, craft, apprenticeship, technical and professional roles.</p> |
| LO.2 Know about presentation methods, the benefits of working in a team, and the contribution engineering makes to the world we live in | <p>Learners will need to find out about the contribution engineering has made to the world we live in. This will include assessing the social and economic impact of engineering.</p> <p>When working in a team, learners will present and communicate the outcomes of their investigation, eg PowerPoint, flipchart, whiteboard, posters.</p> |
| LO.3 Know how environmental factors influence the engineering world | <p>Learners will need to investigate how environmental factors and legislation relate to the engineering world. They will also demonstrate an understanding of various terms, eg reusable, recyclable, sustainable, accountable, lean manufacture, waste reduction.</p> |
-

Learning outcomes and assessment criteria

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about different engineering sectors and employment opportunities | Identify different sectors that form the engineering industry, the work undertaken and potential job roles and responsibilities. |
| LO.2 | Know about presentation methods, the benefits of working in a team, and the contribution engineering makes to the world we live in | Identify the benefits of teamwork. Identify commonly used methods of presentation. Identify examples of the contribution engineering has made on the way we live. Identify the social and economic impact engineering has had on the world we live in. |
| LO.3 | Know how environmental factors influence the engineering world | Identify the environmental factors and green issues engineers should consider and how environmental legislation has influenced the engineering industry. |

How you will be assessed

This unit will be assessed through a 1-hour summative multiple-choice examination that will cover all the learning outcomes and will meet all the requirements of the assessment foci in this unit. The assessment will consist of 30 questions. Each question will have four possible options, and all questions are to be attempted in the time available.

Guidance for teaching this unit

Delivery guidance

The structure of the learning outcomes suggests a logical order for the delivery of this unit.

Learners should be encouraged to identify with the world of engineering and centres should focus on practical everyday examples to identify the impact engineering has on everyday life. Examples may include the supply of utilities such as water, electricity, gas or the manufacture of everyday items such as motor cars or electronic products. Other examples include how artificial materials such as nylon, polypropylene and polyester have influenced the clothing industry, or how chemical engineering is fundamental to the development of makeup, and the mass production of medicine. It is essential that centres focus on examples from all areas of engineering including those listed in the ‘what you need to cover’ section.

Group work and open discussions would enable learners to develop their awareness of engineering and the way it enables us to live. Motivation in learners can be encouraged by highlighting personal links to engineering. Encouraging learners to identify friends or family employed within the industry will help learners relate to the topic. Centres should be encouraged to utilise links with engineering organisations. Visits to, or placements in, the engineering industry will be of significant advantage in enabling learners to experience first-hand opportunities within the world of engineering. The use of role play, group research and presentations will also enhance delivery and the use of video and case studies may also be beneficial.

The time and frequency of examination availability is to be determined.

Learning will be assessed through an externally marked multiple-choice examination. Centres should ensure that learners are sufficiently prepared for the examination and that they are able to demonstrate the following knowledge and skills.

For learning outcome 1, learners should demonstrate a knowledge of, and be able to successfully categorise, key features of each of the following sectors of engineering: aerospace, automotive, bio-engineering, building services, civil, chemical, oil industry, communications, control, electrical, electronic, energy sources and systems, nuclear technologies, marine, manufacturing, mechanical engineering, passenger transport engineering, water management.

For learning outcome 2, learners should demonstrate an understanding of the contribution engineering has made to the world we live in and should be familiar with the following technologies; global positioning systems (GPS), optical fibres, composite materials, microprocessors, remotely operated vehicles (ROV) and the development of bio-fuels, in addition learners should be aware of the impact of the following infrastructures: transport systems and utilities (water, electricity and gas). Further marks are available for learners who can assess the social impact of such technology and demonstrate an understanding of the economic or commercial potential of such a technology.

For learning outcome 3, learners will need to describe factors that engineers should consider to ensure that the manufacture of engineering products is environmentally friendly. Learners will need to be familiar with the following terms and their applications: reusable, recyclable, sustainable, accountable, lean manufacture, waste reduction.

Further marks are available for learners who can demonstrate an understanding of national and international environmental problems that may include the following: storage of nuclear waste and radioactive hazards, limited waste disposal sites (land fills), the affects of pollution on health, increase in noise pollution, affects on global warming, depletion of natural resources and the impact on the environment of an accident (eg, oil spill, nuclear disaster). Learners who can demonstrate awareness of legislation or solutions to environmental problems can also achieve further marks. This could include carbon emissions limits, energy efficiency awareness (labels on white goods) and recyclable and reusable limits in manufacture.

Centres are encouraged to use formative assessments such as presentations, short-answer tests or mini-assessments to monitor progress prior to the examination.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

Although PLTS are not identified within this unit as an inherent part of the assessment criteria, there are opportunities to develop a range of PLTS through various approaches to teaching and learning. (*Annexe B* of this document lists the personal, learning and thinking skills and their elements.)

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | <p>In open discussion and structuring question and answer sessions.</p> <p>Describing different sectors that form the engineering industry. Assessment focus 1.</p> <p>Give examples of the contribution engineering has made to the way we live. Assessment focus 2.</p> <p>Give examples of environmental factors engineers should consider to ensure products are environmentally friendly. Assessment focus 3.</p> |
| Creative thinkers | Not present in this unit. |
| Reflective learners | Analysing how engineering has affected their daily lives. Assessment focus 2. |
| Team workers | Working in a team to develop a presentation, giving examples of the contribution engineering has made to the way we live. Assessment focus 2. |
| Self-managers | <p>Preparation for their multiple-choice assessment.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> |
| Effective participators | Working in a team to develop a presentation, giving examples of the contribution engineering has made to the way we live. Assessment focus 2. |

Functional skills – Level 1

| Skill | When learners are ... |
|--|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Interact with and use ICT systems independently to meet needs | |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | |
| Follow and understand the need for safety and security practices | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently to meet needs | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | |

| Skill | When learners are ... |
|---|---|
| Mathematics | Not present in this unit. |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | |
| Identify and obtain necessary information to tackle the problem | |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | |
| Use appropriate checking procedures at each stage | |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | Taking part in formal and informal discussions when working in a team to use a presentation technique. |
| Reading – read and understand a range of texts | Researching engineering sectors and effects of engineering on the environment. |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | Writing documents to communicate information, ideas and opinions when describing different sectors that form the engineering industry and the social impact engineering has on the world. |

Work experience

Learners will be able to apply knowledge and experience obtained from relevant work experience to many aspects of this unit and should be encouraged to recall and share their experiences for all assessment focuses.

Reference material

Tooley M – *Engineering GCSE Curriculum Support Pack* (Newnes, 2002) ISBN 0750656441

Unit 2: Practical Engineering and Communication Skills

Principal Learning unit

Level 1

Guided Learning Hours: 60

Internally assessed

About this unit

Engineering plays a vital part in the prosperity of the country and the variety of skills needed by industry continue to develop.

In today's society, the engineer must consider how products are researched, designed, developed and manufactured. They need to have an understanding of a range of engineering processes. They need to be able to use both written and graphical methods of communication to interpret what is required and be able to produce a product or component to a customer's required standard.

In this unit you will gain practical experience of some of the engineering skills required at this level. You will develop an understanding of some of the theory behind the selection of materials and the choice of tools and equipment used for manufacture. You will also become familiar with the communication methods used to convey instructions and, just as importantly, the health and safety implications of working on industrial standard machines.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Understand own responsibilities and those of their colleagues under health and safety legislation
 - LO.2. Know about the cutting, forming and joining processes used when producing engineered products
 - LO.3. Be able to disassemble and assemble engineered products
 - LO.4. Be able to produce sketches of an engineered product or assembly
 - LO.5. Be able to plan and produce an engineering product.
-

What you need to cover

- | | |
|---|--|
| LO.1 Understand own responsibilities and those of their colleagues under health and safety legislation | <p>Learners will need to know about health and safety regulations in engineering, eg the Health and Safety at Work Act 1974, the use and correct storage of Personal Protective Equipment (PPE), Control of Substances Hazardous to Health (COSHH) 2002, Risk Assessments as in the Management of Health and Safety at Work Regulations, The Health and Safety (Safety Signs and Signals) Regulations 1996, Provision and Use of Work Equipment Regulations (PUWER) 1998 and the safety related to the machinery that will be used.</p> |
| LO.2 Know about the cutting, forming and joining processes used when producing engineered products | <p>Learners will need to know about the different types of cutting process used in industry, eg thermal cutting, laser cutting, water jet cutting, plasma cutting, oxy-fuel cutting, cutting by shear – guillotine, hand shears reciprocating shears, chip forming processes – drilling, lathe work and milling.</p> <p>Learners will need to know about the different types of forming equipment used, eg vacuum forming, injection moulding, extrusion, rolling, bending and folding, the use of hand forming techniques involving the different types of hammers, mallets and stakes. For rolling, bending and folding, learners must take into account the allowances made for material type and thickness.</p> <p>Learners will also need to know and distinguish between the permanent and non permanent methods of joining:</p> <ul style="list-style-type: none"> • permanent, eg fusion welding, hard soldering, brazing, soft soldering, spot welding, riveting, compression, self secured, thermal – hot shrunk and cold expansion and adhesives • non-permanent, eg screwed fastenings, pins, dowels, keys and circlips. |
| LO.3 Be able to disassemble and assemble engineered products | <p>Learners will need to learn about and be able to use the different types of tools used for assembly and dismantling, eg ring spanners and open ended, impact and torque wrenches, engineers hammer, wood and rubber mallets, those with copper and nylon end caps, socket, pipe grip, Phillips and flat screwdrivers, feeler gauges, drifts.</p> <p>Learners will need to understand and follow procedures for disassembly and assembly through the use of manuals and drawings.</p> <p>Learners will also need to understand and follow procedures for the use of cleaning solutions and releasing reagents and the application of heat to free off components.</p> |
| LO.4 Be able to produce sketches of an engineered product or assembly | <p>Learners will need to learn how to use BS8888:2004, eg to produce sketches of components in orthographic 1st and 3rd angle projection, oblique and isometric projection, interpret dimensions used on component detail drawings, show sectioning and hatching of views, identify different types of line applied, use detailing and common drawing conventions and layouts.</p> |

LO.5 Be able to plan and produce an engineering product

Learners will need to plan and produce a given engineered product making use of engineering drawings.

How you will be assessed

This unit focuses on engineering processes, including cutting, forming and joining, and assembly work. This also involves planning for these processes, and the preparation of sketches to support this work. You will be assessed through an assignment that will provide you with opportunities to show you know about these processes, can carry out the dismantling and reassembly of a product, and produce sketches to support these products and assemblies.

This unit will be assessed by your tutor who will set the assignment for you to complete. You are likely to be given a number of tasks that will cover the material you have studied. Your tutor will give you opportunities to develop evidence. One or more tasks will be set in the workshop and may relate to your work experience. These opportunities could typically consist of four tasks.

Task 1 could cover the requirement of assessment foci 1 and 3 together as combined practical and written activities with planning and inspection documentation for focus 3. For this task you would need to submit your own work in the form of a 'process portfolio'.

Task 2 could cover assessment focus 5, and could give a second opportunity to meet the requirements of focus 1. Again for this task you would need to submit your own work in the form of a 'process portfolio'.

A third task could include a written activity covering assessment focus 2 and you would need to submit either a 'report or presentation', with the fourth and final task being a practical drawing activity covering assessment focus 4 and will need to be submitted in a 'process portfolio'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|--|---|---|-------------------------|
| LO.2 Know about the cutting, forming and joining processes used when producing engineered products | Identifies two cutting and two forming processes used in industry, and a joining process. (0–5) | Describes two cutting and two forming processes used in industry, and a joining process. (6–9) | Compares two cutting and two forming processes and describes a joining process, relating each to specified industrial applications. (10–13) | 13 |
| LO.4 Be able to produce sketches of an engineered product or assembly | Produces sketches of an engineered product or assembly in both orthographic 1st and 3rd angle projection and dimensions the sketches correctly. (0–5) | Produces sketches of an engineered product or assembly in both orthographic 1st and 3rd angle projection and isometric and oblique views. Hatches sections and all sketches dimensioned correctly. (6–9) | Produces sketches of an engineered product or assembly in both orthographic 1st and 3rd angle projection and isometric and oblique views. Identifies on the sketches the correct lines to denote centre lines of views and shows detailed and common drawing conventions and layouts. Hatches sections and all sketches dimensioned correctly. (10–12) | 12 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|---|-------------------------|
| LO.5 Be able to plan and produce an engineered product | Compiles a plan of operation to produce an engineered product; manufactures the product and reviews the success of the plan. (0–5) | Compiles a plan of operation to produce an engineered product; manufactures the product and reviews the success of the plan, suggesting improvements. (6–9) | Compiles a plan of operation to produce an engineered product; manufactures the product and reviews the success of the plan, explaining how changes to the plan would lead to improvements in planning or manufacture. (10–12) | 12 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|--|---|---|---------------------------|
| LO.1 Understand own responsibilities and those of their colleagues under health and safety legislation | Identifies the requirements of working safely with colleagues in a familiar context, complying with responsibilities stated in relevant health and safety legislation. (0–4) | Identifies the requirements of working safely with colleagues in a familiar context, explaining why key aspects of relevant health and safety legislation are necessary. (5–7) | Identifies and applies the requirements of working safely with colleagues in a familiar and unfamiliar context, explaining why key aspects of relevant health and safety legislation are necessary. (8–10) | 10 |
| LO.3 Be able to disassemble and assemble engineered products | Uses documentation and equipment provided to dismantle a product, clean and lay out component parts. Reassembles with replacement parts provided and compiles a report. (0–5) | Uses documentation provided to select appropriate equipment to dismantle a product, clean and lay out component parts. Identifies some parts needing replacement and reassembles; provides a report including parts for replacement. (6–9) | Uses documentation provided to select equipment to dismantle a product, clean and lay out component parts. Identifies parts needing replacement and reassembles. Compiles a report including parts for replacement and reasons for replacing them. (10–13) | 13 |
| Total marks | | | | (13+12+10+13) = 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner’s performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit’s marking grid(s).
- The basic principle is that this is a ‘best fit’ grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the best fit approach. This section should be referred to only once the preliminary judgement has been made by the assessor and is used to guide the assessor as to placement within the mark band.

Marking grid A

| Assessment focus LO.2 | |
|------------------------------|---|
| Mark Band 1 (0-5 marks) | For full marks learners must be able to identify a range of processes, so this band is effectively point marked. One mark can be awarded for identifying each of two suitable cutting processes and each of two forming processes used in industry. One mark can be awarded for identifying a permanent or non-permanent method of joining. No description is required. |
| Mark Band 2 (6-9 marks) | <p>For full marks the answer must be descriptive in style, which means that some characteristics of each process must be given, eg the equipment that would be used to carry out the process, the precision of the cutting, the durability of the join.</p> <p>Responses are likely to be enhanced by explicit reference to actual industrial applications, but answers which refer to 'industry' more generally can still score full marks in this band.</p> <p>A clear description of all three aspects will give full marks. Simple descriptions, perhaps recognising only one or two minor characteristics of the process, will score lower in the band. Strong description of one or two will compensate for simpler description of others and will enable marks at the higher end of the band to be achieved.</p> |
| Mark Band 3 (10-13 marks) | <p>Comparison goes beyond the description of the mark band 2 requirement by explicitly recognising some differences or similarities in the way these processes might be applied, or the materials for which they are used – for example 'injection moulding is expensive to set up and would usually be used to mass produce a large quantity of exactly the same product, while using a hand-forming technique like a hammer or mallet would be cheaper to set up and might be used for making single objects'.</p> <p>For full marks there needs to be comparative statements for cutting processes and forming processes, and description of a joining method. Each should be linked to an identified industrial application, not simply described/compared in theoretical terms. Allow good comparison/description not explicitly linked in this way to achieve marks at the bottom of this band.</p> |

| Assessment focus LO.4 | |
|------------------------------|--|
| Mark Band 1 (0-5 marks) | <p>To achieve full marks from this band the learner must produce sketches that are fully dimensioned and elevations given are correct in terms of content and layout. All details within the sketches must be produced to typically represent the drawing standards found in BS:8888:2004. Work that is incomplete or dimensioned incorrectly can still be awarded marks but elevations must be correct in terms of layout if mark band 1 is to be achieved. Sketches must include the product laid out in orthographic projection, with each of a plan view, front elevation and end elevation in the correct layout for each projection.</p> <p>For full marks learners must identify correctly the layout of elevations in 1st and 3rd angle projection to BS8888 and add the dimensions correctly to sketches.</p> |
| Mark Band 2 (6-9 marks) | <p>For full marks the dimensioning is consistently correct and all views and elevations are correct for both 1st and 3rd angle projection. It is expected at band 2 that drawings are neat and with very little in the way of marks and smudges. Learners must sketch the product in both isometric and oblique views. For full marks sketches must include sectioning of the views and hatching that typically represent the drawing standards found in BS:8888:2004.</p> |
| Mark Band 3 (10-12 marks) | <p>To achieve marks at mark band 3, all work submitted must be neat, clear and correctly dimensioned in a way that represents the drawing standards found in BS8888:2004. The method of identifying the line types on the sketches is neat and well chosen. For full marks learners must identify the correct lines to denote centre lines of views etc; and common drawing conventions and layouts used.</p> |

| Assessment focus LO.5 | |
|------------------------------|--|
| Mark Band 1 (0-5 marks) | <p>For full marks the learner produces a plan that would be simple, which may be in the form of a list of tasks, materials and tools needed. The plan is successfully followed to manufacture the product. There is some simple evaluative comment about the plan, perhaps just stating that some of the tools were not needed.</p> <p>Learners who have a workable plan but fail to successfully manufacture the product can still get some credit. In exceptional cases this could be as much as 4, if they got close to completion and their evaluation recognised what went wrong.</p> |
| Mark Band 2 (6-9 marks) | <p>For full marks there is a clear plan which is more than a list – perhaps with some detail of some key activities or set out as a flow chart – which the learner follows through to successfully manufacture the product. There is some thoughtful evaluation which recognises at least one improvement that would have a significant effect – perhaps identifying some key equipment that was used but which had not been included in the plan.</p> |
| Mark Band 3 (10-12 marks) | <p>For full marks there is a well-thought out plan that covers key activities and is clearly presented. It is followed through to successful manufacture of the product. The evaluation goes beyond statements about what would be done differently next time to add some explanation of how this would improve things – perhaps it would be completed more quickly, or more accurately.</p> |

Marking grid B

| Assessment focus LO.1 | |
|------------------------------|--|
| Mark Band 1 (0-4 marks) | For full marks, essential requirements such as safe use of machinery, appropriate clothing and handling of substances (as appropriate) are correctly identified for a familiar context. Award marks within the band in proportion to the range of requirements identified for the given context. This band is also appropriate for more detailed answers which address only part of the necessary range. |
| Mark Band 2 (5-7 marks) | For full marks the learner can state a reason for each of the essential requirements for health and safety in a familiar context, for example 'Goggles must be worn when using the lathe because bits can fly off the part being machined and could blind you.' Award marks within the band in proportion to the range of requirements identified for the given context. |
| Mark Band 3 (8-10 marks) | For full marks the learner can demonstrate their safety in a familiar context by stating reasons for each of the essential requirements for that context. They will also apply principles in unfamiliar contexts by describing how hazard symbols are used, and where to find out appropriate necessary health and safety information. |

| Assessment focus LO.3 | |
|------------------------------|--|
| Mark Band 1 (0-5 marks) | <p>For full marks all requirements in the grid relating to disassembly, cleaning, laying out of parts and re-assembly are met. If some aspects are not met – perhaps imperfect cleaning, or failure to replace necessary parts – they will score lower in the band. A simple report is provided which may list only the parts they were given to replace.</p> <p>This mark band is appropriate for any learner who requires a level of support whereby appropriate equipment and spare parts must be provided for them.</p> |
| Mark Band 2 (6-9 marks) | <p>For full marks the learner selects their own equipment appropriate to the task, carries out the dismantling, cleaning and laying out requirements of the marking grid, and re-assembles the product having identified and fitted the replacement parts needed. A learner who works independently in this way, but who fails to full meet all requirements – perhaps cleaning imperfectly or reusing several original parts which should have been replaced, will score lower in the band. A learner who makes consistently inappropriate decisions about spare parts must be marked within the mark band 1 range.</p> <p>The report identifies the parts the learner identified for replacing, but does not always give correct/complete reasons for their replacement.</p> |
| Mark Band 3 (10-13 marks) | <p>For full marks the learner selects their own equipment appropriate to the task, carries out the dismantling, cleaning and laying out requirements of the marking grid, and re-assembles the product having identified and fitted all the replacement parts needed. A learner who works independently in this way, but who fails to full meet all requirements – perhaps cleaning imperfectly or reusing one or two original parts which should have been replaced, will score lower in the band. A learner who makes consistently inappropriate decisions about spare parts must be marked within the mark band 1 range.</p> <p>The report states clearly which components were replaced, and explains why these were necessary.</p> |

Approaches to assessment

The marking criteria in the marking grid have all been written so that the same activities can be set for all learners, with opportunities for those working at the upper end of this level to achieve full marks at the same time as giving opportunities for others to gain part marks through a response that might be less detailed or possibly incomplete. For example an activity for assessment focus 2 might ask learners to compare cutting and forming processes, and describe a joining method, all in the context of a specified industry. If the learner does all this, they are eligible for full marks and should be assessed against the requirements of mark band 3. If, on the other hand, they describe some processes and a method without getting across any comparative comments, they best fit the band 2 descriptor and should be assigned a mark within that band.

If this approach is taken it will lessen the assessment burden for those higher achievers while still giving lower achievers opportunities to perform at their level.

Although tasks can be devised for each assessment focus, where possible these should be linked to allow the holistic nature of the unit to come across. It is recognised that this is not always possible in all situations where delivery is spread across a number of institutions, possibly including the learner's work experience location.

Four tasks could be devised for the assessment of this unit.

Task 1 could cover the requirements of assessment foci 1 and 3, with activities requiring the learner to demonstrate a knowledge of health and safety responsibilities in a context familiar to themselves and their colleagues. These could be varied and include giving the learner a number of warning or mandatory signs and asking what they mean, and asking them to put on protective clothing appropriate to an activity from a selection of clothing provided. Linking this with assessment focus 3 enables the learner to demonstrate their health and safety understanding in relation to the assembly task they are going to carry out. However, before they start the work for assessment focus 3, they could also be asked what they would do to ensure safe working if they were going to perform a task for the first time, in order to give opportunities to achieve at assessment focus 1, band 3. Obviously if some of this evidence is generated in a practical manner learner observation record sheet and annotated photographs would be appropriate.

Assessment focus 3 includes differentiation according to the degree of independence with which a learner can complete a task. Ahead of the assessment, learners should have been taught and practised the necessary skills across a range of products that allows all of the content requirements regarding tools and processes to be covered. When they are ready to be assessed on disassembly and assembly it will be a product they have not previously worked on, and chosen by the tutor. Support should be given, either if asked for or if the learner is at risk of working unsafely or inappropriately. This support should be recorded on a learner observation record sheet and annotated photographs and form part of the evidence for the allocation of marks. If a learner is to be re-assessed on this task at some stage, it must be on a different product. All of the evidence for this task will need to be in the form of a 'process portfolio'.

Task 2 could address assessment focus 5 and could be a mix of practical and written activities. Differentiation is on the basis of how the learner approaches the planning and manufacturing task, not on the complexity of the product, so all learners should be guided towards something that is simple to make, such as a toolbox or a screwdriver. This task could also allow them to re-visit any missing parts of assessment focus 1 on health and safety. Obviously as this evidence is generated in a practical manner learner observation record sheet and annotated photographs would be appropriate along with any annotation on the original plans. All of the evidence for this task will need to be in the form of a 'process portfolio'.

Task 3 could involve activities asking learners to identify, describe and justify the cutting, forming and joining processes for assessment focus 2. As such this could result in a 'report or presentation'.

Task 4 could address assessment focus 4. Learners could be given a product to represent in sketch form to show the three views in orthographic projection in both 1st and 3rd angle. The product should then be represented in isometric and oblique projection. It is important that drawing convention is used and lines and sectioning details used. It would aid understanding and spatial awareness of the learner if the product being sketched related at least in part to the product produced in assessment focus 5. Activities should be structured appropriately to allow learners to achieve across the mark bands. As such this could result in a 'process portfolio'.

Guidance for teaching this unit

Delivery guidance

This unit is 60 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 20 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

It is envisaged that the bulk of the work will be delivered through practical activities with integrated theory.

For the health and safety elements, it is suggested that learners use a college or school workshop that is fitted out to industry standards to enable them to understand the need for PPE, identify hazards under PUWER and COSHH, identify specific safety signs applicable to the processes used and then carry out a risk assessment. It would also be beneficial, for assessment purposes, for health and safety to be covered during workshop sessions.

'Cartoon' safety sheets, where the learner is asked to identify hazards and non safe working practices may be used to get the message across. The knowledge gained from this exercise would then be employed within the workshop prior to practical activities taking place.

The disassembly/assembly tasks could be the removal of the valve cover, timing belt, valve gear and cylinder head of a static car engine on a rig or something as simple as the construction of a kitchen or similar type unit. These exercises would provide sufficient rigour, especially if the learner used a car manual to guide them in the disassembly and assembly routine or the instructions for assembly of a prefabricated unit. Assembly and disassembly tasks may be recorded on a witness testimony sheet that details the activity undertaken and is signed by the tutor.

The drawing element will be delivered through practical activity whereby learners will be given theory input but have practical tasks, in the form of drawing exercises (sketches), to complete. This will be delivered on a progressive approach whereby the tutor will start with the basics and gradually introduce the more demanding elements, thus building up the learner's knowledge.

The practical activities need to be of a simple nature at this level. Tasks suggested are the manufacture of a screwdriver with a knurled aluminium handle and carbon steel blade, the manufacture of a simple toolbox with tray that will require the use of cutting and forming machinery and specialist hand tools usually found in an industrial type workshop or the injection moulding of a component as part of a wider activity. Remember that there must be opportunities to gain marks for a range of tolerances on the manufactured product. Ideally there should be a least six tolerances specified; although at this level need not be too precise.

It is essential for health and safety purposes that the learner fully understands the workings of the machines to be used so that they feel comfortable when carrying out practical tasks. For this reason, it is suggested that an investigative approach be used when identifying the component parts of the machines and their function. This could be in the form of a multiple choice type handout whereby they select the correct name of the component from a list and add the name against a drawing or picture of the component.

It is envisaged that the learner will develop skills through a progressive approach, firstly carrying out simple activities and then building up to a level where they are capable of undertaking the complete task.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | Identifying coursework questions and problems to resolve. Identifying the requirements of working safely with colleagues in a familiar context, complying with responsibilities stated in relevant health and safety legislation. Assessment focus 1. Identifying, describing and justifying cutting and forming processes. Assessment focus 2. |
| Creative thinkers | Not present in this unit. |
| Reflective learners | Setting goals for the development of each of their assignments. Reviewing their progress against the completion of their assignments. Compiling a plan of operation to produce an engineered product; manufacturing the product and review the success of the plan. Assessment focus 5. |
| Team workers | Not present in this unit. |
| Self-managers | Planning and organising the creation of their assignments for this unit. Dealing with time pressures and deadlines for the production of their assignments. Seeking advice and support from their peers and tutors when needed. Using documentation and equipment provided to dismantle a product, clean and lay out component parts. Reassembling with replacement parts provided and compiling a report. Assessment focus 3. Compiling a plan of operation to produce an engineered product; manufacturing the product and review the success of the plan. Assessment focus 5. |
| Effective participators | Not present in this unit. |

Functional skills – Level 1

| Skill | When learners are ... |
|--|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Interact with and use ICT systems independently to meet needs | |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | |
| Follow and understand the need for safety and security practices | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently to meet needs | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | |

| Skill | When learners are ... |
|---|---|
| Mathematics | |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | Comparing dimensions of completed work with those given on engineering drawings. |
| Identify and obtain necessary information to tackle the problem | Carrying out measuring tasks. |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | Comparing results and establish variance. |
| Use appropriate checking procedures at each stage | Checking of dimensions whilst work is in progress. |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | Recording results of measuring and producing a plan of action. |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | Taking part in formal and informal discussions with a supervisor when describing different types of engineering drawings and different sorts of documentation used when planning a production task. |
| Reading – read and understand a range of texts | Reading and understand a range of engineering drawings and recording sheets. |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | Devising a written plan of operation to produce a engineered product. |

Work experience

This unit can be delivered and assessed in a vocational environment where work experience is taking place. Although it may not always be possible for a learner to make a product on work experience, research into health and safety could be carried out on such visits. Learning about suitable cutting, forming and joining processes and methods could form part of any work experience. An industrial partner could also be valuable in supplying a range of simple products for learners to sketch. However, care should be taken as many companies will have planning mechanisms but some may be too complex for this level and may confuse learners.

Specialist resources

When delivering this unit, centres need to ensure that learners have access to the necessary equipment required.

Where possible, the equipment should be of industry standard to allow learners to gain a full appreciation of the types of machines available and develop a genuine feel for the process. The use of simulation will not be permitted.

The assembly/disassembly element will also require an engineered product that will allow learners to cover all aspects of the learning outcome. Reference materials should be available as well as a range of hand tools that are fit for purpose.

The working environment should include health and safety information and signage, with procedures already in place that will guide the learning process.

Unit 3: Introduction to Computer Aided Engineering

Principal Learning unit

Level 1

Guided Learning Hours: 30

Internally assessed

About this unit

Until quite recently most of the machines used in an engineering workshop or factory were controlled manually. However, computers have increasingly become an essential feature of modern engineering industry and the use of computer software and computer-controlled machinery is now commonplace within all sectors of engineering.

In this unit you will be given opportunities to learn about computer aided engineering through designing and producing a simple component using computer-aided design and manufacturing software linked to computer controlled machine tools. You will use CAD (computer aided design) software to design and create a working drawing of a simple 2D (two dimensional) component. You will then convert the drawing data into a CNC (computer numerical control) machine tool operating program using compatible CAM (computer aided manufacture) software. In addition, you will demonstrate the versatility of CAD software by creating a simple circuit diagram using standard component symbols (eg electrical/electronic, hydraulic or pneumatic circuits).

Once the CNC operating program is complete, you will load it into a CNC machine tool, set work coordinates and sufficient tooling data to enable production of the component. Finally, you will check the component for quality in terms of its dimensional accuracy.

Learning outcomes

On completion of this unit, a learner should:

- LO.1 Be able to use a CAD system to produce a working drawing of a 2D component and an electrical circuit
 - LO.2 Be able to use a CAM system to convert the drawing data into a computer numerically controlled (CNC) operating program
 - LO.3 Be able to set and safely operate a CNC machine tool to produce an accurately machined component and check their own production.
-

What you need to cover

- LO.1 Be able to use a CAD system to produce a working drawing of a 2D component and an electrical circuit**
- Learners will need to learn about and use the following basic features of a 2D CAD system: basic drawing commands, modification and manipulation of drawn features, using object snaps for accurate geometry definition, dimensioning, outputting to a print or plot device, saving the drawing data in an appropriate format.
- They will also need to use appropriate drawing standards, eg BS 8888, BS 3939.
- Typical simple 2D components could be a rectangular plate with radiused corners with an array of drilled holes, requiring movement in a different plane in later outcomes. The simple electrical circuit could involve simply a battery, lamp/bell, switch and fuse.
- LO.2 Be able to use a CAM system to convert the drawing data into a computer numerically controlled (CNC) operating program**
- Learners will need to understand and use the following component features of a 2½D CAM system: using a drawn profile from the CAD system used to achieve LO1 above, inputting cutting tool data and machining information, creating an efficient cutter path from the input data, converting cutter path data into a coded CNC program.
- LO.3 Be able to set and safely operate a CNC machine tool to produce an accurately machined component and check their own production**
- Learners will need to know how to machine a component using a CNC machine tool, taking account of the following: health and safety issues associated with the use of machinery, loading a coded program manually or via computer link, selecting and setting cutting tools, using an appropriate work-holding method, setting work datums and tool offsets, executing the program to produce a first-off component, checking the machined part for dimensional accuracy.
-

How you will be assessed

This unit will focus on the use of computer engineering systems. As such you will be assessed through an assignment that will give you opportunities to demonstrate that you can use a CAD system to produce working drawings of simple components and electrical circuits, use a CAM system to convert drawing data into a CNC operating program, and set and safely operate a CNC tool to produce a machined component.

This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given a number of tasks that will cover all of the material you have studied. Your tutor will give you opportunities to develop evidence and one or more tasks could be set in the laboratory or workshop, and may relate to your work experience. These opportunities might typically consist of two tasks.

For example, the first task could cover assessment focus 1 and would include opportunities for the different drawings to be produced. This could include producing the drawing that could be used for the second task and will also help you to meet the requirements of assessment foci 2 and 3, eg drawing the component that will be used for the CAM and CNC machining elements. The evidence you should submit for this task will be within a 'process portfolio'.

The second task could be about using the drawings and other information to generate a cutter path and CNC program, execute the program with opportunities to edit the program, meeting the requirements of assessment focus 2 and some of focus 3. Once this has been done you will be asked to check the machined part to show that your CNC programming was correct which would introduce you to the important concept of product quality, further meeting the requirements of assessment focus 3. Again the evidence you should submit for this task will be within a 'process portfolio'.

Marking grid

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|---|--|--|-------------------------|
| LO.1 Be able to use a CAD system to produce a working drawing of a 2D component and an electrical circuit | Produces a dimensioned drawing of a simple engineered component in line with BS:8888 and a simple circuit diagram in line with BS 3939. (0–8) | Using separate layers produces a fully dimensioned drawing of a simple engineered component in line with BS:8888 and a simple circuit diagram in line with BS 3939 complete with annotation. (9–14) | Prepare a simple template and using separate layers produces a fully dimensioned drawing of a simple engineered component in line with BS:8888 and a simple circuit diagram in line with BS 3939 complete with annotation. (15–20) | 20 |
| LO.2 Be able to use a CAM system to convert the drawing data into a computer numerically controlled (CNC) operating program | Uses CAM software and cutting information to convert a CAD drawing geometry into a machine tool cutter path, processes the cutter path data into a coded CNC operating program. (0–10) | Uses CAM software and cutting information to convert CAD drawing geometry into a machine tool cutter path, processes the cutter path data into a coded CNC operating program. Identifies and describes errors in program operation by using cutter path graphic simulation. (11–16) | Uses CAM software and cutting information to convert CAD drawing geometry into a machine tool cutter path, processes the cutter path data into a coded CNC operating program. Identifies and amends errors in program operation and reruns cutter path graphic simulation. (17–20) | 20 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|--|--|---|-------------------------|
| LO.3 Be able to set and safely operate a CNC machine tool to produce an accurately machined component and check their own production | Loads a CNC program into the controller, sets work datums and tool offset values. Safely executes the program to produce a first-off component and checks the component for dimensional accuracy and compliance. (0–10) | Loads a CNC program into the controller, sets work datums and tool offset values. Safely executes the program to produce a first-off component. Records the results of the dimensional checks in a structured format and makes comments about the checks. (11–15) | Loads a CNC program into the controller, sets work datums and tool offset values. Safely executes the program to produce a first-off component. Uses feed and speed override controls to gain optimum performance. Edits the program to incorporate override values. Compiles an inspection report including reasons for non compliance and actions. (16–20) | 20 |
| | | | Total marks | 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

| Assessment focus LO.1 | |
|---------------------------------------|--|
| <p>Mark Band 1-3 (0-20 marks)</p> | <p>The learner is required to produce two drawings, one drawing will be partially dimensioned and of a simple engineered component and the other a simple circuit diagram. Up to 4 marks can be awarded for the completion of each separate drawing to the required standard for their sector. For each drawing, 2 marks should be awarded for the quality of the drawing based on how easily it is understood and 2 marks for compliance with the appropriate conventions.</p> <p>To achieve mark band 2 the learner should produce both the drawings. Up to 2 marks can be awarded for the full and correctly dimensioned simple engineered component and 1 mark for the dimensioning being on a separate layer. Up to 2 marks can be awarded for the correct annotation on the simple circuit diagram and 1 mark for the use of a layer for this annotation. To be awarded marks from mark band 2 the layers have to be at least partially completed.</p> <p>The learner should produce both the drawings of a simple engineered component and a simple circuit diagram fully and correctly dimensioned and annotated respectively and the dimensioning and annotation should be on a separate layer. For mark band 3 the learner must prepare and use an additional layer that contains a drawing template (2 marks). The template should contain a full title block (1 mark), a border (1 mark) and appropriate text (2 marks). The text must be correctly fitted to the title block in terms of size and be correct in terms of content.</p> |

| Assessment focus LO.2 | |
|---------------------------------------|--|
| <p>Mark Band 1-3 (0-20 marks)</p> | <p>To achieve full marks from mark band 1 the learner must have imported the CAD drawing (possibly the one from assessment focus 1) into the CAM system in a compatible format (2 marks) and with tool and cutting data supplied (2 marks). They must use the CAM software to convert the geometry data into machine tool cutter path data (3 marks); this data will then be post-processed to produce a coded CNC program (3 marks). The learner should have had the opportunity to practice this process prior to attempting the task. For full marks from mark band 1 all stages must be fully completed. Learners who do not achieve all the stages can still get credit and be marked for work done within this band.</p> <p>At mark band 2 the learner must be able to identify and understand errors made during the stages described in band 1. Using cutter path graphical simulation learners must be able to correctly identify errors or possible improvements (up to 2 marks can be awarded for using this software correctly and up to 2 marks can be awarded for actual error identification). The learner must describe the errors in sufficient details as to show they understand what the errors are (2 marks for description). In the event that learners' work does not have sufficient errors present tutors may simulate errors for learners to identify.</p> |

| Assessment focus LO.2 (continued) | |
|--|---|
| | For mark band 3 the learner must amend the program based on the errors revealed in band 2. The cutter path simulation program should be re run to check amendments made are effective (up to 4 marks for amending errors and proving solutions). In the event that learners' work does not have sufficient errors present from band 2, learners may make amendments to the program with tutor guidance. |

| Assessment focus LO.3 | |
|---------------------------------------|---|
| <p>Mark Band 1-3 (0-20 marks)</p> | <p>The learner should load the CNC program from assessment focus 3.2 into the controller (2 marks), set work datums and tool offset values (2 marks). They will then need to safely execute the program and produce a first-off component (2 marks) and check the component for dimensional accuracy and compliance (2 marks) using appropriate measuring equipment. Learners must show a consideration of the health and safety issues when operating and running a 'first off' program (1 mark). They must also show they have considered this before running the program (1 mark).</p> <p>In mark band 1 the learner produced the component, and checked it against the drawing specification using appropriate measuring equipment. To achieve marks in mark band 2 they must record the results of the dimensional checking in a structured format. Up to 3 marks can be awarded for correctly recording the measurements taken, based on how easy the record displays the expected information. Up to 2 marks are available for the comments about the results. Analysis is not expected at this level, however clear indication, supported by the results, should show whether the first off component meets the product requirements and whether further components can be produced or not.</p> <p>To achieve marks in mark band 3 the learner should use feed and speed override to improve the performance (1 mark), build these new override values into the program (1 mark), use the dimensions recorded in band 2 and prepare a report detailing non compliance (1 mark) and giving reasoning why it has occurred and actions to take (2 marks). A structured inspection report would be a suitable format. More analysis is likely to be seen within a response within this mark band.</p> |

Approaches to assessment

In the two suggested tasks evidence may be varied. Learner observation record sheet is acceptable and should be supported by annotated photographs showing learners operating the CAM software and CNC machine within the practical elements of this assignment.

Task 1 could cover assessment focus 1 and include activities that require learners to produce the two drawings to correct standards. For mark band 3 the activity should include producing a simple template that can be used for both drawings. The appropriate use of drawing commands should also be captured either by using screen dumps or learner observation record sheets indicating which CAD commands were used. Prints of the finished drawing and circuit will also need to be included. The evidence required for this task will need to be submitted in a 'process portfolio'.

To help motivate learners, the dimensioned working drawing produced for this task could be used to generate the machine tool cutter path and post processing activity on a CNC machine.

Task 2 could include activities asking learners to convert a CAD drawing into a tool cutter path by processing the data into a coded program. These activities would give opportunities for assessment focus 2. Further activities to load the program, set the datums and tool offsets etc to safely produce the first component could be given to provide some of the evidence for assessment focus 3. As well as learner observation record sheets and annotated photographs, print outs of the program and tables of values would also need to be gathered.

Another activity would need to be given asking learners to check the component against the requirements of the drawing. A table of measurements taken will be required to support this as evidence. All the evidence for this task would need to be submitted in a 'process portfolio'.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

This unit is designed to be almost entirely 'hands on' and aims to present CAD/CAM as an exciting and attractive engineering option. Also, being a 30 GLH unit means that there is insufficient time to deliver topics other than those directly concerned with achieving the assessment tasks, all of which rely upon learners' practical skills. To emphasise this, the 'machined component' referred to in the learning outcomes must be of a very simple, non-complex nature, as again, time constraints and lack of learner knowledge will prevent the use of components of any great complexity. The design of the component to be machined is left to centres to decide and will be largely governed by the resources available. However, the component should be of sufficient complexity to make its manufacture by traditional manual methods either difficult, overly time consuming or impracticable. Components with simple curves and drilled holes may be suitable.

The amount of guidance/assistance given to the learner is important. To gain a working knowledge of a CAD system, CAM software and the safe operation of a CNC machine tool within the time available without varying degrees of assistance would not only be very difficult, but in the case of operating the CNC machine tool, potentially hazardous. Learners must be fully aware of the hazards associated with the use of CNC machinery and the measures used to control them. CAD and CNC usage may be recorded on a witness testimony sheet that details exactly what was carried out and is signed by the tutor.

An appropriate delivery method would be practical demonstration supported by tutor input. For those learners likely to achieve mark band 1 in the assessment foci, the level of tutor guidance will need to be relatively high, whilst those achieving mark band 2, proportionately less so. mark band 3 achievers will, after initial guidance, be capable to a large degree, of independent working.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | <p>Identifying coursework questions and problems to resolve.</p> <p>Using CAM software and cutting information to convert a CAD drawing geometry into a machine tool cutter path, processing the cutter path data into a coded CNC operating program. Assessment focus 2.</p> <p>Few computer controlled machine tool operating programs achieve efficient running and component specification at the first attempt. Assessment foci 3.2 and 3.3 require the learner to display a level of independent enquiry in order to identify and resolve problems associated with the CNC program. Also, assessment focus 3 requires those achieving mark band 3 to locate and use manufacturers’ published cutting data to search for the suitable sources of information.</p> |
| Creative thinkers | <p>There are always a number of ways of using CAD software to create the geometry that forms a profile. The creative thinker reasons the most appropriate route to achieving assessment focus 1.</p> |
| Reflective learners | <p>Setting goals for the development of each of their assignments.</p> <p>Reviewing their progress against the completion of their assignments.</p> <p>Loading a CNC program into the controller, setting work datums and tool offset values. Safely executing the program to produce a first-off component and checking the component for dimensional accuracy and compliance. Assessment focus 3.</p> |
| Team workers | <p>Not present in this unit.</p> |
| Self-managers | <p>Planning and organising the creation of their assignments for this unit.</p> <p>Dealing with time pressures and deadlines for the production of their assignments.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> <p>Using CAM software and cutting information to convert a CAD drawing geometry into a machine tool cutter path, processing the cutter path data into a coded CNC operating program. Assessment focus 2.</p> <p>CAD/CAM software requires a disciplined and structured approach to completion of the task in hand. Assessment foci 1–3 require learners to display this skill.</p> |
| Effective participators | <p>Not present in this unit.</p> |

Functional skills – Level 1

| Skill | When learners are ... |
|--|--|
| ICT – Use ICT systems | |
| Interact with and use ICT systems independently to meet needs | Using CAD and CNC software to input information and produce drawings and programs. |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | Correctly save and store .dwg extension files produced whilst developing CAD drawings. |
| Follow and understand the need for safety and security practices | |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently to meet needs | Using 'raw' data including 2D drawings and CNC program codes. |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | Producing CAD drawings. |
| ICT – Develop, present and communicate information | |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | Creating CAD drawings. |
| Bring together information to suit content and purpose | Bringing together images and text within drawings. |
| Present information in ways that are fit for purpose and audience | Producing drawings in correct format. |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | Using CAD software to produce drawing and CNC software to operate CNC machinery. |

| Skill | When learners are ... |
|---|---|
| Mathematics | |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | Ensuring dimensioning of engineering drawings is accurate and proportional. |
| Identify and obtain necessary information to tackle the problem | Transfer of dimensions from source materials to CAD software. |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | |
| Use appropriate checking procedures at each stage | Checking proportionality of finished CAD drawings. |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | |
| Reading – read and understand a range of texts | Reading and understanding CNC programs requirements. |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | Producing drawings and reports. Recording results. |

Work experience

As the work covered by this unit is intended to be at a basic level, a period of work experience in a CNC machine shop and/or CAD drawing office would be highly beneficial to learners. It would be particularly advantageous if the work experience illustrated the high levels of complexity and production that computerised production is able to achieve. Learners would however, require suitable induction training relevant to the working environment into which they were entering.

Specialist resources

Centres will need to provide learners with access to the following:

- Industry standard 2D CAD software package with file export capability.
- CAM software application including:
 - dxf or .dwg file import capability
 - cutter path data generation
 - cutter path graphic simulation
 - post-processing software appropriate to the machine tool controller
 - data transmission capability for computer – machine controller link (desirable but not essential).
- 2 or 3 axis computer controlled machine tool and ancillary equipment.
- Measuring equipment such as micrometers, vernier callipers, dial test indicator (DTI).

Health and safety issues relating to VDU use and machinery hazards could be covered by appropriate HSE leaflets that are available online or in class-sized packs.

Cutting tool information is available from various manufacturers such as Sandvik UK, Kennametal etc, either online or via their customer services.

Reference material

Godfrey N and Wallis S – *GCSE Engineering* (Nelson Thornes, 2004) ISBN 0748785515

Unit 4: Developing Routine Maintenance Skills

Principal Learning unit

Level 1

Guided Learning Hours: 30

Internally assessed

About this unit

Most engineered products, equipment and systems require regular adjustment, servicing and repair during their lifetime to ensure that they continue to work properly. Maintenance engineers are responsible for ensuring such systems are properly maintained and we all depend on them at some time or other. For example, if we lost our cash card in an ATM when trying to withdraw money or if the central heating system broke down in mid-winter because it had not been maintained we would not be very happy. Similarly in industry, manufacturers must have plant and equipment that works. This plant and equipment relies on products and systems. Breakdowns are non-productive and cost money and persistent breakdowns could also result in lost contracts and jobs.

In this unit you will be able to get involved with the carrying out of a maintenance task. This is a practical unit that will involve hands-on activities, putting knowledge and understanding into practice. The unit lends itself to support from local workplace providers so you may well receive an insight into maintenance procedures within a real engineering environment.

You will find out about different types of maintenance, carry out a maintenance task and see if a product, equipment or system is likely to fail.

There will be opportunities to collect naturally occurring evidence from any appropriate work experience.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about different types of maintenance procedures and supporting documentation used in industry
 - LO.2. Be able to use tools safely and effectively to carry out a routine maintenance task
 - LO.3. Be able to assess a product, piece of equipment or system against causes of failure.
-

What you need to cover

- | | |
|---|--|
| <p>LO.1 Know about different types of maintenance procedures and supporting documentation used in industry</p> | <p>Learners will need to find out about the following types of maintenance procedures that are carried out in industry: planned, un-planned, routine, preventative, repair to fix.</p> <p>Learners will also need to discover how documentation is used when planning and carrying out maintenance of engineering products, equipment or systems, eg records, drawings, manuals.</p> |
| <p>LO.2 Be able to use tools safely and effectively to carry out a routine maintenance task</p> | <p>Learners will need to carry out a simple maintenance task, to a given schedule, involving the assembly and disassembly of an engineered product, equipment or system and in a safe and effective manner, eg personal protective clothing (such as footwear, hand, eye and head protection; general duties of employees at work (such as those found within the Health & Safety at Work Act); hazards and hazard warning signs (such as high voltage, dangerous chemicals, corrosive, head room, slip or trip hazard, anti static, overhead crane); mandatory signs (such as ear and eye protection, respirator, face mask, gloves, guards, hygiene and food consumption).</p> <p>Learners will select and use appropriate tools and equipment, eg sockets, spanners, torque wrench, sprocket pullers, screwdrivers, circlip pliers, hexagon and star keys.</p> <p>They will also extract relevant information for the task from given documentation, eg records, drawings, manuals.</p> |
| <p>LO.3 Be able to assess a product, piece of equipment or system against causes of failure</p> | <p>Learners will need to investigate an engineered product, piece of equipment or system to see why it may fail in service, eg age, maloperation, wear, vibration, corrosion, fouling, hostile environment, lack of maintenance, lubrication failure, inherent design faults.</p> <p>Learners will plan how to use tools and equipment to make simple measurements and then use appropriate tools and equipment to make simple measurements, eg basic test instruments, basic conditioning monitoring, micrometers, feeler gauges, vernier gauges.</p> |
-

How you will be assessed

This unit focuses on developing the skills of a maintenance engineer. As such you will be assessed through an assignment giving opportunities, through a theme of maintenance, to demonstrate that you know about maintenance procedures and the use of documentation. You will be expected to show that you can safely carry out maintenance tasks and assess a product, piece of equipment or system against causes of failure, similar to those that a maintenance engineer working in industry is likely to come across.

This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given one or more tasks which will cover all the material you have studied. At least some of these tasks will be set in the workshop and may relate to your work experience. Your tutor will give you opportunities to develop evidence. These opportunities could typically consist of 3 tasks.

Task 1 could cover the requirements of assessment foci 1.1 and 1.2 with written or oral activities. For this task you need to submit your work in the form of a 'report' or in the form of a 'process portfolio'.

A second task could cover the requirements for assessment focus 2 as a practical task and will be the main assessment in this unit and thus carries a higher weighting of marks. It will therefore give you an opportunity to develop and use your practical skills applied to maintenance tasks. For this task you need to submit your own work in the form of a 'process portfolio'.

The third and final task could cover the requirements for assessment focus 3 and would again be mainly a practical exercise for you to do. Again, for this task, you need to submit your own work in the form of a 'process portfolio'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|--|-------------------------|
| LO.1.1 Know about different types of maintenance procedures | Gives examples of three different types of maintenance procedures that are carried out in industry and states where each could be used. (0–6) | Describes three different types of maintenance procedures, stating where each could be used and how they are carried out. (7–10) | Describes three different types of maintenance procedures, stating where each could be used, how they are carried out and why each is needed. (11–14) | 14 |
| LO.1.2 Know about different types of maintenance documentation | Gives examples of two sorts of documentation used when planning and/or carrying out maintenance tasks and gives an example of a maintenance task where each would be used. (0–4) | Describes two different sorts of documentation used when planning and/or carrying out maintenance tasks, stating what the documentation covers and giving examples of maintenance tasks where each would be used. (5–6) | Explains how to use two different sorts of documentation when planning and carrying out identified maintenance tasks. (7–8) | 8 |
| LO.3 Be able to assess a product, piece of equipment or system against causes of failure | Devises a plan and uses appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. (0–4) | Devises a plan and uses appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. Records key measurements. (5–7) | Devises a plan and uses appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. Records key measurements. Reviews the effectiveness of the plan to make improvements to it. (8–10) | 10 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|---|--|--------------------------|
| LO.2 Be able to use tools safely and effectively to carry out a routine maintenance task | Carries out, with guidance, a routine maintenance task following a given schedule and uses given documentation, tools and equipment in a safe manner. (0–12) | Carries out, with limited guidance, a routine maintenance task following a given schedule and uses given documentation to select and use tools and equipment in a safe manner. (13–20) | Carries out, independently, a routine maintenance task following a given schedule. Selects and uses documentation and selects and uses tools and equipment in an effective and safe manner. (21–28) | 28 |
| Total marks | | | | (14+8+10+28) = 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the best fit approach. This section should be referred to only once the preliminary judgement has been made by the assessor and is used to guide the assessor as to placement within the mark band.

Examples of ‘*guidance*’ might include (but not limited to):

- instructions given verbally telling learners what to do and how to do it, how to follow the schedule and use the documentation and how to select and use tools and equipment for assessment focus LO.2
- when carrying out these tasks the learner consistently needs reminding of what to do
- constant demonstration of what to do
- if they were not guided through each stage of the use of the schedule and documentation and selection of tools and equipment the learner would not be able to complete the maintenance task for assessment focus LO.2.

Examples of ‘*limited guidance*’ might include (but not limited to):

- the tutor gives a variety of options upon which learners decide. They discuss how to follow the schedule and use the documentation and how to select and use tools and equipment for assessment focus LO.2. The learner will then confirm how to use the schedule and documentation and what are appropriate tools and equipment before they commence the activity
- after this initial support to start the processes and ensure the learner is safe to do so, the tutor is likely to only react to questions the learner asks
- the learner checks matters of detail to ensure they are progressing as needed, this may be on a regular basis but would be checking for confirmation that they are progressing satisfactory and doing things correctly
- in some cases the tutor may have to assist and intervene to ensure actions are progressing satisfactory and correctly.

Examples of ‘*independence*’ might include (but not limited to):

- the learner feels comfortable to carry out the tasks without support, the tools, equipment and documentation they select and use will be those that are most suitable for the task and they will always show due regard to safety
- initially the tutor will support the learner to ensure they are able and know what they need to do when carrying out the required tasks, although this may be more apparent during the formative assessment stages than with the summative assessment
- the tutor will monitor and recognise that the learner can carry out the tasks but may on occasions have to assist
- learners may seek confirmation that they are doing things right before they carry out stages of the tasks required.

Tasks that involve learners working independently or with guidance should not be attempted until it is clear that they have been taught and have practised the relevant knowledge and skills and are suitably ready to generate and gather evidence.

Marking grid A

| Assessment focus LO.1.1 | |
|--------------------------------|---|
| Mark Band 1 (0–6 marks) | Characterised by lists or simple statements such as ‘routine maintenance would be used on automatic production lines’. One mark can be awarded for each example given and one mark can be awarded for each appropriate application stated against each maintenance procedure given. This band would also be appropriate for responses which only cover one procedure, even if well described. |
| Mark Band 2 (7–10 marks) | The learner’s description shows some understanding of how procedures are carried out, for example, ‘routine maintenance would be used on automatic production lines by looking at parts of the line on a regular basis’. For full marks all three examples should be described in this way. One description with two mark band 1 style answers would just get into the bottom of this band. |
| Mark Band 3 (11–14 marks) | The descriptions are enhanced by linking the procedures to their need, for example, ‘routine maintenance would be used on automatic production lines by looking at parts of the line on a regular basis and would involve activities such as replacing some components before they fail’. |

| Assessment focus LO.1.2 | |
|--------------------------------|---|
| Mark Band 1 (0–4 marks) | One mark can be awarded for each example given and one mark can be awarded for each appropriate maintenance task stated, for example, ‘a manufacturer’s manual could be used’. This band would also be appropriate for the answer that covers only one example, even if well described. |
| Mark Band 2 (5–6 marks) | Rather than the simple statement in mark band 1, responses getting credit in this band must describe something of the nature of the documentation, for example, ‘a manufacturer’s manual could be used as it shows how to remove the guards and the areas of the machine to lubricate’. Both examples may focus on either ‘planning’ or ‘carrying out’ – it is not necessary to address both. |
| Mark Band 3 (7–8 marks) | It is important that both ‘planning’ and ‘carrying out’ of tasks are covered for full marks, even if one example focuses on planning and the second focuses on carrying out. In addition to describing the documentation there is a statement indicating how it is used. |

| Assessment focus LO.3 | |
|------------------------------|---|
| Mark Band 1 (0–4 marks) | For full marks the learner (i) draws up a plan that would be simple and basic, probably in the form of a list of key actions and (ii) follows the plan using appropriate tools and equipment. There are typically up to 2 marks for each of the two aspects of the response but could go to 3 if one aspect is answered well and above that required for this mark band but up to a maximum of 4 marks. |
| Mark Band 2 (5–7 marks) | For full marks the learner (i) draws up a plan, probably with some instructions for key actions or as a flow chart; (ii) follows the plan using appropriate tools and equipment; (iii) records key measurements. Allow up to 3 marks for each aspect, to a maximum of 7 marks for the band. |
| Mark Band 3 (8–10 marks) | For full marks the learner (i) draws up a plan, probably with some instructions for key actions or as a flow chart; (ii) follows the plan using appropriate tools and equipment; (iii) records key measurements; (iv) reviews the success of the plan with a suggestion for improvement. Allow up to 3 marks for each aspect, to a maximum of 10 marks for the band. |

Marking grid B

| Assessment focus LO.2 | |
|------------------------------|--|
| Mark Band 1 (0–12 marks) | <p>For full marks the learner is working with guidance and (i) carries out a routine maintenance task; (ii) follows a given schedule; (iii) uses given documentation; and (iv) uses given tools and equipment.</p> <p>There are typically up to 2 marks for each of the four aspects of the response, up to a maximum of 8 marks, but the balance could be 3:2:2:1 (in any order) if one aspect is more strongly addressed and above that required for this mark band. The safety considerations during the carrying out of the maintenance task should include personal protective clothing, general duties, hazards/hazard warning signs and mandatory signs. One mark can be awarded for the consideration of each. In all cases the learner has to be guided and advised throughout to ensure that progress is made. The learner relies on the support of the tutor, who has to assist in most aspects of the work. The level of support given to the learner restricts the learner's mark to mark band 1, irrespective of the quality of the outcomes.</p> |
| Mark Band 2 (13–20 marks) | <p>For full marks the learner is working with limited guidance and (i) carries out a routine maintenance task; (ii) follows a given schedule; (iii) uses given documentation; and (iv) selects and uses tools and equipment. There are typically up to 4 marks for each of the four aspects of the response, up to a maximum of 16 marks, but the balance could be 6:4:4:2 (in any order) if one aspect is more strongly addressed and above that required for this mark band. The safety considerations during the carrying out of the maintenance task should include personal protective clothing, general duties, hazards/hazard warning signs and mandatory signs. One mark can be awarded for the consideration of each. The tutor supports the learner initially in carrying out the task and following the schedule. Thereafter the tutor reacts to questions from the learner and suggests a range of ideas/activities that the learner acts on. The learner frequently checks matters of detail. The tutor needs to assist in some aspects of the work. This level of support restricts the learner's mark to bands 1 or 2, irrespective of the quality of the outcomes.</p> |

| Assessment focus LO.2 (continued) | |
|--|---|
| <p>Mark Band 3 (21–28 marks)</p> | <p>For full marks the learner is working independently and (i) carries out a routine maintenance task; (ii) follows a given schedule; (iii) selects and uses documentation; and (iv) selects and uses tools and equipment. There are typically up to 6 marks for each of the four aspects of the response, up to a maximum of 24 marks. The safety considerations during the carrying out of the maintenance task should include personal protective clothing, general duties, hazards/hazard warning signs and mandatory signs. One mark can be awarded for the consideration of each. The tutor supports the learner initially in carrying out the task and following the schedule. Thereafter the tutor occasionally assists the learner, and only when asked, but monitors progress throughout. This level of support gives access to all three mark bands.</p> |

Approaches to assessment

In order to reflect the applied nature of the unit a greater weighting of marks has been allocated to assessment focus 2. This provides opportunities for learners to apply their knowledge and understanding to practical, problem solving activities and to demonstrate when doing so that they can do this with guidance, with limited guidance or independently. Clearly the requirement for this assessment focus will need a learner observation record sheet supplemented by annotated photographs and other forms of evidence such as diagrams. Annotation on the given maintenance schedule and other documentation will also need to be included.

The evidence should clearly state the level of support given to learners and be detailed enough for the assessor to make a judgement as to whether the response falls into mark band 1, 2 or 3. Assessment focus 3 also involves practical activities and again adds to the applied nature of this unit.

It may be best to devise three tasks for the assessment of this unit.

Task 1 could cover the requirements of assessment foci 1.1 and 1.2 with written activities asking for examples of three different types of maintenance procedures, descriptions of different types of maintenance procedures and their use and a description of how different types of maintenance procedures are carried out and why they are needed. The centre has freedom of choice with regards to the products, plant and equipment used when considering types of maintenance. Their appropriateness will come from the experience that learners have had during the delivery of this unit (see delivery guidance).

Further written activities could cover assessment focus 1.2, requiring learners to give examples of, describe and explain different sorts of documentation, what the documentation covers and where each would be used.

The evidence for these assessment foci may not always be in a written/word-processed format. A video or audio recording would be acceptable for the requirements of assessment foci 1.1 and 1.2, as long as the assessor has made a judgement about the evidence and it is accessible and individually 'owned' by each learner. A detailed learner observation record sheet would equally be good evidence to capture this sort of response.

All of the evidence for this task will need to be in the form of a 'report' if the learner has been able to respond in a written manner or in the form of a 'process portfolio' if the learner has collected evidence in other forms such as learner observation record sheets.

Task 2 could cover assessment focus 2 as a practical activity. Learners will need to be given a maintenance task to carry out and a schedule to follow, with opportunities to safely use appropriate tools included in the documentation. The task should ensure through the schedule and other documentation that disassembly and assembly takes place and that safety involves considering personal protective clothing, general duties of employees at work, hazards and hazard warning signs and mandatory signage.

A typical scenario may be to look at a simple lathe within the engineering workshop or a motor vehicle. If the manufacturer's requirements are not known, a simulated set of instructions would suffice. Initially, learners will need to be given opportunities to select the appropriate documentation before any guidance is given.

Because assessment focus 2 requires practical work, evidence will need to include a learner observation record sheet supplemented by annotated photographs and diagrams and annotation on the given maintenance schedule and other documentation. This evidence should clearly state the level of support given to the learner, how effectively they used the documentation, tools and equipment and be detailed enough for the assessor to make a judgement as to whether the response falls into mark band 1, 2 or 3.

All of the evidence for this task will need to be in the form of a 'process portfolio'.

Task 3 could cover assessment focus 3 and would be a practical activity. Learners could investigate an engineered product, piece of equipment or system to establish whether it might fail in service. The process of carrying this out is more important than the product, piece of equipment or system failure. A range of tools needs to be used, with measurements recorded and judgements made about probable failure. Without real benchmarks to make this judgement a centre may have to set up a scenario for the learner. Because assessment focus 3 requires practical work, evidence will need to be in the form of a learner observation record sheet supplemented by annotated photographs and diagrams as well as annotation on any given documentation. The plan for mark band 1 will be simple and may be in the form of a list or bullet points, whereas that for mark band 2 and the one reviewed for mark band 3 is likely to be more than a list of actions and would include fuller instructions. All of the evidence for this task will need to be in the form of a 'process portfolio'.

The three tasks could be carried out on a work experience placement provided the right organisation could be found. In this case the centre staff will need to brief the company staff and engineers very carefully about the unit requirements. It is important to remember that often an employer, if the activities being carried out relate to their business and operations, is likely to want a different form of evidence. This may be in the form of a 'paper' or a 'briefing note' or a formally structured 'report'. In supporting an employer the diverse range of forms of evidence should be taken into consideration. In these cases learner observation record sheets, annotated photographs and video recordings of what the learner did will be vital. In tasks 1 and 2, the documentation could be real and supplied by the company.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

The learning outcomes could be taught in the order in which they appear in the content. As this unit is about the development of routine maintenance skills, and Unit 7 at Level 2 of the Engineering Diploma is about the application of maintenance techniques, it may be possible for a centre to deliver these units concurrently. However, centres would need to ensure that the evidence produced against the different levels of the Diploma is relevant and appropriate to that level and the unit requirements.

It is important that learners are introduced to a range of different types of maintenance procedures that are used in industry. This should cover products, equipment or systems. Visits to, or placements in, the engineering industry or other organisations that have a maintenance department or function would be helpful in giving learners first-hand experience of maintenance procedures. Alternatively, a visit to the centre by a maintenance engineer to talk about different types of maintenance procedures and their application would be beneficial.

Learners will also need to be taught about the different types of documentation used when planning and carrying out maintenance procedures. Any drawings given should be simple to read and understand, for example exploded diagrams, whilst in reality much more information can be seen with other types of drawings such as orthographic projection learners at this stage may not have the skills to read these types of drawings. Often, manufacturers' manuals will give sufficient detail about the maintenance requirements without the need to read detailed engineering drawings.

Learners will need to be shown the correct way to carry out simple maintenance tasks which should include disassembly, assembly and detailed safety considerations. They will need to be able to do this following manufacturers’ guidance on any engineered product, equipment or system. They will also need to be given opportunities to use a range of tools and equipment for this task.

Learners should be shown how to use appropriate tools and equipment to make simple measurements to help them assess a product, equipment or system against causes of failure. If condition monitoring is used it must be remembered that the learner just needs to know what to look for using an outcome from this and not the principles involved.

As already stated, opportunities should be taken throughout the delivery of this unit to reiterate the health and safety requirements of the second learning outcome. It is important that learners are made aware of the correct use and storage of Personal Protective Equipment (PPE), relevant health and safety regulations and the use of warning signs which would include hazards and hazard warning signs and other mandatory signage such as ear and eye protection signs. It is important to cover those safety issues that are likely to be required for any maintenance activity that will be carried out during the delivery and assessment of this unit. Care should be taken to limit the health and safety regulations covered to those directly linked to the activities being carried out, so as not to overburden learners.

The use of industrial visits or a visiting engineer will develop learners’ knowledge of causes of failure and health and safety requirements in a practical context. The internet can be used to research health and safety requirements and classroom activities, such as a competition on who can identify the most health and safety regulations and warning signs, might also help motivate learners.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|------------------------------|--|
| Independent enquirers | Identifying coursework questions and problems to resolve. Justifying the use of different types of maintenance procedures for different applications. Assessment focus 1.1. Using appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. Assessment focus 3. |
| Creative thinkers | Giving, describing and explaining the use of different sorts of documentation used when planning and carrying out maintenance tasks. Assessment focus 1.2. Using appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. Assessment focus 3. |
| Reflective learners | Setting goals for the development of each of their assignments. Reviewing their progress against the completion of their assignments. Devising a plan and using appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. Assessment focus 3. |

| Skill | When learners are ... |
|--------------------------------|---|
| Self-managers | <p>Planning and organising the creation of their assignments for this unit.</p> <p>Dealing with time pressures and deadlines for the production of their assignments.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> <p>Carrying out a routine maintenance task following a given schedule and using given documentation, tools and equipment in a safe manner. Assessment focus 2.</p> |
| Effective participators | <p>Devising a plan and using appropriate tools and equipment to see if a product, piece of equipment or system might fail in service. Assessment focus 3.</p> |

Functional skills – Level 1

| Skill | When learners are ... |
|--|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Interact with and use ICT systems independently to meet needs | |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | |
| Follow and understand the need for safety and security practices | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently to meet needs | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | |

| Skill | When learners are ... |
|---|--|
| Mathematics | Not present in this unit. |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | |
| Identify and obtain necessary information to tackle the problem | |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | |
| Use appropriate checking procedures at each stage | |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | Taking part in formal and informal discussions/exchanges with a supervisor when they are describing different types of maintenance and different sorts of documentation used when planning a maintenance task. |
| Reading – read and understand a range of texts | Carrying out a given simple maintenance task to a given schedule and using given documentation in a safe manner, using appropriate tools and equipment. |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | |

Work experience

Evidence for this unit could be gathered from a work placement. Learning about maintenance procedures within a real engineering company would give learners opportunities to maximise their potential.

Engineering companies are likely to have maintenance procedures that learners could follow and maintenance requirements that could be carried out to see if a product, piece of equipment or system is likely to fail. They will also have the benchmarks to make this judgement against.

Specialist resources

Centres will need to identify a range of locally available engineered products, equipment and systems on which learners will base their maintenance investigations. Most centres will already have suitably equipped workshops and laboratories. In addition, specialised reference material, such as maintenance manuals, exploded views, component lists, adjustment charts, service sheets and other data, should be made available. A well-stocked library, complete with internet research facilities should also be provided. Appropriate health and safety materials, including a range of signs and warning notices, should be prominently displayed in workshops and practical resource areas.

When delivering this unit, centres should also consider the use of resources that can be accessed within local industry. These are likely to make excellent case study material and will help bring to life the more theoretical parts of this unit. Industrial contacts will usually be able to suggest maintenance tasks that learners can observe, including those that involve the use of tools and equipment to recognise a likely product, equipment or system failure.

Reference material

Dummer G, Winton C and Tooley M – *An Introduction to Reliability* (Elsevier, 1997)
ISBN 0750635533

Godfrey N and Wallis S – *GCSE Engineering* (Nelson Thornes, 2004) ISBN 0748785515

Hughes P and Ferrett E – *Introduction to Health and Safety at Work* (Elsevier, 2005)
ISBN 0750666234

Mobley K – *Maintenance Fundamentals* (Butterworth-Heinemann, 2004) ISBN 0750677988

Unit 5: Introduction to Engineering Materials

Principal Learning unit

Level 1

Guided Learning Hours: 30

Internally assessed

About this unit

Have you ever wondered what the engineered products that we use every day are made of? Things such as computers, refrigerators and motor vehicles are made from a range of materials that have been selected by the design engineer as being best suited to that purpose. If you become an engineering technician you will need to know about the materials that are specified on engineering drawings and service schedules.

As part of your duties, you may have to select raw materials in the form of bars, sheets, plate and wire from stores. You may also have to identify and select fastening such as rivets and nuts and bolts made from different materials, that have been specified for a particular use.

Some pure metals, such as copper and lead, are easy to identify because of their colour and weight but others such as the different grades of steel, brass and aluminium alloy are not so easy to tell apart. The same difficulty applies to some thermoplastic and thermosetting plastic materials, which may have the same colour and surface texture but very different properties.

In this unit you will find out about the properties of engineering materials and the range of simple workshop tests that can be used to identify and evaluate their properties. You will also find out about the processes best suited for forming the different materials. There will be opportunities to put this knowledge into practice and collect naturally occurring evidence during practical workshop activities and from an appropriate work experience placement.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about the properties that are used to describe the performance of engineering materials
 - LO.2. Know about the materials that engineers use and their forming processes
 - LO.3. Be able to identify engineering materials and carry out tests to evaluate their properties.
-

What you need to cover

- | | |
|--|--|
| LO.1 Know about the properties that are used to describe the performance of engineering materials | Learners will need to investigate different material properties, including tensile and compressive strength, hardness, toughness, brittleness, malleability, ductility, electrical and thermal conductivity, corrosion and solvent resistance, and resistance to environmental degradation. |
| LO.2 Know about the materials that engineers use and their forming processes | <p>Learners will need to need to find out about the properties and typical applications of the following engineering materials:</p> <ul style="list-style-type: none"> • ferrous metals, eg cast iron, plain carbon steels, stainless steel, high speed steel, • non-ferrous metals, eg copper, tin, zinc, lead, aluminium, brasses, bronzes, solders, aluminium alloys • thermoplastics, eg PVC, nylon, PTFE, Perspex, polythene; and elastomers, eg natural rubber, neoprene, silicone rubber • thermosetting plastics, eg bakelite, Formica, melamine, Kevlar, fibre reinforced epoxy and polyester resins. <p>Learners will also research the related forming processes, eg casting, forging, moulding, drawing, extrusion, rolling, machining, pressing, lay up, vulcanising.</p> |
| LO.3 Be able to identify engineering materials and carry out tests to evaluate their properties | <p>Learners will need to know how materials are specified on engineering documents, drawings, and service schedules, eg cast iron (CI), bright drawn mild steel (BDMS), solid diameters, pipe and tube diameters, wire gauge.</p> <p>Learners will need to be able to identify the materials from which engineering components have been made.</p> <p>They will also need to use basic test procedures to evaluate the mechanical properties of materials, eg tensile test, ductility test, surface hardness test, impact test, malleability test.</p> |
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How you will be assessed

This unit will focus on engineering materials and their properties. As such you will be assessed through an assignment that will give you opportunities to demonstrate what you know about the properties used to describe the performance of materials, the materials that engineers use and their forming processes and show that you can identify engineering materials and carry out tests to evaluate their properties.

This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given a number of tasks that will cover all of the material you have studied. Your tutor will give you opportunities to develop evidence and one or more tasks could be set in the laboratory or workshop, and may relate to your work experience. These opportunities might typically consist of three tasks.

Task 1 may cover the requirements of assessment foci 1, 2.1 and 2.2 with written activities. Evidence for this task will therefore be in the form of a 'report'.

The second task could cover the requirements of assessment foci 2.3 and 2.4, also using written activities. Again, evidence will be in the form of a 'report'.

The third task covering the requirements of assessment foci 1, 3.2 and 3.3 would be mainly a practical exercise that could be carried out in a workshop setting or during your work placement. Evidence from this practical task will be in the form of a 'process portfolio' and a 'report'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|--|---|-------------------------|
| LO.1 Know about the properties that are used to describe the performance of engineering materials | States four different material properties that describe the performance of engineering materials. (0–4) | States four different material properties that describe the performance of engineering materials and defines three of them. (5–7) | States four different material properties that describe the performance of engineering materials, defines three of them and explains how the application of two materials (each with a different material property) would be affected. (8–9) | 9 |
| LO.2.1 Know about ferrous metals and their forming processes | Gives an appropriate forming process and an engineering application for each of three different ferrous metals. (0–3) | Gives an appropriate forming process and an engineering application for each of three different ferrous metals and describes the properties of two of them. (4–5) | Gives an appropriate forming process and an engineering application for each of three different ferrous metals, describes the properties and justifies the use of the forming process of two of them. (6–7) | 7 |
| LO.2.2 Know about non-ferrous metals and their forming processes | Gives an appropriate forming process and an engineering application for each of three different non-ferrous metals. (0–3) | Gives an appropriate forming process and an engineering application for each of three different non-ferrous metals and describes the properties of two of them. (4–5) | Gives an appropriate forming process and an engineering application for each of three different non-ferrous metals, describes the properties and justifies the use of the forming process of two of them. (6–7) | 7 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|---|---|-------------------------|
| LO.2.3 Know about thermoplastics and elastomers and their forming processes | Gives an appropriate forming process and an engineering application for each of two different thermoplastic and one elastomer material. (0–3) | Gives an appropriate forming process and an engineering application for each of two different thermoplastic and one elastomer material and describes the properties of one thermoplastic and one elastomers. (4–5) | Gives an appropriate forming process and an engineering application for each of two different thermoplastic and one elastomers. Describes the use the forming process of one thermoplastic and one elastomers. (6–7) | 7 |
| LO.2.4 Know about thermosetting plastics and their forming processes | Gives an appropriate forming process and an engineering application for each of three different thermosetting plastic materials. (0–3) | Gives an appropriate forming process and an engineering application for each of three different thermosetting plastic materials and describes the properties of two of them. (4–5) | Gives an appropriate forming process and an engineering application for each of three different thermosetting plastic materials, describes the properties and justifies the use the forming process of two of them. (6–7) | 7 |
| LO.3.1 Identify materials specified on an engineering drawing or service schedule | Describes how three given different engineering materials are shown in abbreviated form on an engineering document. (0–3) | Describes how three given different engineering materials are shown in abbreviated form on an engineering document and identify two other materials that are specified on a given engineering document. (4–5) | Describes how three given different engineering materials are shown in abbreviated form on an engineering document and identifies two other materials that are specified on a given engineering document together with the forms of raw material and their dimensional requirements. (6–7) | 7 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|--|---|-------------------------|
| LO.3.3 Carry out tests on engineering materials | Carries out two given tests on two given engineering materials to evaluate given mechanical properties. (0–4) | Carries out two given tests on two given engineering materials to evaluate and compare given mechanical properties. (5–6) | Select and carry out two appropriate tests on two given engineering materials to evaluate and compare given mechanical properties. (7–9) | 9 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|---|--|--|-------------------------------|
| LO.3.2 Identify engineering materials | Identifies the materials from which three given engineering components are made by carrying out a visual and tactile inspection. (0–3) | Identifies the materials from which three given engineering components are made by carrying out a visual and tactile inspection and describe the properties of two of them. (4–5) | Identifies the materials from which three engineering components are made by carrying out a visual and tactile inspection, describes the properties of two of them and justifies their selection for the component. (6–7) | 7 |
| Total marks | | | | (9+7+7+7+7+7+9+7) = 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

Marking grid A

| Assessment focus LO.1 | |
|------------------------------|---|
| Mark Band 1-3 (0-9 marks) | <p>One mark can be awarded for each of the four relevant material properties stated, eg tensile and compressive strength, hardness, toughness, etc.</p> <p>One mark can be awarded for each of the three relevant property definitions. The definition need not be 'textbook' but must indicate a sufficient grasp of the key factors associated with each of the material properties defined.</p> <p>One mark can be awarded for each of the two relevant explanations of how a material's property affects its application.</p> |

| Assessment focus LO.2.1 | |
|------------------------------|---|
| Mark Band 1-3 (0-7 marks) | <p>The three ferrous metals chosen by the learner should be significantly different, eg low carbon steel, high carbon steel and grey cast iron, to demonstrate a knowledge of the range of ferrous metals and related forming processes. One mark can be awarded for each of the three relevant forming processes and engineering applications of ferrous metals given.</p> <p>One mark can be awarded for each of the two appropriate descriptions of properties of the ferrous materials.</p> <p>The justification should be in terms of the matching of material properties with the forming processes and applications. One mark can be awarded for each of two appropriate justifications.</p> |

| Assessment focus LO.2.2 | |
|------------------------------|--|
| Mark Band 1-3 (0-7 marks) | <p>The three non-ferrous metals chosen by the learner should be significantly different, eg lead, copper and aluminium, to demonstrate a knowledge of the range of non-ferrous metals and related forming processes. One mark can be awarded for each of the three relevant forming processes and engineering applications of the non-ferrous materials chosen.</p> <p>One mark each can be awarded for an appropriate description of the properties of two of them.</p> <p>One mark can be awarded for each of two appropriate justifications, which should be in terms of the matching of material properties with the forming processes and applications.</p> |

| Assessment focus LO.2.3 | |
|--------------------------------------|--|
| <p>Mark Band 1-3 (0-7 marks)</p> | <p>The two thermoplastic materials chosen should be significantly different in terms of their properties and applications, eg nylon, polythene, Perspex, to demonstrate a knowledge of the range of thermoplastic materials. One mark can be awarded for each forming process and relevant engineering application for each material chosen, eg two different thermoplastics and one elastomer.</p> <p>One mark each can be awarded for an appropriate description of properties of one thermoplastic material and one elastomer.</p> <p>One mark can be awarded for each of two appropriate justifications, which should be made in terms of the matching of material properties with the forming processes and their applications.</p> |

| Assessment focus LO.2.4 | |
|--------------------------------------|--|
| <p>Mark Band 1-3 (0-7 marks)</p> | <p>The three thermosetting materials chosen should be significantly different in terms of their properties and applications, eg Bakelite, melamine and a GRP, to demonstrate a basic knowledge of the range of thermosetting plastic materials. One mark can be awarded for each forming process and relevant engineering application for each of the three thermosetting plastic materials chosen.</p> <p>One mark each can be awarded for an appropriate description of the properties of two of the thermosetting materials.</p> <p>One mark can be awarded for each of two appropriate justifications, which should be made in terms of the matching of material properties with the forming processes and their applications.</p> |

| Assessment focus LO.3.1 | |
|--------------------------------------|---|
| <p>Mark Band 1-3 (0-7 marks)</p> | <p>One mark can be awarded for each description of the abbreviated form used on engineering documents for each of the three engineering materials.</p> <p>One mark each can be awarded for identifying two other materials specified on an engineering document.</p> <p>One mark each can be awarded for identifying each of the two raw material forms and dimensional requirements.</p> |

| Assessment focus LO.3.3 | |
|--------------------------------|--|
| Mark Band 1-3 (0-9 marks) | <p>Up to four marks can be awarded for the tests carried out on the engineering materials. Typically one mark can be awarded for each of the two tests carried out on each of the two given engineering materials and for the correct evaluation of their mechanical properties.</p> <p>Up to two marks can be awarded for comparing the mechanical properties of the two engineering materials.</p> <p>Up to three marks can be awarded for selecting two tests to be carried out. Typically one mark each can be awarded for the choice of each valid test and one mark for either one or both being the most significant mechanical property to test for the given material(s).</p> |

Marking grid B

| Assessment focus LO.3.2 | |
|--------------------------------|---|
| Mark Band 1-3 (0-7 marks) | <p>One mark can be awarded for identifying the engineering material used for each of the three engineering components. It is the outcome of the correct identification that marks can be awarded and not the process of visual or tactile inspection. However, information from books or the internet for example should not be used.</p> <p>One mark each can be awarded for describing the properties of two of the identified engineering materials.</p> <p>One mark each can be awarded for justifying the selection of the two identified engineering materials.</p> |

Tasks, set within the context of each assessment instrument, can be varied according to the known ability of the learners within the cohort. For example, for assessment focus 2.1, those working at the higher mark band may be asked to give an appropriate forming process and an engineering application for each of three ferrous metals, describe the properties and justify the use of the forming process and an engineering application for two of them. When carrying out this task, the appropriate forming processes and engineering applications satisfy the requirements of mark band 1 and justification of the use of two of them requires a listing and description of their properties which satisfies mark band 2. Provided that the response meets the requirements of mark band 3 they can be awarded the marks from this band without worrying about the requirements of mark bands 1 and 2. However, other learners who may only be able to work at mark band 1 could be given a less challenging task that asks them to give only an appropriate forming process and an engineering application for two different ferrous metals.

This approach may be used to lessen the assessment burden for the higher achievers and give the lower achievers opportunities to perform at their most appropriate level. If a learner's ability has been misjudged and they are unable to achieve the higher level, an appropriate task at a lower level should be given, taking care not to lose the validity of the assessment, eg change the material being considered.

Approaches to assessment

The assignment for this unit could consist of three tasks.

Task 1 could cover the requirements of assessment focus 1, with written activities requiring examples and definitions of different material properties plus an explanation of how the properties might affect the application of a material. An appropriate mark would be awarded for each property in each band.

This task could also cover the requirements of assessment foci 2.1 and 2.2, which are concerned with ferrous and non-ferrous metals. Written activities could be set which require property descriptions for three different ferrous and three different non-ferrous metals, together with appropriate forming processes and typical applications. This would enable learners to achieve marks from mark bands 1 and 2. Activities requiring justification for the use of a forming process appropriate to the materials would provide the opportunity to achieve marks from mark band 3.

If a learner needs to retake this assessment it is essential that different material properties and materials be chosen as the focus of the assignment. The evidence would need to be submitted in a 'report'.

Task 2 could use a similar approach to that in task 1, covering assessment foci 2.3 and 2.4 for thermoplastics, elastomers and thermosetting plastics. Written activities could be set that require examples, descriptions and justification for the use of different thermoplastics and an elastomer and different thermosetting plastics and their forming processes. An appropriate mark would be awarded for each assessment focus in each band. Where retakes are required there is a sufficient list of materials to choose from in the 'what you need to cover' section for each foci to ensure the validity of the assessment. Evidence would need to be submitted in a 'report'.

Task 3 could bring together the assessment foci 3.1, 3.2 and 3.3 in a mainly practical activity. This could be carried out in the training workshop or on work placement. An appropriate written or oral response describing how three different materials are shown in abbreviated form on engineering documents would be sufficient for the requirements of mark band 1 in assessment focus 3.1. An activity to achieve the requirements of mark band 2 would require learners to identify a further two different materials given on a given engineering document. To meet the requirements of mark band 3 learners would need to identify the raw material form and dimensional requirements for these two materials. This might be bar, sheet, tube etc of suitable dimensions or castings, or mouldings in finished or rough form.

Assessment focus 3.2 requires learners to physically identify the engineering materials from which three given engineering components are made. Identification from a visual and tactile inspection is required to achieve the requirements of mark band 1. As such a learner observation record sheet may be needed. Annotated photographs could be used to supplement the learner observation record sheet and/or any other form of written record, eg a suitable chart with a record of the learner's observations against each component. To achieve the requirements of mark band 2 learners will need to describe the properties of the materials. To achieve the requirements of mark band 3 learners will additionally need to justify the selection of the materials for the given components.

Assessment focus 3.3 is concerned with basic material testing techniques. To achieve the requirements of mark band 1, learners will need to carry out two given tests on two given engineering materials and evaluate their mechanical properties. A learner observation record sheet supplemented by annotated photographs as well as annotation on any given testing documentation will be needed. Learners will also need to give a reasoned comparison of their mechanical properties to meet the requirements of mark band 2. To achieve mark band 3, learners need to select two appropriate tests themselves and to evaluate and compare the given properties of two materials. In the task the evidence would need to be submitted in a 'process portfolio' for the practical work and a 'report' for the written activities.

Where retakes are required for 3.1, 3.2 and 3.3, learners should work with different drawings/materials/tests etc.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

The learning outcomes could be delivered in order. It is important that learners are introduced at first to the definitions of properties that are used to describe the suitability of engineering materials for particular applications. Delivery could be aided through the use of film or video resources, such as the BBC craft studies and technical studies series.

Learners can then be introduced to the range of ferrous metals, their properties, forming processes, applications and forms of supply. A brief description of the crystal lattice and granular structure of metals will help to explain their various properties. A range of material specimens will be essential and practical activities could include simple workshop tests to distinguish between metals, for example, cast iron, plain carbon steels and alloy steels. These could be visual and tactile tests to observe the granular structure and detect the presence of free graphite in cast iron. They could also include file tests, bend tests and spark tests to distinguish between cast iron and the different grades of plain carbon steel.

Although it is not essential to give detailed coverage of heat treatment processes, learners should be aware that plain carbon steels in particular, can be hardened and tempered or case hardened. This might be demonstrated in the workshop together with appropriate tests to confirm the change of properties.

Learners can then start to look at the range of non-ferrous metals and alloys. Loss of ductility and malleability, due to work hardening, could be demonstrated together with the annealing process to restore their properties. Appropriate workshop tests could be carried out to demonstrate the effectiveness of the process. BBC Craft Studies and Technical Studies videos might be useful to supplement the delivery.

Before looking at the range of plastic materials, it would be useful to identify some of the more common elements that form polymers, and the ways in which they combine. The structure of polyethylene (polythene) could be used as a typical example. Learners could then be introduced to a range of thermoplastic and elastomer materials, their properties, forming processes, applications and forms of supply.

The glass transition temperature should be explained and the change of properties demonstrated when it is exceeded. The process of cross-linking should be outlined and it will be useful to contrast the structure of polymer materials with particular reference to this cross-linking for elastomers and the granular structure of metals. A range of thermosetting plastics should be presented, together with typical composites such as printed circuit board, Kevlar and fibre reinforced epoxy and polyester resins. As with metals and thermoplastics, their properties, forming processes, applications and forms of supply should be identified. The list should not be exhaustive. It should be limited mainly to the engineering materials that learners are likely to encounter in the training workshop or work placement.

Learning outcome 3 covers the identification of materials specified on engineering documents, identification of the materials from which given engineering components are made and the use of basic test procedures to evaluate mechanical properties. Learners should be introduced to the abbreviations commonly used on engineering drawings and service schedules. This applies not only to the material type but also to the dimensions such as the indicated bar and pipe diameters, wire gauge and different kinds of finish and protective coating. Exemplar documents should be made available for viewing and interpretation.

Learners should also be made aware of the colour codes that are commonly used for bar stock and castings to denote material type and grade. The use of sophisticated test equipment is not expected and the tests should be workshop/laboratory devised using readily available tools, equipment and materials. A tensile/ductility test could involve loading a suspended wire specimen and recording the breaking load and amount of permanent extension. Bench shears or tinsnips could be used to devise a shear strength test. A centre punch, file or saw could be used to assess surface hardness. Alternatively, a test in which a hardened steel ball bearing is dropped from a given height and its rebound measured could be devised to assess surface hardness and elasticity. Toughness/brittleness/malleability could be assessed by striking a specimen held in a vice with a hammer and noting its effect. Learners should be encouraged to devise their own tests to suit different materials.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | Identifying coursework questions and problems to resolve. Explaining how material properties affect the application of materials. Assessment focus 1. Justifying the use of engineering materials in selected applications. Assessment foci 2.1, 2.2, 2.3 and 2.4. Identifying materials from which components are made. Assessment focus 3.2 Carrying out two given tests on two given engineering materials to evaluate given mechanical properties. Assessment focus 3.3. |
| Creative thinkers | Not present in this unit. |
| Reflective learners | Setting goals for the development of each of their assignments. Reviewing progress against the assessment of their assignments. |
| Team workers | Not present in this unit. |
| Self-managers | Planning and organising the creation of their assignments for this unit. Dealing with time pressures and deadlines for the production of their assignments. Seeking advice and support from their peers and tutors when needed. Carrying out two given tests on two given engineering materials to evaluate given mechanical properties. Assessment focus 3.3. |
| Effective participators | Carrying out two given tests on two given engineering materials to evaluate given mechanical properties. Assessment focus 3.3. |

Functional skills – Level 1

| Skill | When learners are ... |
|--|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Interact with and use ICT systems independently to meet needs | |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | |
| Follow and understand the need for safety and security practices | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently to meet needs | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | |

| Skill | When learners are ... |
|---|---|
| Mathematics | |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | |
| Identify and obtain necessary information to tackle the problem | Describing how three given different engineering materials are shown in abbreviated form on an engineering document. |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | Identifying the materials from which three given engineering components are made by carrying out a visual and tactile inspection. |
| Use appropriate checking procedures at each stage | |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | Giving oral descriptions of appropriate forming process, materials and their properties and justifications for their use. |
| Reading – read and understand a range of texts | |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | Writing descriptions of appropriate forming process, materials and their properties and justifications for their use. |

Work experience

This unit is well suited to the use of an appropriate work placement. Seeing the application and use of materials in a real engineering company would provide additional opportunities and help learners maximise their potential.

Engineering companies are likely to have a range of material stock, relevant engineering documents and possibly material testing facilities. Learners would also be able to observe material forming processes to reinforce the links between material properties and applications.

Specialist resources

Centres will need a range of materials and learners will require occasional access to workshop facilities. A selection of engineering drawings and other appropriate documents containing specifications in an abbreviated form should also be available.

Although not essential, a metallurgical microscope with mounted and etched material specimens will be of benefit to demonstrate the grain structure of metals. Library and internet access will also be an advantage for information retrieval exercises.

The BBC engineering craft studies and technical studies videos will provide a useful reinforcement to delivery. These are available from:

BBC Videos for Education and Training
Woodlands
80 Wood Lane
London W12 0TT

Telephone: 0208 576 2541

Reference material

Godfrey N and Wallis S – *GCSE Engineering* (Nelson Thornes, 2004) ISBN 0748785515

Higgins R – *Materials for Engineers and Technicians* (Newnes, 2006) ISBN 0750668504

Timings R L – *Engineering Materials, Volume 1* (Longman, 1998) ISBN 0582319285

Timings R L – *Engineering Materials, Volume 2* (Longman, 2000) ISBN 0582404665

Unit 6: Electronic Circuit Construction and Testing

Principal Learning unit

Level 1

Guided Learning Hours: 30

Internally assessed

About this unit

Electronics underpins much of the equipment used in both industry and your home.

Electronic equipment consists of either a single electronic circuit board or multiple circuit boards joined together. A circuit board will typically consist of a number of electronic components put together in such a way that they produce the desired output signal required to drive, for instance, a robot used in a factory to build cars or the television in your home.

In this unit you will identify the common components used in electronics, learn how to put them together to produce an electronic circuit diagram and how to turn that diagram into a prototype and a practical circuit board. You will have an opportunity to work in a team to plan how best to construct an electronic circuit. Having produced the prototype, you will use test equipment to ensure the correct working of the circuit. The unit will be practically based throughout.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know how electronic components are identified
 - LO.2. Be able to use symbols to produce an electronic circuit diagram
 - LO.3. Be able to work in a team to plan the construction of an electronic circuit from a circuit diagram and then individually build the circuit
 - LO.4. Be able to test an electronic circuit.
-

What you need to cover

- LO.1 Know how electronic components are identified**
- Learners will need to recognise the standard symbols (to British Standard BS3939) used to represent electronic components and recognise that the circuit symbols used are a representation rather than a picture of the component, eg battery, power supply, conductor, junctions, crossovers, ground connection, fuse, switch, resistor, variable resistor, capacitor, electrolytic capacitor, inductor, transformer, transistor, IC, operational amplifier, logic gates, lamp, diode, LED, photodiode, LDR, thermistor, 7 segment display.
- Learners will explore the key features associated with the electronic components represented, eg tolerances, working voltages, power rating, maximum current, temperature ranges.
- In addition, learners will need to recognise that the components have values, and sometimes markings that can determine their value and the way they are connected, eg polarised capacitors, diodes, transistors, IC pin 1, etc. (Note that there is no need at this stage to understand the electrical/electronic principles behind this.)
- Learners will consider a range of circuit diagrams using symbols produce to British Standard BS3939, eg simple series circuit such as containing a supply, switch, fuse, a series resistor and LED; an analogue circuit; a digital circuit.
- LO.2 Be able to use symbols to produce an electronic circuit diagram**
- Learners will need to know how to examine a circuit and from it produce a circuit diagram, starting with simple circuits (resistors in series and parallel) and progressing to circuits that are more complex (inverting amplifier). All the circuits should be capable of working and produce a measurable or indicated output.
- Whilst learners will be encouraged to sketch (freehand) some circuits, they should also be able to use a simulation package, eg Electronics Workbench (Multisim), Tina or similar to draw the circuits, which can also be used for simulated testing in LO.4.
- Learners will need to be able to explore simple series circuit diagrams that include a supply, switch, fuse, a series resistor and LED, an analogue circuit and a digital circuit.
- LO.3 Be able to work in a team to plan the construction of an electronic circuit from a circuit diagram and then individually build the circuit**
- Learners will need to work in a team and collaborate with others to plan how to prototype a circuit using breadboard (protoboard) techniques. They will need to appreciate that electronic circuit layout is physically not the same as the circuit diagram. The use of pre-printed sheets is to be encouraged in the planning process.
- Learners will need to be able to use relevant tools when constructing circuits, eg wire strippers, side cutters and small pliers to neatly place the conductors and bend the component leads for insertion into the board.
- Learners will be expected to construct at least one electronic circuit from a given circuit diagram using a breadboard, one using a strip board and one using a pre-prepared printed circuit board (PCB). This will include the use of soldering tools and the use of heat sinking techniques.

Learners will need to be made aware of and observe the health and safety aspects associated with working with tools and soldering.

LO.4 Be able to test an electronic circuit

Learners will need to be able to make electronic circuit measurements using appropriate equipment (simulated and physical test equipment), eg multimeter, signal generator, oscilloscope, logic pulser, logic clip and logic probe. It is not intended that learners will use an oscilloscope to make frequency measurements but rather to explore signal size and shape.

Learners will need to be able to examine and test circuits such as alternating or direct current single stage transistor amplifier circuits or inverting amplifier circuits using an operational amplifier. Learners should be made aware of the expected input and output signals from the circuit.

How you will be assessed

This unit will focus on the work of an electronics engineer when dealing with electronic circuit diagrams, prototyping and building circuits and testing circuit performance. You will be assessed through an assignment that provides you with opportunities to read electronic circuit diagrams, use symbols to prepare diagrams that represent a given circuit, build circuits and test them.

The unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given one or more tasks that will cover the material you have studied. At least some of these tasks will be set in the workshop and may relate to your work experience. One of these tasks will require you to work in a team when planning how to carry out the construction of an electronic circuit. Your tutor will give you opportunities to develop evidence. These opportunities could typically consist of three tasks.

The first task could cover assessment focus 1 with practical and written activities. Your evidence will need to be submitted as a 'process portfolio'.

A second task could cover assessment focus 2 and include the practical activity of preparing an electronic circuit diagram. The evidence will be in a 'process portfolio'.

A third task could be used to cover assessment foci 3 and 4 with practical and written activities to build and test an electronic circuit. The evidence for this task will need to be submitted in two separate 'process portfolios'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|---|---|---|-------------------------|
| LO.1 Know how electronic components are identified | Identifies six different electronic components on a given circuit diagram from the standard symbols that have been used to represent them. (0–6) | Identifies six different electronic components on a given circuit diagram from the standard symbols that have been used to represent them and identifies the symbol that would be used to represent a further four physical components. (7–10) | Identifies six different electronic components on a given circuit diagram from the standard symbols that have been used to represent them, identifies the symbol that would be used to represent a further four physical components and uses either a physical or web-based catalogue to identify the order code, key features and cost of five given electronic components. (11–15) | 15 |
| LO.2 Be able to use standard circuit symbols to produce an electronic circuit diagram | Sketches an electronic circuit diagram, which includes at least six components, using standard symbols. (0–6) | Sketches an electronic circuit diagram, which includes at least six components, using standard symbols, reproduces the circuit diagram using a computer-based electronic circuit simulation package and saves the completed drawing. (7–11) | Sketches an electronic circuit diagram, which includes at least six components, using standard symbols, reproduces the circuit diagram using a computer-based electronic circuit simulation package, saves the completed drawing and then retrieves, modifies the circuit diagram and resaves the revised version. (12–15) | 15 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|--|--|-------------------------|
| LO.3 Be able to work in a team to plan the construction of an electronic circuit from a circuit diagram and then individually build the circuit | Works in a team to plan the construction of a given electronic circuit, and individually prototypes the circuit using a breadboard. (0–6) | Works in a team to plan the construction of a given electronic circuit, and individually prototypes the circuit using a breadboard and safely builds the circuit using stripboard. (7–11) | Works in a team to plan the construction of a given electronic circuit, and then individually prototype the circuit using a breadboard, safely builds the circuit using stripboard and constructs the circuit on a given printed circuit board. (12–15) | 15 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|---|---|-------------------------|
| LO.4 Be able to test an electronic circuit | Uses an electronic circuit simulation package to test the operation of a given electronic circuit by measuring six different circuit input and output signals. (0–6) | Uses an electronic circuit simulation package and sets-up to test the operation of the given electronic circuit by measuring six different circuit input and output signals for each. (7–11) | Uses an electronic circuit simulation package and sets-up and uses physical test equipment to test the operation of the given electronic circuit by measuring six different circuit input and output signals for each and compares the results, advantages and disadvantages of each approach. (12–15) | 15 |
| Total marks | | | | (15+15+15+15) = 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

Marking grid A

| Assessment focus LO.1 | |
|-------------------------------|--|
| Mark Band 1-3 (0–15 marks) | <p>Up to 6 marks can be awarded for identifying the six electronic components from the standard symbols that have been used to represent them on the given electronic circuit. One mark should be awarded for each correctly identified component.</p> <p>Up to 4 marks can be awarded for identifying the four standard symbols that would be appropriate to represent the further four different physical components to be added to circuit diagram. One mark should be awarded for each correctly identified symbol.</p> <p>Up to 5 marks can be awarded for correctly identifying the order code, key features and cost of five components from a component catalogue (physical or web-based). One mark should be awarded for each correctly identified component.</p> |

| Assessment focus LO.2 | |
|-------------------------------|--|
| Mark Band 1-3 (0–15 marks) | <p>Up to 6 marks can be awarded for a working sketch of an electronic circuit that uses correct symbols for at least six components. Two marks can be awarded for the correct use of symbols for the six components, 3 marks for presentation (correct orientation, correct values and units indicated) and 1 mark for the usability of the circuit sketch, based on its clarity. To achieve full marks for mark band 1, the learner must be able to prepare a sketch of the circuit diagram using standard symbols and relevant notation/values where applicable. The sketch should be a freehand working diagram.</p> <p>Up to 5 marks can be awarded for reproducing the sketch using a computer-based simulation package. 3 marks should be awarded for the actual use of the package (accessing the software, using the software tools, dealing with problems), 1 mark for saving the drawing in an appropriate location with an appropriate file name and 1 mark for a correct circuit diagram. This diagram should be more formal than the working sketch and as such, it could be expected to include a title block. Evidence of the document being saved appropriately is also required.</p> <p>Up to 4 marks can be awarded for the modification of a circuit diagram produced using a computer-based simulation package. One mark should be awarded for accessing the file, 2 marks awarded for the modification (this must include the introduction of new component symbols and substantial change to layout – changing unit values would not be sufficient) and 1 mark for saving the revised circuit drawing with a new and relevant file name.</p> |

| Assessment focus LO.3 | |
|---------------------------------------|--|
| <p>Mark Band 1-3 (0–15 marks)</p> | <p>To achieve full marks for mark band 1, the learner should collaborate with the team to plan the construction of a given circuit and then individually prototype the circuit using a breadboard. Two marks should be allocated and based on the contribution the learner makes to the team effort and 1 mark allocated for the record of the planning outcome and up to 3 marks for the construction of the circuit prototype onto breadboard (accuracy, neatness, it works).</p> <p>To achieve full marks for mark band 2, the learner should reconstruct the breadboarded prototype using stripboard techniques. One mark should be allocated for the safe building of the circuit using stripboard, 2 marks for the quality of the finished board (layout and use of space) and 2 marks for the positioning and soldering of the joints.</p> <p>Up to 4 marks can be awarded for the construction of the circuit using a given PCB. Three marks awarded for quality of finish (positioning components, soldering, neat and industry standard appearance) and 1 mark for its correct function.</p> |

Marking grid B

| Assessment focus LO.4 | |
|---------------------------------------|--|
| <p>Mark Band 1-3 (0–15 marks)</p> | <p>Up to 6 marks can be awarded for the use of a computer-based circuit simulation package to test a circuit (computer-based circuit simulation can be provided by tutor or learner may use their own from assessment focus 2 Band 2) and record the results of six different circuit input/output signals. Each correct measurement (correct use of system to carry out input/output measurement and a suitable record of the result) can be allocated 1 mark each.</p> <p>Up to 5 marks can be awarded for the set-up and use of physical equipment to test a circuit (actual circuit can be provided by the tutor or learner may use their own from assessment focus 3 Band 1, 2 or 3) and record the results of six different circuit input/output signals. Two marks should be awarded for the set-up of the equipment and 3 for the correct measurement (use of test equipment to carry out input/output measurement and a suitable record of the result).</p> <p>Up to 4 marks can be awarded for the comparison of the simulated test and physical test equipment methods. One mark should be awarded for the comparison of the respective results and 4 marks for relevant comments about the advantages and disadvantages (at least two valid advantage and two valid disadvantages should be provided).</p> |

Approaches to assessment

It may be appropriate to devise three tasks for the assessment of this unit.

Task 1 could cover the requirements of assessment focus 1 and learners should be given a copy of an electronic circuit diagram that includes at least 6 different components. The circuit diagram should have the component symbols annotated so that learners can then identify the components represented by six different symbols to achieve mark band 1. Care should be taken when capturing the records for individual learners, the symbols/components identified and the circuit diagrams used.

A similar approach could also be adapted for mark band 2, with evidence of the symbols identified for four physical components. These components should be different to those identified for mark band 1.

The evidence for mark band 3 would need to be collected from an investigation to identify the order code, key features and cost of five components (different to those used for mark band 2). The use of tutor observation/oral questioning during practical work with relevant circuit diagrams means that evidence would need to be presented in a 'process portfolio'.

Task 2 could cover assessment focus 2. This task could include three related activities that require learners to produce three circuit diagrams – a sketched circuit diagram, the same diagram produced using a computer-based simulation package and a modified version of this diagram. The circuit diagram should be an appropriate representation of an actual electronic circuit (eg a printed circuit board or stripboard circuit) that includes at least six components and that has been given to the learner by the tutor. The activity for mark band 3, should be provided by the tutor in the form of a modified sketch that is based on the original circuit provided for mark band 1. The evidence for this task will be the sketch and drawings plus tutor observation of the development of the circuit diagrams (use of software tools) and the relevant saved files. All the evidence should be presented in a 'process portfolio'.

Task 3 could cover assessment foci 3 and 4. This task could include three related activities that require learners to construct and test circuits. The first activity, covering assessment focus 3, would require learners to work collaboratively with others in a team to plan the construction of an electronic circuit and then individually prototype and build the circuit. Learners will need opportunities to collaborate within the team to plan the construction of a given circuit (this should be a different circuit to that used for assessment focus 2) and then individually prototype the circuit using a breadboard. Evidence will be in the form of tutor observation of the planning process, plus any team minutes, and the final prototyped circuit or an annotated photograph. The evidence for mark band 2 will be tutor observation of the construction techniques used (safety aspects, preparation of components, use of tools, soldering) and the finished stripboard circuit or an annotated photograph. To achieve mark band 3, learners should construct the same circuit using a given pre-prepared printed circuit board (PCB). Once again, the evidence will be in the form of observation and the finished PCB. All the evidence for this planning and construction activity would be presented in a 'process portfolio'.

The second activity in task 3, covering assessment focus 4, would require the learner to test the operation of a simulated and an actual circuit (this could be the same circuit produced for assessment focus 3).

Learners will need an opportunity to use a computer-based electronic circuit simulation package to test the operation of a given circuit (this could be the simulated circuit produced by the learner for assessment focus 3, mark band 2, although if the learner has not achieved this then the tutor will need to provide the circuit simulation). The evidence could be a tutor observation record of the learner's use of the software tools and a written record (printout/screenprint if supported by the software) of the relevant test results.

Learners will also need opportunities to use physical test equipment (eg oscilloscope, signal generator for an analogue circuit, logic pulser, probe and clip for a digital circuit) to test an actual electronic circuit (this could be either the breadboard, stripboard or PCB circuit produced for assessment focus 3 or any other relevant circuit but must be the same as that used in the simulation – see mark band 3). The tutor observation record should capture both the setting-up and use of the test equipment. The observation record could indicate the care taken and fitness for purpose of the way the measurements were carried out and the skilful and appropriate use of the test equipment. The test results should be captured in a suitable tabulated format or sketches of waveforms.

Mark band 3 requires learners to compare the results (learners are not expected to give reasons for any discrepancy, merely to note it) and advantages and disadvantages of the two approaches (simulation and actual testing). This activity should generate evidence in the form of relevant notes, results, tutor observation records, printouts and/or screen-prints from the software package (where applicable), the circuit tested or annotated photographs, records of the test instruments used and sketches of the set-up or annotated photographs. The evidence for this simulation and testing activity will be in the form of a 'process portfolio'.

If a learner needs to retake any of the tasks it is essential that a different circuit diagram, standard circuit symbols, components, circuits and tests be used to retain the validity and reliability of the assessment.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

A practical approach to delivery should be taken with the aim of giving learners the knowledge and skills needed for electronic component identification, assembly of components, working with circuit diagrams and the use of hand tools and test equipment. It is not intended that learners will cover the theory of electronics.

When delivering learning outcome 1, learners should be introduced to the actual components and their respective symbols to show that the symbols are a representation rather than a picture of the component. The use of manufacturers' or suppliers' catalogues (eg RS, Maplin) and British Standard (BS3939) is to be encouraged throughout the unit. These can also be accessed through the web and learners should be given the opportunity to experience web-based sources for obtaining key information about electronic components. Whilst it is not expected that learners would remember the resistor colour code it should be introduced. Although testing appears in learning outcome 4, an introduction to the use of a multimeter would be helpful, for testing resistors, capacitors and diodes. A basic understanding of the multipliers/divisors (eg k Ω , M Ω , μ F and nF) will be required.

For learning outcomes 2 and 3, it would be useful to have some commercial circuit diagrams and circuit boards to introduce the topics. These could include circuits that have been constructed using surface mount techniques and through the board methods to show the differences. In teaching these topics (plus LO.4) it would seem sensible to use a staged approach by starting with a simple circuit that is drawn, constructed and tested and then advance to more complex circuits. The use of breadboards will enable learners to build a range of circuits from diagrams and test them relatively quickly. However, learners should be given the opportunity to use stripboard to enable them to learn and practise their soldering techniques and experience the use of a range of different approaches to circuit layout.

The use of a simulation package is now industry standard and should be introduced to show how circuits can be drawn and simulated before building the prototype. Although many of these packages also contain circuit board design from the circuit diagram, it is not expected that this facility will be used. It is unlikely that health and safety rules would allow the use of etching methods to produce a printed circuit board (PCB) and milling the tracks involves relatively expensive machinery. However, pre-prepared PCBs should be provided to enable the learner to gain the required skills to drill the board and solder components into it. The use of the simulated test instruments, within the programs, is to be encouraged, so that comparisons can be made with the results from the constructed circuits.

There are some good websites that give interesting projects as well as useful diagrams of components, for example the electronics club www.kpsec.freeuk.com.

Health and safety should be stressed throughout the unit, especially in the use of hand tools and soldering irons. It should also be stressed that many components contain hazardous material within the packaging and that they should not be forced open. Antistatic rules should also be stressed when using integrated circuits.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|---|
| Independent enquirers | Identifying coursework questions and problems to resolve. Using manufacturers' catalogues to find components. Assessment focus 1. Planning the construction of the sketched circuit. Assessment focus 3. Designing a printed circuit board. Assessment focus 3. |
| Creative thinkers | Drawing a circuit and adding further stages. Assessment focus 2. Planning the construction of the sketched circuit. Assessment focus 3. |
| Reflective learners | Setting goals for the development of each of their assignments. Reviewing their progress against the completion of their assignments. Testing circuits using a simulation package and/or physical test equipment. Assessment focus 4. |
| Team workers | Working in a team to plan the construction of a given electronic circuit. Assessment focus 3. |
| Self-managers | Planning and organising the creation of their assignments for this unit. Dealing with time pressures and deadlines for the production of their assignments. Seeking advice and support from their peers and tutors when needed. Using manufacturers' catalogues to find components. Identifies six different electronic components using standard symbols on a circuit diagram provided. Assessment focus 1. Individually, prototyping the circuit using a breadboard, building the circuit using stripboard and constructing the circuit on a given printed circuit board. Assessment focus 3. Using an electronic circuit simulation package and setting-up and using physical test equipment (SM2, SM3) to test the operation of the given electronic circuit by measuring six different circuit input and output signals for each. Assessment focus 4. |
| Effective participators | Testing circuits using the simulation package and/or physical test equipment. Assessment focus 4. |

Functional skills – Level 1

| Skill | When learners are ... |
|--|---|
| ICT – Use ICT systems | |
| Interact with and use ICT systems independently to meet needs | Using simulation software package to test circuits. Producing parts list using WP or spreadsheet. |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | Saving various versions of files. |
| Follow and understand the need for safety and security practices | Working correctly at all times following safety practices and methodology behind system storage and security. |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently to meet needs | Transferring circuit diagrams to simulation software. Using online and physical manufacturers' data. |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | Interpreting simulation software results. Using online manufacturers' data. |
| ICT – Develop, present and communicate information | |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | Entering circuits and details into simulation software. Producing parts list using WP or spreadsheet. Tabulating results from tests. |
| Bring together information to suit content and purpose | Producing circuits. Producing parts list using WP or spreadsheet. Tabulating results from tests. |
| Present information in ways that are fit for purpose and audience | Ensuring circuits produced follow convention for electronics. Producing parts list using WP or spreadsheet Tabulating results from tests. |

| Skill | When learners are ... |
|---|---|
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | |
| Mathematics | |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | Calculating values of components and circuits. Using tolerances in electronic components. |
| Identify and obtain necessary information to tackle the problem | Identifying and interpreting symbol values. |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | Carrying out calculation about circuit values. |
| Use appropriate checking procedures at each stage | Checking the calculation. |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | Producing results from testing and comparing to standard. |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | Discussing results with tutor. |
| Reading – read and understand a range of texts | Reading and understanding task requirements and symbols values. Interpreting relevant British Standards. |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | Recording results in tables. Comparing results from different tests. |

Work experience

Some parts of this unit are well suited to delivery in the workplace. Learning about drawings and circuit diagrams and electronic component recognition when applied to real engineering solutions will enhance learning. Engineering companies are likely to have sets of components and drawings (hard copies or computer copies) that learners could study. They will also have circuit construction facilities. Learners could also become involved in taking measurements and testing circuits.

All assessment foci except perhaps assessment focus 3 lend themselves to the production of evidence within the workplace. The recognition of components, drawing of circuits and testing of circuits could be undertaken during a workplace visit. Staff at any organisation helping in this manner would however need careful guidance on expectations.

Specialist resources

Manufacturers' and suppliers' catalogues should be made available along with relevant Standards, ie BS3939.

The following resources should be also available in sufficient quantities to allow all learners individual access:

- multimeter
- signal generator
- power supply
- double beam oscilloscope
- logic probe
- logic pulser
- logic clip
- simulation software
- wire strippers
- small side cutters
- small pliers
- soldering iron
- breadboard (Protoboard)
- strip board
- printed circuit board
- solder
- sufficient quantities of components.

Unit 7: Engineering the Future

Principal Learning unit

Level 1

Guided Learning Hours: 30

Internally assessed

About this unit

All products are the result of research and development that evolves over a period of time. As part of any new development we need to know about existing technologies, so that the lessons learnt from their development can be applied to new products or processes. Engineers must also be aware that the manufacturing or recycling processes will require the use of scarce resources that can or will have an impact on the environment. We are now living in a world where everything we do will be monitored to ensure that when we produce a product or recycle it, damage to the environment must be minimised coupled with minimal use of energy.

In this unit you will find out about some of the new developments in materials and engineering technology that either have an impact on life today or will do so in the very near future. You must be aware of safe recycling methods of materials or products so that in the future, the work that you do will not add to the environmental problems we have today. As an engineer, you will also be expected to be aware of the available energy sources, how energy can be stored and its impact on the environment.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about the new developments in materials and engineering technology that impact on everyday life
 - LO.2. Know how products are recycled or safely disposed of at the end of their useful life
 - LO.3. Be able to identify renewable energy sources and the environmental issues of each one.
-

What you need to cover

| | |
|--|--|
| LO.1 Know about the new developments in materials and engineering technology that impact on everyday life | <p>Learners will need to find out about new developments in materials and their uses, eg high temperature materials used in jet engines and turbines, metallic foams and other cellular materials used in insulation and energy absorption, biomedical materials such as metals, ceramics and polymers, powder metallurgy, structural composites such as carbon fibre and shape memory alloys.</p> <p>Learners will need to know about the new technologies available, eg hybrid car engines, the Guy Negre MDI engine, fuel cells, bio fuels, microprocessors, nano technology, bionics, intelligent living environments, robotics and flexible manufacturing systems, magnetic levitation.</p> <p>Learners will also need to know about the social and economic impact of engineering, eg climate change, genetic engineering.</p> |
| LO.2 Know how products are recycled or safely disposed of at the end of their useful life | <p>Learners will need to know about the materials cycle and about recycling, eg metals, plastics (biodegradable and non-degradable packaging), glass, batteries, electronic equipment and components, heavy metals, PCBs.</p> <p>Learners will investigate the disposal of other products through landfill, incineration and vitrification, eg asbestos and lubricant and chemical disposal.</p> |
| LO.3 Be able to identify renewable energy sources and the environmental issues of each one | <p>Learners will need to research the basic principles of energy generation and be able to identify each one, eg micro-generation solar energy and solar cells, hydropower and wind power, bio fuels.</p> <p>Learners will need to know about the storage of energy, eg chemical and mechanical.</p> <p>They will also need to identify the positive and negative effects on the environment, eg reduction in carbon emissions from fossil fuels, loss of landscape, visual/noise pollution, energy loss.</p> |

How you will be assessed

This unit focuses on the world of engineering in relationship to new developments and the impact on the way we live. As such you will be assessed through an assignment giving you opportunities, through a theme of engineering technology and its impact, to demonstrate that you know about these new developments, how products are recycled or safely disposed of and the use of renewable energy.

This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given a number of tasks within the assignment that will cover the material you have studied. Your tutor will give you opportunities to develop evidence. These opportunities could typically consist of 3 tasks. The evidence you produce for each task will be in the form of a 'report' or a 'presentation'.

Task 1 could cover the requirement of assessment foci 1.1 and 1.2, and would involve describing the properties and applications of engineering materials.

Task 2 could cover assessment focus 2 and would focus on the recycling of products and the disposal of materials.

A third task could cover assessment focus 3 and would involve you describing how energy is generated from different sources, how it is stored and the related environmental impact.

Marking grid

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|---|---|-------------------------|
| LO.1 Know about the new developments in materials and their uses | Gives examples of three different new or smart engineering materials and states an appropriate application for each. (0–6) | Describes the properties and an appropriate application of three different new or smart engineering materials. (7–10) | Describes the properties and an appropriate application of three different new or smart engineering materials, and explains how properties and use are linked. (11–14) | 14 |
| LO.1.2 Know about engineering technology that impacts on everyday life | Uses own and others' ideas and experiences to identify three new engineering technologies and gives an example of how each is being used in everyday life. (0–6) | Uses own and others' ideas and experiences to describe the application of three new engineering technologies in use in everyday life. (7–10) | Uses own and others' ideas and experiences to describe the application of three new engineering technologies in use in everyday life and shows how new technology can have an impact on society and the environment. (11–14) | 14 |
| LO.2 Know how products are recycled or safely disposed of at the end of their useful life | Gives an example of two different products which can be recycled, stating for each how they are recycled, and two which cannot, stating how they can be safely disposed of. (0–6) | Outlines the recycling process for two different products, and identifies the benefits of recycling. Outlines the safe disposal of two different products and states why this is done instead of recycling. (7–11) | Describes the recycling process for two different products, and the method of safe disposal of two others. Explains why some products are recycled while others are not, and the benefits of recycling. (12–16) | 16 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|--|---|--|---------------------------------|
| LO.3 Be able to identify renewable energy sources and the environmental issues of each one | Identifies how energy is generated from two different renewable sources. States the environmental impact of using renewable sources and how energy can be stored. (0–6) | Describes how energy is generated from two different renewable sources, and outlines the positive and negative environmental impacts of these forms of energy generation. Identifies how energy from these sources could be stored. (7–11) | Describes clearly how energy is generated from two different renewable sources, and for each compares the positive and negative environmental impacts. Describes how energy from these sources could be stored, with an indication of the benefits and disadvantages of storing it. (12–16) | 16 |
| Total marks | | | | (14 + 14 + 16 + 16) = 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the best fit approach. This section should be referred to only once the preliminary judgement has been made by the assessor and is used to guide the assessor as to placement within the mark band.

| Assessment focus LO.1 | |
|------------------------------|--|
| Mark Band 1 (0–6 marks) | Likely to be one mark for each appropriate material stated, and a second mark for an application. A simple list is acceptable for this band. However, a response which perhaps gives an inappropriate application, but goes into more detail about another material (by linking its use to a property, for example) could also get full marks. This band is also appropriate for the learner whose response addresses only one or two appropriate materials throughout, even if it is very detailed. |
| Mark Band 2 (7–10 marks) | For full marks each of the three materials has some properties (eg hardness, malleability, thermal conductivity) described, and an application identified. Responses which identify three materials but give appropriate properties for only one or two of them, or those with very limited properties identified, should be given credit at the lower end of the band. |
| Mark Band 3 (11–14 marks) | This band is characterised by some explicit linking of property to use for at least one material. It is not enough simply to say that ‘carbon fibre is used in Stealth bombers because it is strong’ – this level of response would be more appropriate in band 2. There needs to be a more precise link, such as ‘carbon fibre is used in Stealth bombers because it is stronger than traditional materials like aluminium’. For full marks, one strong statement linking properties and use might be enough, in addition to the description expected at band 2, but it may be more likely that there are two or three more simple links made, such as the example above. |

| Assessment focus LO.1.2 | |
|--------------------------------|---|
| Mark Band 1 (0–6 marks) | There is likely to be 1 mark for each example of an appropriate new technology stated, and a second mark for an application. A simple list is acceptable for this band. However, a response which perhaps gives an inappropriate application, but goes into more detail about another new technology, perhaps achieved by their own and others’ experiences gained, (by also giving a benefit, for example) could also get full marks. This band is also appropriate for the learner whose response addresses only one or two appropriate new technologies throughout, even if it is very detailed. |
| Mark Band 2 (7–10 marks) | For full marks, all three new technologies are described to make clear what they are and how they are used. This is likely to be achieved by reflecting on their own and others’ experiences gained. Not all may be described to the same standard, and strong descriptions in one or two may balance weaker descriptions in another to allow full marks. Responses which identify three technologies but give appropriate descriptions for only one or two of them, or those with very limited descriptions, should be given credit at the lower end of the band. |

| Assessment focus LO.1.2 (continued) | |
|--|---|
| Mark Band 3 (11–14 marks) | For full marks in this band the description should show not just how each new technology is being used, but how some impact on society and the environment. This is likely to be achieved by reflecting on their own and others' experiences gained. These could be positive or negative effects (eg energy saving, or greater use of single-use disposable products). It is not necessary to link every new technology described to such effects, and one well balanced description of the impacts could be enough when added to the description expected in band 2, but it is more likely to be a few simpler statements. |

| Assessment focus LO.2 | |
|------------------------------|---|
| Mark Band 1 (0–6 marks) | For full marks the learner lists the appropriate products and against each states how they could be recycled or disposed of safely. The 'how' could be a process or a product, eg 'aluminium drinks cans can be melted down to be used again', or 'plastic drinks cups can be recycled into fleece jackets'. Credit lists of products with no valid 'how' statements to a maximum of half marks. This band is also appropriate for responses which address only one recyclable and one non-recyclable product throughout, even if they are very detailed. |
| Mark Band 2 (7–11 marks) | The 'outline' description requires more than a list, but does not expect all the technical details. The aluminium can example above might be expanded to meet band 2 requirements to include some details of the process – perhaps describing the crushing, smelting at very high temperatures and casting back into bars ready for manufacture. A flow chart might show this neatly. For full marks this sort of detail is given for each product, together with a comment about the benefits of recycling, or why the disposed product has not been recycled. Full marks may also be achieved from an answer which is a bit light on the recycling/disposal process, but which goes into greater detail about the benefits, for example. At the lower end, responses must have mentioned the four examples, but perhaps provide clear detail about only one or two. |
| Mark Band 3 (12–16 marks) | At this level the learner is starting to demonstrate some generalisations, going beyond descriptions of the chosen examples to give some broader principles about why some things are recycled and others are not. This might include an awareness of the difference between what is technically possible and what is economically practical, or could include comments on people's values. For full marks, responses will cover the descriptive aspects in line with band 2 requirements, but will offer at least two clear reasons why some things are recycled and others not and gives explanations of the benefits of recycling. Simply stated ideas such as 'sometimes it costs more to recycle than to make more products from scratch' would bring response into the lower half of this band. |

| Assessment focus LO.3 | |
|------------------------------|--|
| Mark Band 1 (0–6 marks) | <p>In this band answers will be characterised by lists or statements which may be unconnected – for example the environmental impact might not be explicitly linked to any of the sources. Likewise, the methods of storage might not be directly related to the source.</p> <p>For full marks the source must be clear (not just ‘wind’ or ‘sun’ for example, but a mention of wind turbines or photovoltaic cells.) The environmental impact and storage methods could be a few very simple statements about each such as ‘visual pollution’ or ‘pumped storage’ or one more detailed comment about each, such as ‘reservoirs can flood good farmland’.</p> |
| Mark Band 2 (7–11 marks) | <p>For this band there should be a connection between the different parts of the answer, so as well as giving more details about the wind turbines, perhaps outlining how the turning blades create electricity, there is also some positive and negative comment on their environmental impact – ‘it does not give off carbon dioxide but can look very unsightly in an area that was once wild and unspoilt.’ The storage methods are also appropriate for the type of energy generation.</p> <p>For full marks both examples are described in this linked style; marks lower in the band will be for descriptions where only one is linked, or where both descriptions are linked but light on detail.</p> |
| Mark Band 3 (12–16 marks) | <p>This band looks for some greater evaluation of the environmental impact – do the benefits outweigh the disadvantages, perhaps. There is also an understanding that while there are ways of storing the energy, they may not be very efficient.</p> <p>For full marks the response covers the description requirements of band two, but in addition makes at least one sound evaluative comment about each of the environmental and storage issues. One simple statement that recognises energy loss in storage, for example, would be enough to get credit at the bottom of this band if the other descriptive requirements have been met. Good evaluative comments would help balance slightly weaker (lower band 2-style) descriptions and could be enough to get into the bottom of this band.</p> |

Approaches to assessment

The marking criteria in the marking grid have all been written so that the same task can be set for all learners. Opportunities will be provided for those working at the upper end of this level to achieve full marks at the same time as giving opportunities for others to gain part marks through a response that might be less detailed or possibly incomplete. For example a task for assessment focus 1.1 could give learners some specific new and smart materials they have already investigated in the workshop, on their work placement or from other sources. They could be asked to use the records they have kept to identify properties and uses for these materials, and what makes them suitable for these uses. Learners who can do all this will get marks from mark band 3, while the learner who is able to state the materials and how they might be used will get marks in mark band 1. If a learner can describe properties but cannot make the link with a use, they will be in mark band 2. If a learner needs to retake this assignment, it is essential that different materials are used.

Although tasks can be devised for each assessment focus, where possible these should be linked to allow the holistic nature of the unit to come across. It is recognised that this is not always possible where delivery is spread across a number of institutions, possibly including the learner's work experience location.

It may be appropriate to devise three tasks for the assessment of this unit.

Task 1 could be a 'report' or 'presentation' covering assessment foci 1.1 and 1.2. An activity should be set to allow learners to describe the properties and an appropriate application of three different new or smart engineering materials, and explain how properties and use are linked for focus 1.1. A further activity needs to be set to ensure learners describe the application of three new engineering technologies in use in everyday life and shows how new technology can have an impact on society and the environment. They should be encouraged to reflect on their own and the experiences of others when thinking about this activity addressing assessment focus 1.2.

Task 2 could again be a 'report' or 'presentation' covering assessment focus 2. An activity needs to be set to allow learners to describe the recycling process for two different products, and the method of safe disposal of two others and another activity to explain why some products are recycled while others are not, and the benefits of recycling.

Task 3 could be a 'report' or 'presentation' covering assessment focus 3. An activity needs to be set to allow learners to describe how energy is generated from two different renewable sources, and for each compares the positive and negative environmental impacts. Another activity to describe how energy from these sources could be stored, with an indication of the benefits and disadvantages of storing it also needs to be set.

In all three tasks the activities suggested provides full opportunity at mark band 3 but the activities could be amended to meet learner ability range.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

The development of knowledge for learning outcome 1 could be based on practical work undertaken in the workshop or on work experience, supplemented by investigation of products or services derived from new engineering technologies. This would ensure that learners were not simply accepting researched material downloaded from the internet.

The development of the knowledge for learning outcome 2 could take the same form as that suggested for 1. There will be many local opportunities for learners to get practical experience of some aspects of recycling, and this could form the basis of the learner's course notes. As far as possible, other aspects of recycling and disposal could be covered by visits, speakers from industry and case studies of actual projects.

The development of the knowledge for learning outcome 3 could take the same form as that suggested for 1 however is more likely to require a greater degree of study as fewer learners will have opportunities for direct experience of energy generation.

Deep technical explanations are not required for any of the content of the unit, just an overall understanding of the subject matter.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|------------------------------|---|
| Independent enquirers | <p>Identifying coursework questions and problems to resolve.</p> <p>Giving examples of three different new or smart engineering materials and three different new technologies and stating how each might be used. Assessment focus 1.1.</p> <p>Giving an example of two different products which can be recycled, stating for each how they are recycled, and two which cannot, stating how they can be safely disposed of. Assessment focus 2.</p> <p>Identifying how energy is generated from two different renewable sources. Stating the environmental impact of using renewable sources and how energy can be stored. Assessment focus 3.</p> |
| Creative thinkers | <p>Identifying three new engineering technologies and giving an example of how each is being used in everyday life. Assessment focus 1.2.</p> <p>Giving an example of two different products which can be recycled, stating for each how they are recycled, and two which cannot, stating how they can be safely disposed of. Assessment focus 2.</p> |
| Reflective learners | <p>Assessing themselves and others, identifying opportunities and achievements.</p> <p>Setting goals for the development of each of their assignment.</p> <p>Reviewing their progress against the completion of their assignment.</p> <p>Listing three new engineering technologies and give a reason for their use. Assessment focus 1.2.</p> <p>Giving an example of one recycled and one non-recycled product stating why they can or cannot be recycled, and two which cannot, stating how they can be safely disposed of. Assessment focus 2.</p> <p>Identifying how energy is generated from two different renewable sources. Stating the environmental impact of using renewable sources and how energy can be stored. Assessment focus 3.</p> |
| Team workers | Not present in this unit. |

| Skill | When learners are ... |
|--------------------------------|---|
| Self-managers | <p>Working towards goals showing initiative, commitment and perseverance.</p> <p>Organising time and resources, prioritising actions</p> <p>Planning and organising the creation of their assignment for this unit.</p> <p>Dealing with time pressures and deadlines for the production of their assignment.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> |
| Effective participators | Not present in this unit. |

Functional skills – Level 1

| Skill | When learners are ... |
|--|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Interact with and use ICT systems independently to meet needs | |
| Use ICT to plan work and evaluate their use of ICT systems | |
| Manage information storage | |
| Follow and understand the need for safety and security practices | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently to meet needs | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information to suit its meaning and purpose, including: <ul style="list-style-type: none"> • text and tables • images • numbers • graphs • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, independently, responsibly and effectively | |

| Skill | When learners are ... |
|---|---|
| Mathematics | Not present in this unit. |
| Understand practical problems in familiar and unfamiliar contexts and situations, some of which are non-routine | |
| Identify and obtain necessary information to tackle the problem | |
| Select and apply skills in an organised way to find solutions to practical problems for different purposes | |
| Use appropriate checking procedures at each stage | |
| Interpret and communicate solutions to practical problems, drawing simple conclusions and giving explanations | |
| English | |
| Speaking and listening – take full part in formal and informal discussions/exchanges | Taking part in formal and informal discussions/exchanges with a supervisor when they are describing different types of energy sources and uses. |
| Reading – read and understand a range of texts | Reading about and researching recycling/reusable materials. |
| Writing – write documents to communicate information, ideas and opinions using formats and styles suitable for their purpose and audience | |

Work experience

It may be possible for learners to gather some of the information required from work placements but the process should be controlled to ensure that the end result is their own work.

Specialist resources

Learners will need access to suitable research materials such as books, magazines, information pamphlets and the internet. Learners should also be encouraged to contact companies undertaking research and development of new materials or technologies to broaden their own experiences and learning. This should be done in a managed way to ensure that learners are not overburdened by information that does not apply or is too technical for this unit.

Reference material

Budinski K and Budinski M – *Engineering Materials – Properties and Selection* (Prentice-Hall, 2004) ISBN 0131327917

For information on polymer materials – www.farapackpolymers.com

For information on metallic materials – www.shef.ac.uk/materials/research/intro.html

Level 2 units

Unit 1: Exploring the Engineering World

Principal Learning unit

Level 2

Guided Learning Hours: 60

Internally assessed

About this unit

Have you ever wondered what makes the technology we use everyday work, or what goes on inside your mobile phone, computer or digital camera?

In this unit, you will discover the world of engineering. You will develop an understanding of the diverse sectors within engineering and how these interlink to offer a range of services and products. You will investigate the achievements and developments of the engineering world from a local and national perspective and investigate the effect engineering has on the modern world.

The world of engineering offers diverse and exciting opportunities to individuals who are looking for a dynamic and productive career. You will identify the opportunities that exist within engineering and the reward and satisfaction gained from a career as an engineer.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about engineering sectors and their products or services
 - LO.2. Know about job opportunities available within the engineering industry and the role of professional engineering institutions
 - LO.3. Know about the achievements in engineering that relate to social and economic development
 - LO.4. Understand the rights and responsibilities of employers and employees in engineering.
-

What you need to cover

- | | |
|--|---|
| LO.1 Know about engineering sectors and their products or services | <p>Learners will need to be aware of the variety of sectors within the engineering and manufacturing industries including an understanding of specialist areas eg, aerospace, automotive, bio-engineering, building services, chemical, communications, control, electrical, electronic, energy sources and systems, marine, manufacturing, mechanical and passenger transport engineering.</p> <p>Learners will also investigate how the sectors interlink and what services and products are produced by the industry.</p> |
| LO.2 Know about job opportunities available within the engineering industry and the role of professional engineering institutions | <p>Learners will need to investigate the dynamic opportunities and career pathways available within engineering at a local and national level.</p> <p>They will also examine the role of an engineer and determine the qualifications and skills required of a good engineer and engineering technician.</p> <p>Learners should be aware of the role of the professional institutions in engineering, eg Agricultural Engineers, Chemical Engineers, Engineering and Technology (including Electrical Engineers), Engineering Designers, Mechanical Engineers, Nuclear Engineers, Civil Engineers, Building Services Engineers, Water and Environmental Management; and the function of the Engineering Council UK.</p> |
| LO.3 Know about the achievements in engineering that relate to social and economic development | <p>Learners will need to examine the significant contribution engineering achievements and developments have made to society. This will include a reflection of achievements and developments from the 19th, 20th and 21st century and the contribution they have made to social and economic development.</p> |
| LO.4 Understand the rights and responsibilities of employers and employees in engineering | <p>Learners will need to learn about the legislation applicable to employers and employees in engineering and will show an understanding of the current Employment Act (eg 2002) and demonstrate a knowledge of other acts, eg Disability Discriminations Act, Work and Families, Health Act 2006, Equality Act, Sex Discrimination Act, Race Relations Act, Employment Equality Regulations.</p> <p>Learners will also need to understand the function of the Department for Business, Enterprise and Regulatory Reform and its relevance to employers and employees in engineering.</p> |
-

How you will be assessed

This unit will focus on giving you an overall understanding of the engineering world. As such you will be assessed through an assignment that will give you opportunities to demonstrate what you know about the different engineering sectors and their products and services, the job opportunities available within engineering, the role of professional engineering institutions, the main achievements in engineering that relate to social and economic development and the rights and responsibilities of engineering employers and employees.

This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given a number of tasks that will cover all of the material you have studied. Your tutor will give you opportunities to develop evidence and one or more tasks could be set in the laboratory or workshop, and may relate to your work experience. These opportunities might typically consist of four tasks.

Task 1 could cover the requirements of learning outcome 1 with a written activity on the different engineering sectors, products and services. All of the evidence for this task will need to be in the form of a 'report'.

Task 2 could assess learning outcome 2, with a written activity exploring the job opportunities available in engineering and the role of professional institutions. Again, evidence will need to be in the form of a 'report'.

Task 3 could link learning outcome 3 and could use a written activity and may also include a presentation. Evidence for this task could be in the form of a 'report' or 'presentation'.

Task 4 could cover learning outcome 4 and could consist of a short written activity taken under supervised conditions. Evidence for this task will also need to be in the form of a 'report'.

Marking grid

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|--|---|-------------------------|
| LO.1 Know about engineering sectors and their products or services | Describes two different sectors in engineering and identifies products or services from each. (0–4) | Describes two different sectors in engineering and identifies the function of engineering products or services from those sectors. (5–7) | Describes two different sectors in engineering and explains the operation of commercially available products provided by engineering companies from different sectors in engineering. (8–10) | 10 |
| LO.2 Know about job opportunities available within the engineering industry and the role of professional engineering institutions | Describes four examples of job opportunities within engineering at a local and/or national level. Outlines the roles of the Engineering Council UK and of its licensed professional engineering institutions. (0–8) | Describes four examples of career progression opportunities within engineering at a local and/or national level. Describes the function of the engineering council and its relationship to licensed professional engineering institutions. (9–14) | Evaluates the qualifications and skills required for a range of career opportunities within engineering at a local and/or national level. Evaluates the reasons for professional engineering registration at a national and international level. (15–20) | 20 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|---|-------------------------|
| LO.3 Know about the achievements in engineering that relate to social and economic development | Describes the key achievements in engineering in the 19th, 20th and 21st centuries and refers to social and economic development. (0–8) | Describes impacts on economic and social life of key developments and achievements in engineering in the 19th, 20th or 21st centuries. (9–14) | Explains impacts of key developments and achievements in engineering in the 19th, 20th or 21st centuries on economic and social life. (15–20) | 20 |
| LO.4 Understand the rights and responsibilities of employers and employees in engineering | Describes key responsibilities of employers and employees as defined in the current Employment Act and other relevant legislation. (0–4) | Refers to given employment legislation to comment on the rights and responsibilities of employers and employees within engineering. (5–7) | Comments on the rights and responsibilities of employers and employees within engineering; explains how employers can encourage employees to meet their responsibilities in accordance to employment legislation. (8–10) | 10 |
| Total marks | | | | 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the best fit approach. This section should be referred to only once the preliminary judgement has been made by the assessor and is used to guide the assessor as to placement within the mark band.

| Assessment focus LO.1 | |
|------------------------------|--|
| Mark Band 1 (0–4 marks) | <p>For full marks there needs to be a description of each sector which is more than a simple statement – as well as identifying the sector there should be some characteristics of the sector and a range of products or services that makes it clear the learner understands its scope. For example, ‘implementing technology to improve communication and distribution of data’ gives a broad definition of the communications industry, and it could then be linked to products such as satellite communications, radio, television, mobile phones, networks and Bluetooth technology. Two sectors simply stated with some examples, eg ‘The automotive engineering sector makes cars and lorries and parts for them’ can gain marks only in the bottom half of this band.</p> <p>This band is also appropriate for responses which are limited to one sector, even if described in detail.</p> |
| Mark Band 2 (5–7 marks) | <p>In addition to describing the chosen sectors, learners’ responses will clearly identify the function of products or services that come from the sector. Building on the example in band 1 above, a response might explain the function of the global positioning system (GPS) in pinpointing the precise location of a GPS receiver, and to determine its direction and velocity. For example, for higher marks in this band, learners should include an understanding of how a signal is triangulated from a signal from a collection of satellites. For full marks there needs to be a detailed explanation of the function of one product or service from each sector. A clear identification of the function of one could offset a little less detail in the other, to also achieve full marks.</p> |
| Mark Band 3 (8–10 marks) | <p>For band 3, learners must explain both the function and operation of products or services. For example, an investigation of the operation and function of the Tom-Tom GO 910, describing how the product operates by bringing together and utilising both GPS technology and Bluetooth connectivity to aid drivers with navigation and identification of traffic congestion. For higher marking within the band, learners should include details of ease of operation and demonstrate a clear understanding of the intended audience of the products or services chosen as part of their explanation of function.</p> |

| Assessment focus LO.2 | |
|------------------------------|--|
| Mark Band 1 (0–8 marks) | <p>For full marks the descriptions of the four different job opportunities should focus on the nature of the work undertaken with an idea of the product or service that is provided. The jobs could all be in the same sector if the learner has a particular interest, and could be generic roles in the industry or precise roles with a particular employer. In addition, the key purposes and activities of the engineering council^{UK} should be stated, together with the generic role played by professional institutions.</p> <p>Detailed descriptions of job roles can offset slightly weaker descriptions of the roles of the institutions, and vice versa, but do not let the total marks for ‘jobs’ or ‘institutions’ reach more than 5.</p> |
| Mark Band 2 (9–14 marks) | <p>For full marks in this band the job roles must go beyond being described in isolation, as for band 1, and be shown as part of overall career opportunities. This would include showing what roles might normally be undertaken before reaching the featured role, and what the progression opportunities might be on from this role.</p> <p>Similarly, the separate roles of the engineering council^{UK} and the professional institutions must be brought together so that not only are the roles of each clearly described, but how the council relates to the professional institutions by regulating the engineering profession and maintaining registers of professional engineers.</p> <p>While detailed description of career opportunities can offset weaker description of the institutions, and vice versa, do not let marks go above 12 if the weaker one is developed little beyond the band 1 expectations.</p> |
| Mark Band 3 (15–20 marks) | <p>To achieve marks in this band at least some of the descriptions of career opportunities expected in band 2 are extended to show the particular skills and/or qualifications that are needed to get into the role, and the further skills and/or qualifications that might be needed to progress to higher roles. At the top of this band this will be developed across most of the careers.</p> <p>In order to evaluate the reasons for professional engineering registration the learner must recognise the role of the engineering council^{UK} and the professional institutions, as for band 2, but goes beyond this to give views on the benefits and obligations it confers.</p> |

| Assessment focus LO.3 | |
|--------------------------------------|---|
| <p>Mark Band 1 (0–8 marks)</p> | <p>For full marks at this band all three centuries must be considered, with referral to both social and economic factors, although descriptions of some achievements may be more complete than others. Good descriptions above the expectation for the band can gain up to 3 marks, but the maximum for this band is 8 marks. In addition to stating the three achievements, details such as dates, key people involved, and a description of what was actually achieved can all gain extra credit.</p> <p>An engineering achievement is used to identify a milestone in human history made possible by engineering, for example landing on the moon.</p> <p>This level would be appropriate for the response that considers only one or two centuries throughout.</p> |
| <p>Mark Band 2 (9–14 marks)</p> | <p>The overall achievements identified in band 1 must be looked at closely to describe the key developments that made them possible. An engineering development refers to developments in technology that have made this achievement possible, for example the development of the rocket.</p> <p>To get marks at this band there must be some description of a relevant development, with a comment on its social or economic impact. A description of a development alone can be seen as improving the description of the band 1 requirement, not as starting to meet band 2 requirements.</p> <p>For full marks a development must be described as part of an overall achievement in each century, together with some comment on the social and economic impacts. Some impacts will be both social and economic, and in these cases both aspects ought to be brought out. For this band the link between engineering development and social or economic impact may not be explicit. For example, the development of steam locomotives may be described, and with it the growth of industry and employment, but how one directly contributed to the other is not made clear.</p> <p>As this is a best fit model, particularly strong responses relating to one century, starting to meet band 3 expectations, can offset weaker responses about another century.</p> |
| <p>Mark Band 3 (15–20 marks)</p> | <p>For this band the response should be developed beyond the band 2 requirements to show clearly how the engineering development directly led to the social and economic impacts described. In the example of railways (above) a link such as the ability to move bulky raw materials around the country efficiently and quickly could be made.</p> <p>For full marks all three centuries should include an explanation of a social and an economic impact of a development, and the response is likely to refer to particular communities or industries rather than generalisations.</p> |

| Assessment focus LO.4 | |
|------------------------------|--|
| Mark Band 1 (0–4 marks) | <p>Likely to be 1 mark for each clear description of the main responsibilities, up to 3, of employees and a mark for each clear description, up to 3, of employers’ responsibilities based on relevant legislation. The maximum mark for this band is 4, so if more than 4 responsibilities are offered, only 4 can be credited.</p> <p>For this band the responsibilities do not have to be directly related to employment in engineering.</p> |
| Mark Band 2 (5–7 marks) | <p>For full marks in this band, some of the responsibilities described should be directly related to engineering employment. In addition to the description there should be some comment such as the need for the legislation. One such comment, if particularly detailed, might be enough, but it is more likely that there will be two or three such comments.</p> |
| Mark Band 3 (8–10 marks) | <p>In addition to the expectations of band 2, responses analyse what employers can undertake to encourage employees to work in accordance with their responsibilities as identified in applicable employment legislation. Full marks could be gained with one detailed and insightful piece of analysis, but it is more likely to be two or three such comments. The award of the marks should be based on how well what is being suggested will encourage employees to meet their responsibilities.</p> |

Approaches to assessment

It may be appropriate in some circumstances for tasks to be targeted at a particular mark band. However, where this is not necessary it carries the risk of increasing the assessment burden, as learners may need to be given a further task at a later stage to give them the opportunity to achieve at a higher band.

Therefore in some circumstances it may be better for the same activity to be set for all learners, with opportunities for those working at the upper end of this level to achieve full marks at the same time as giving opportunities for others to gain part marks through a response that might be less detailed or possibly incomplete. For example, a task for assessment focus 3 could be for learners to research significant engineering achievements and developments across the three centuries, and to explain the impacts these had on social and economic conditions. The learner who can do all this will get marks from band 3, while the learner whose response covers only the broader achievements will get marks in band 1. If a learner can describe some of the developments within those achievements and make some reference to social or economic impacts they will be in band 2.

If this approach is taken it will lessen the assessment burden for those higher achievers while still giving lower achievers opportunities to perform at their level.

Assessment evidence for this unit could typically consist of four tasks, although these do not have to be taken separately.

Task 1 could cover the requirements of assessment focus 1, with a written activity requiring learners to identify different sectors in engineering and give an example of a product or service from each sector. It would be wise to research at least three different sectors of engineering to enable learners to achieve maximum marks for mark band 1, although the assessment focus only requires a response for two different sectors.

Progression on to mark band 2 would require learners to identify the function or operation of engineering products from different sectors in engineering. An in depth investigation of an actual product or service provided by engineering companies from different sectors in engineering would allow for marks to be awarded from mark band 3. For example, describing communication engineering as ‘implementing technology to improve communication and distribution of data’ gives a broad definition of the communications industry. Identifying products developed within this sector as including satellite communications, radio, television, mobile phones, networks and Bluetooth technology gives an indication of products and services provided by the sector, thus allowing marks to be awarded from mark band 1. For progression to mark band 2 learners could identify the function of GPS to pinpoint the precise location of a GPS receiver, and to determine its direction and velocity, including an explanation of triangulating a signal from a collection of satellites. An investigation of the operation and function of the Tom-Tom GO 910, explaining how this product utilises both GPS technology and Bluetooth connectivity to aid drivers with navigation and identification of traffic congestion or hot spots would allow progression to mark band 3. Evidence for this task will need to be in the form of a ‘report’.

Task 2 could focus on assessment focus 2 and be in the form of a written activity. The centre should assist learners with links to local engineering companies as explained in the delivery guidance. Learners should be encouraged to research local and national companies that may offer opportunities to learners in the future. The career opportunities do not need to be currently available, but if they are not they should reflect relevant opportunities that have been previously available. Assessment focus 2 offers flexibility to enable the centre to focus on engineering sectors relevant to its learners. Evidence for this task will need to be in the form of a ‘report’.

Task 3 could cover assessment focus 3 and the evidence could be presented as a ‘report’ or ‘presentation’. For mark band 1, learners are required to identify a key achievement in engineering from the 19th, 20th and 21st centuries (one for each). Progression into mark bands 2 and 3 would require learners to investigate the social and economic implications of developments in engineering. In this context an engineering achievement is used to identify a milestone in human history made possible by engineering, for example landing on the moon. An engineering development refers to developments in technology that have made this achievement possible, for example the development of the rocket. Centres may wish to encourage learners to research achievements and developments by specific engineers, or specific sectors in engineering as they feel appropriate. Assessment focus 3 could be assessed in full or part by individual or group presentations that would allow the opportunity of some peer review and ultimately allow learners to share their research with their peers.

Suitable topics of assessment can be from any sector of engineering but should include a range of achievements and developments from past to present. For example the building of the Stockton and Darlington railway commenced in 1822 and was witness to the first passenger railway in 1825 when Stephenson’s engine *Locomotion* pulled 18 passengers just under 9 miles. The social impact of the railway allowed the public easier access to travel, increased communication and allowed delivery of goods in much larger volume. By widening the trade links between towns, merchants were able to benefit from a larger market, increasing profits and economic development, the steam locomotive being much more efficient than the horse drawn cart.

Evidence for this task will need to be either in the form of a ‘report’ or a ‘presentation’.

Task 4 could cover assessment focus 4. This requires learners to define responsibilities of employers and employees in engineering in accordance to relevant employment legislation. This could be quite a ‘dry’ topic for many learners and it is therefore important to make maximum use of work placements, visiting speakers and industry training materials to bring it to life. The use of the internet may be of assistance to some learners, in particular resources available from the DBERR. It is likely that some information will also need to be directly taught.

This task is likely to be in the form of a short written activity taken under supervised conditions, in a single teaching session, with tasks based on the current Employment Act (eg 2002) and other legislation. Topics that could be covered include discrimination (due to gender, sexual orientation, religious belief, age, disability, race, ethnicity), equal opportunities, health or parental issues. Learners can refer to their course and research notes to help complete the task.

If it proves necessary for a learner to retake the task, a different set of questions and/or legislation should be employed. Evidence for this task will need to be in the form of a ‘report’.

Guidance for teaching this unit

Delivery guidance

This unit is 60 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 20 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

It is essential that learners develop a clear understanding of the range of sectors in engineering before undertaking further study in this unit. Group work and open discussions would enable learners to share their existing knowledge of engineering and determine the predominant sectors within the industry. Some sectors in engineering will be more relevant to centres due to geographical location, resources or individual preference and these areas may dominate open discussions. In addition learners should also be encouraged to broaden their awareness of the many sectors that make up the engineering industry.

Centres should be encouraged to utilise links with engineering organisations. Visits to, or placements in the engineering industry will be of significant aid earners to experience first-hand opportunities within the world of engineering.

By identifying career opportunities within engineering, centres should focus on real opportunities available to potential engineers at a local and national level. Learners should be encouraged to investigate opportunities at local engineering establishments and should be aware of local apprenticeship and training programmes. Links with engineering companies or local job centres could provide appropriate mock job interviews to allow learners to identify the qualities and skills employers in engineering look for. Such tasks may be recorded on a witness testimony sheet that details the activity undertaken and is signed by the tutor.

Learners should be advised on career openings at a national level and how to identify such opportunities. The use of the internet will be an aid when researching opportunities within engineering.

Learners should be encouraged to investigate and discuss what they feel makes a good engineer and define the qualities and skills that are essential to all engineers. These qualities are not specific to particular job roles or careers but generic to all engineers such as ‘good logical thought process’ or ‘ability to work in a team’.

Learners should recognise the professional levels in engineering (Engineering Technician, Incorporated Engineer and Chartered Engineer) and should be aware of the Engineering Council and the Licensed Professional Engineering Institutions. A visit or talk from an Incorporated or Chartered Engineer would be an advantage. Learners may benefit from use of the internet in researching professional engineering institutions.

To acknowledge the impact of engineering in the 19th, 20th and 21st centuries learners should recognise key achievements and developments in engineering during this time. Learners should be encouraged to look at achievements and developments in new technology and identify the impact this has had on their daily lives. Technologies may include 3G mobile phone communications, GPS navigation or the development of bio fuels. A reflection of engineering achievements and developments of past generations should help learners identify how engineering has impacted on peoples’ daily lives and how new technology has affected the local economy and economic growth of the country. Visits to local museums or exhibitions would broaden learners awareness of the impact engineering has had on the development of the modern world. The use of video and interactive presentations may be an advantage and role play of life ‘before’ and ‘after’ the development of a new technology may also be beneficial. Centres should focus on achievements and developments past or present that have also had a significant

local impact. Visits from local historians, or trips to previous locations of significance will bring more depth to the topic.

Topics should focus on every day life and may tell the story of progression of a development in engineering. For example from the telegram to G3 mobile technology, or from the steam locomotive to the Eurostar, TGV and the Shinkansen (Japanese bullet). The internet would be a useful resource but should not be relied on as the only input.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | Identifying coursework questions and problems to resolve. Describing two different sectors in engineering and identify products or services from each. Assessment focus 1.1. Identifying the rights and responsibilities of employees within engineering. Assessment focus 1.4. |
| Creative thinkers | Describing four examples of job opportunities within engineering at a local and/or national level. Assessment focus 1.2. Describing the key achievements in engineering in the 19th, 20th and 21st centuries and referring to social and economic development. Assessment focus 1.3. Analysing how employers can encourage employees to meet their responsibilities in accordance to employment legislation. Assessment focus 1.4. |
| Reflective learners | Setting goals for the development of each of their assignments. Reviewing their progress against the completion of their assignments. Describes four examples of job opportunities within engineering at a local and/or national level. Outlines the roles of the engineering council and licensed professional engineering institutions. Assessment focus 1.2. |
| Team workers | Not present in this unit. |
| Self-managers | Planning and organising the creation of their assignments for this unit. Dealing with time pressures and deadlines for the production of their assignments. Seeking advice and support from their peers and tutors when needed. |
| Effective participators | Not present in this unit. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently for a complex task | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |

| Skill | When learners are ... |
|--|---|
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | Not present in this unit. |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | |
| Identify the situation or problem and the mathematical methods needed to tackle it | |
| Select and apply a range of skills to find solutions | |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | |
| Draw conclusions and provide mathematical justifications | |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Taking part in formal and informal discussions/exchanges with a supervisor when they are describing engineering sectors and products. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | Reading a range of source materials when undertaking research into sectors and products, history of engineering and career opportunities. |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | Producing documents supporting research into sectors and products, history of engineering and career opportunities. |

Work experience

Learners will be able to apply knowledge and experience obtained from relevant work experience to many aspects of this unit and should be encouraged to recall their experiences when describing the operation and function of products and services from different sectors in engineering (assessment focus 1.1).

Learners may be able to identify career opportunities within engineering and evaluate first-hand the qualifications and skills required of an engineer (assessment focus 1.2).

Learners will also be able to identify the appropriate context for employer legislation, and how effectively employers encourage employees to meet their responsibilities in accordance with employment legislation (assessment focus 1.4 mark band 3).

Specialist resources

Resources will be dependent on the relevant sectors of engineering focused on throughout the delivery of this unit. The use of local contacts and publications would be a great asset.

Reference material

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Tooley M – *Engineering GCSE* (Newnes, 2002) ISBN 0750656441

Department for Business, Enterprise and Regulatory Reform – www.berr.gov.uk

The Engineering Council UK (EC UK) – www.engc.org.uk/institutions/institutions.aspx

Unit 2: Investigating Engineering Design

Principal Learning unit

Level 2

Guided Learning Hours: 60

Internally assessed

About this unit

The engineered products that you use in everyday life must be fit for purpose. They must be designed so that they are safe to use, give good service and are available at a reasonable cost. Product design is a complex activity requiring individual inputs from a whole group of people who make up the design team. The design team must be managed efficiently, bringing together experts in marketing, customer liaison, design specification, concept design, materials technology, manufacturing methods, finance and legislation. Some products are, of course, more complex than others and the number of people in the team may range from less than a dozen to more than a hundred. Whatever the product, the design process has the same objective which is to satisfy the needs of the customer with a quality product.

In this unit you will find out how products function by dismantling and reassembling them. You will also be looking at the overall design process and how it begins with a design brief from a customer. You will investigate the issues and constraints that influence product design and whether a proposal should be developed into a final solution suitable for manufacture. You will then examine the ways in which a final design solution is prepared and presented.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about the construction and function of an engineered product or system
 - LO.2. Be able to prepare a product design specification
 - LO.3. Be able to prepare initial design proposals
 - LO.4. Be able to prepare and submit a final design solution.
-

What you need to cover

- | | |
|---|--|
| LO.1 Know about the construction and function of an engineered product or system | Learners will need to investigate how a range of engineered products function and perform by dismantling and reassembling them, making appropriate use of engineering drawings and service manuals, eg motor vehicle sub-systems, pumps, compressors, power tools, domestic appliances. |
| LO.2 Be able to prepare a product design specification | Learners will need to be able to interpret a given design brief and produce a design specification. They will need to examine the key requirements of design briefs and the key considerations influencing product design specifications including eg requirements in terms of size, mass, product life, reliability, service requirements and the implications of standards and legislation such as British Standards (BS), Electromagnetic Compatibility Directive (EMC), European Conformity (CE), Environmental Protection Act, Waste Electronic and Electrical Equipment Directive. |
| LO.3 Be able to prepare initial design proposals | Learners will need to be able to examine alternative design proposals, eg by brainstorming, analysis of existing products, evaluation (including scientific and mathematical calculations) in terms of aesthetics, ergonomics, cost, manufacturing constraints, technical performance, safety and quality. |
| LO.4 Be able to prepare and submit a final design solution | Learners will need to be able to prepare and submit a final design solution, eg design documents (such as flow charts, circuit diagrams, general arrangement and detail engineering drawings by hand or use of a commercial CAD system), written report (containing design log and mathematical and scientific calculations), written or oral presentation (making use of models, PowerPoint and simulation using computer software). |
-

How you will be assessed

This unit focuses on the work of a design engineer and as such you will be assessed through an assignment giving opportunities, through a theme of design and development, to demonstrate what you know about the function of an engineered product. You will be expected to show that you can prepare a product specification, a range of initial ideas and present a design solution, similar to the work that a design engineer working in industry is likely to come across.

This unit will be assessed by your tutor who will set tasks for you to complete. You are likely to be given one or more tasks that will cover the material you have studied. Your tutor will give you opportunities to develop evidence and at least one of the tasks will be set in the workshop, and may relate to your work experience. These opportunities might typically consist of three tasks.

Task 1 could cover the requirements of assessment focus 1 with practical and written activities and your evidence will need to be presented in a 'process portfolio' for the practical work and a 'report' for the written work.

Task 2 could cover the requirements of assessment foci 2.1 and 2.2 with written activities on the interpretation of a given design brief and production of a product design specification (PDS) and your evidence will need to be presented in a 'report'.

Task 3 could be a continuation of the design process, covering the requirements of assessment foci 3 and 4 with activities to produce and evaluate alternative design proposals and present a final design solution and your evidence will need to be presented in a 'process portfolio'.

Marking grid

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|---|-------------------------|
| LO.1 Know about the construction and function of an engineered product or system | Dismantles and reassembles an engineered product or system and describes its construction and function. (0–6) | Dismantles and reassembles engineered product or system, describes its construction, function and mode of operation. (7–10) | Dismantles and reassembles engineered product or system, describes its construction, function and mode of operation and evaluates its range of performance and fitness for purpose. (11–14) | 14 |
| LO.2.1 Design brief | Identifies the physical constraints in a given design brief for an engineered product or system. (0–4) | Identifies the physical constraints and performance requirements in a given design brief for an engineered product or system. (5–7) | Identifies the physical constraints, performance requirements and reliability indicators in a given design brief for an engineered product or system. (8–9) | 9 |
| LO.2.2 Design specification | Produces a product design specification that contains the dimensional constraints and functional requirements for an engineered product or system. (0–4) | Produces a product design specification that contains the dimensional constraints, functional requirements and operating performance needs for an engineered product or system. (5–7) | Produces a product design specification that contains the dimensional constraints, functional requirements, operating performance and the economic and manufacturing considerations for an engineered product or system. (8–9) | 9 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|--|--|--|-------------------------|
| LO.3 Be able to prepare initial design proposals | Uses own and others' ideas and experiences to produce three initial design proposals for consideration. (0–6) Prepares and submits final design solution documents. (0–6) | Uses own and others ideas and experiences to produce and then compare three initial design proposals. (7–10) Prepares and submits final design solution documents including a written design report or a presentation. (7–10) | Uses own and others ideas and experiences to produce three initial design proposals and justifies the choice for a final design solution. (11–14) Prepares and submits final design solution documents including a written report and a presentation. (11–14) | 14 |
| LO.4 Be able to prepare and submit a final design solution | | | | 14 |
| Total marks | | | 60 | |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

| Assessment focus LO.1 | |
|-------------------------------|--|
| Mark Band 1–3 (0–14 marks) | <p>Up to 2 marks can be awarded for dismantling and reassembling an engineered product or system, 2 marks for describing its construction and another 2 marks for describing its function.</p> <p>Up to 4 marks can be awarded for describing the mode of operation of the product or system, which could include the use of freehand sketches, circuit diagrams or flow charts. The number of marks awarded is based on how well the description clearly shows how the product or system operates. It does not necessarily need sketches etc, providing a written description is clear. Where sketches, diagrams or flowcharts are used the ability to produce them should not be influential when awarding marks, only that they help describe the mode of operation.</p> <p>Up to 4 marks are available for evaluating the product's or system's range of performance and its fitness for purpose (eg in terms of its ergonomics, efficiency and reliability can be awarded).</p> |

| Assessment focus LO.2.1 | |
|--------------------------------|--|
| Mark Band 1–3 (0–9 marks) | <p>Up to 4 marks can be awarded for identifying the physical constraints of the product or system, for example the limiting weight, major dimensions and colour/surface finish.</p> <p>Up to 3 marks can be awarded for identifying the performance requirements of the product or system. These requirements will be more than simple one word answers, they will have some clarification of what is required by the product or system.</p> <p>Up to 2 marks can be awarded for identifying the reliability indicators of the product or system (eg expected service life and quality requirements). These indicators will be more than simple one word answers, they will have some clarification of the relationship to the reliability of the product or system.</p> |

| Assessment focus LO.2.2 | |
|--------------------------------|--|
| Mark Band 1–3 (0–9 marks) | <p>Up to 4 marks can be awarded for producing a product design specification that contains the dimensional constraints and functional requirements of a product or system. There are typically up to 2 marks for each of the two aspects, but could go to 3 if either the dimensional constraints or the functional requirements is covered well and above that required at mark band 1, up to a maximum of 4 marks.</p> <p>Up to 3 marks can be awarded for including the required operating performance parameters of a product or system. The marks gained will depend on the important parameters being present, some minor considerations can be omitted without losing marks.</p> <p>Up to 2 marks can be awarded for including the economic and manufacturing constraints of a product or system. One mark can be awarded for each aspect included in the response.</p> |

| Assessment focus LO.3 | |
|-------------------------------|---|
| Mark Band 1–3 (0–14 marks) | <p>At mark band 1, the marks awarded are based on the clarity of the idea and not about its feasibility. However there should be three alternative design proposals for a product or system. There are typically up to 2 marks for each of the three designs, but this could go to 3 if either are covered well and above that required for this mark band, up to a maximum of 6 marks.</p> <p>Up to 4 marks can be awarded for making a reasoned comparison of the three alternative design proposals for a product or system. To gain all 4 marks there is an expectation that there will be evidence of objective testing within the comparison that has links to the requirements of the product design specification.</p> <p>Up to 4 marks can be awarded for justifying the choice of final design solution for a product or system. This should link back to the requirements of the product design specification.</p> |

| Assessment focus LO.4 | |
|-------------------------------|--|
| Mark Band 1–3 (0–14 marks) | <p>Up to 6 marks can be awarded for preparing and submitting the final design solution (eg sketches, drawings, circuit diagrams or flow charts). At mark band 1 the solution does not have to be documented in a technical design report or presented in any other manner. The marks are awarded based on how well the design documents address the requirements of the design brief.</p> <p>Up to 4 marks can be awarded for the additional submission of a detailed written design report or the delivery of a presentation. This report would normally include a design log and mathematical and scientific calculations, typically with 1 mark available for each. Another mark can be awarded if the report is presented well and is easy to understand.</p> <p>Up to 4 marks can be awarded for delivering a presentation of the final design solution in addition to the written report. This presentation would normally involve the use of models (could be CAD generated), PowerPoint and simulation that must be done utilising software. There is 1 mark for each of these present and an additional mark for how effective the presentation conveyed the final design solution.</p> |

Approaches to assessment

It may be appropriate to devise three tasks for the assessment of this unit.

Task 1 could cover assessment focus 2.1 and could start with a practical activity requiring learners to dismantle and reassemble an engineered product or system. Evidence for this practical element may be best captured through learner observation record sheet and annotated photographs. A written or oral activity could then require learners to describe its construction and function to obtain marks from mark band 1. A further written or oral activity to describe its mode of operation would enable learners to achieve marks from mark band 2. A final written or oral activity to evaluate the range of performance and fitness for purpose of the product or system would enable learners to achieve marks from mark band 3. All of the evidence for this task will need to be in the form of a 'process portfolio' for the practical work and a 'report' for the written work.

Task 2 could be set to cover assessment foci 2.2.1 and 2.2.2. The first activity would require learners to identify the physical constraints in a given design brief for an engineered product or system. These would likely be the limiting weight, major dimensions and required colour or surface finish etc enabling learners to achieve marks from mark band 1 in assessment focus 2.2.1. Further written activities to identify the performance requirements and identify the reliability indicators of the product or system would enable learners to achieve marks from mark bands 2 and 3 respectively.

The task could continue with activities to cover the requirements of assessment focus 2.2.2. The first would be to produce a product design specification (PDS) containing the dimensional constraints and functional requirements for the product or system outlined in the given design brief. This would enable learners to achieve marks from mark band 1. Specification of the operating range and performance would enable learners to achieve marks from mark band 2 and further specification of the economic limitations and manufacturing constraints would enable learners to achieve marks from mark band 3. All of the evidence for this task will need to be in the form of a 'report'.

Task 3 could be set to cover assessment foci 2.3 and 2.4. The first activity would require learners to use their own and others experience and ideas to produce three alternative designs to meet the requirements of the PDS. These could be in the form of free hand sketches, charts and diagrams with accompanying explanatory notes and calculations, and would enable learners to be awarded marks from mark band 1 of assessment focus 2.3. A reasoned comparison, perhaps in the form of a scoring matrix, would enable learners to achieve marks from mark band 2 and a justification of the choice of final design solution would enable marks from mark band 3 to be awarded. The PDS should be selected to ensure the learner can carry out some objective testing during their comparison.

Submission of a final design solution containing, where applicable, drawings, circuit diagrams, flow charts, material etc would enable learners to be awarded marks from mark band 1 of assessment focus 2.4. Again, care needs to be taken to select the correct PDS to give opportunities for the written report to contain a design log, outlining the sequence of activities and decisions, mathematical and scientific calculations. Learners will then have an opportunity to be awarded additional marks from mark band 2. If the submission is accompanied by a written or oral presentation, marks from mark band 3 could also be awarded. In the task given for this it emphasis should be placed on the use of models, PowerPoint and simulation. The evidence for this activity is best captured through learner observation record sheets and annotated photographs. All of the evidence for this task will need to be in the form of a 'process portfolio'.

Although separate tasks could be devised for each assessment focus, where possible these should be linked to allow the holistic nature of the unit and the work of a design engineer to be delivered. It is recognised that this is not always possible, particularly where delivery is spread across a number of institutions, possibly including the learner's work experience location.

If a learner needs to retake any of the above suggested tasks then it is essential that a different product, design brief and design proposal should be used to retain the validity of the assessment.

Guidance for teaching this unit

Delivery guidance

This unit is 60 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 20 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

It is desirable that the dismantling of an engineered product or system be carried out in the workshop environment and could form part of a work placement. Depending on the practical skills that learners have acquired, they may need some preliminary instruction on workshop safety and the safe use of hand tools. The products or systems chosen should not be overly complex. Workshop items such as a three-jaw lathe chuck, tailstock or machine slide would suffice. If facilities exist, learners could dismantle and describe a disc brake assembly, alternator or water pump from a motor vehicle. Appliances such as a power drill, hair drier or smoothing iron which are designated to be used only for training purposes, might also be dismantled. Learners should be encouraged to make notes and freehand sketches during the exercise but may alternatively give an oral description of the function, performance and fitness for purpose of the product or system.

The centre should allow learners to practise the use of a design brief similar to that required for assessment foci 2.2.1 and 2.2.2. It should contain the basic requirements of a fictional customer for an engineered product or system. Some latitude of interpretation should be built in so that learners are able to progress from the general outline and decide what should be the specific requirements of the artefact or system. The design brief should be such that learners are able to specify reasoned parameters such as range of performance, expected working life, end of life disposal, limiting costs, maintenance requirements etc which have not been precisely stated by the customer. Possible products for the design brief could be a continuity tester, battery charger, a powered car jack, a simple drilling jig and a lawn sprinkler. The items chosen should be neither too complex nor too simplistic and learners should be encouraged to submit their own ideas. They should, however, have physical constraints, performance requirements and some reliability indicators.

The initial design proposals required to be developed for assessment focus 2.3 should take the form of freehand sketches, circuit diagrams, flow charts etc and accompanying notes and as such the centre should develop learners' skills in these areas before they are given the summative assessment. Learners should practice using relevant calculations associated with material quantities, costs, loading and performance. Learners should be encouraged to devise a scoring matrix to compare the degree to which the alternative designs fulfil the requirements of the PDS. This technique can then be used to justify the choice of final design solution when they are working on their summative assessment.

During the delivery of this unit, in teaching and learning sessions learners should be encouraged to keep a log of their design activities. This type of record is typical of what can be presented along with general arrangement drawings, detail drawings, models, circuit diagrams and flow charts etc as part of the final design submission for assessment focus 2.3. It is probable that some time will be needed to explain presentation and reporting techniques. This will be the case especially if learners have had no experience of engineering drawing. In addition to the generation of documentary evidence, learners should also be allowed to practice and encouraged to deliver a written/oral presentation of solutions. This could be to the whole class or carried out on a one-to-one basis with the tutor where disability or other personal reasons make it more appropriate. Again this practice will allow the skills to be developed necessary to carry out the presentation elements of this assessment focus when attempting the summative assessment.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|---|
| Independent enquirers | Identifying coursework questions and problems to resolve. Dismantling and reassembling an engineered product or system and describing its construction and function. Assessment focus 1. Identifying the physical constraints in a given design brief for an engineered product or system. Assessment focus 2.1. Producing a product design specification that contains the dimensional constraints and functional requirements for an engineered product or system. Assessment focus 2.2. |
| Creative thinkers | Producing a product design specification that contains the dimensional constraints and functional requirements for an engineered product or system. Assessment focus 2.2. Producing three initial design proposals. Assessment focus 3. |
| Reflective learners | Setting goals for the development of each of their assignment. Reviewing progress against the assessment of their assignment. Dismantling and reassembling an engineered product or system and describing its construction and purpose. Assessment focus 1. |
| Team workers | Not present in this unit. |
| Self-managers | Planning and organising the creation of their assignment for this unit. Dealing with time pressures and deadlines for the production of their assignment. Seeking advice and support from their peers and tutors when needed. Preparing product design specification. Assessment focus 2.2. Preparing design proposals. Assessment focus 3. Submitting final design solution documents. Assessment focus 4. |
| Effective participators | Dismantling and reassembling an engineered product or system and describing its construction and purpose. Assessment focus 1. Producing three initial design proposals. Assessment focus 3. Submitting final design solution documents. Assessment focus 4. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---|
| ICT – Use ICT systems | |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | Submitting final design solution documents. |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently for a complex task | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | Submitting final design solution documents. |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | Submitting final design solution documents. |
| Evaluate the selection and use of ICT tools and facilities used to present information | |

| Skill | When learners are ... |
|--|---|
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | |
| Identify the situation or problem and the mathematical methods needed to tackle it | Producing three initial design proposals and justifying choice for final design solution. Submitting a detailed design activity log and final design solution documents. |
| Select and apply a range of skills to find solutions | |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | |
| Draw conclusions and provide mathematical justifications | Producing three initial design proposals and justifying choice for final design solution. Submitting a detailed design activity log and final design solution documents. |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Submitting a detailed design activity log, final design solution documents and delivering a presentation. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | |

Work experience

As already indicated this unit lends itself to gathering evidence from an appropriate work placement. Participating in the assembly or dismantling of engineered products or systems could provide evidence of achievement and reinforce the links between engineering design and manufacture. The assessment and guidance section indicate where this would be useful.

Specialist resources

Access to workshop facilities is desirable for the dismantling activities required for learning outcome 1. A selection of hand tools should be available together with a selection of engineered products or systems for dismantling and re-assembly. Drawing equipment and instruments or access to CAD facilities, will be required for the design activities and internet access will be of advantage.

Reference material

Darbyshire A and Taylor D – *GNVQ Advanced Engineering* (Nelson Thornes, 1997)
ISBN 9780748728862

Godfrey N and Wallis S – *GCSE Engineering* (Nelson Thornes, 2004) ISBN 9780748785513

Tooley M, O’Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O’Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

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Unit 3: Engineering Applications of Computers

Principal Learning unit

Level 2

Guided Learning Hours: 60

Internally assessed

About this unit

In the modern global economy, engineering industries have had to embrace computer technology in their manufacturing systems, products and services in order to remain at the forefront of innovation and design. Continuing advances in computer-aided systems can give those that invest in their development a competitive edge, enabling them to achieve greater productivity, reliability and quality.

In this unit you will discover how computer systems are applied to every aspect of engineering manufacturing, from product design and development to automated packaging, to maintenance operations. You will also learn how many everyday products use microprocessor technology for the benefit of consumers.

You will develop and apply skills of investigation and research in a systematic way to discover how computers are employed in a range of engineering industries.

This unit will provide you with the opportunity to conduct your research and investigation in appropriate work placements and through visits to companies, using computer technology in their business.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about computer applications in process control and manufacturing
 - LO.2. Be able to use computer-based systems to solve an engineering problem
 - LO.3. Understand microprocessor control applications in everyday consumer products
 - LO.4. Know about computer aided technology in maintenance operations.
-

What you need to cover

- | | |
|--|--|
| LO.1 Know about computer applications in process control and manufacturing | <p>Learners will need to investigate and experience a range of common computer applications as they are employed in engineering manufacturing industries, eg chemical, polymer, electronic, automotive, aerospace. They will learn that computer aided engineering systems are capable of dealing with the design, analysis, manufacture and inspection in a unified way.</p> <p>Learners will need to know about computer technologies as they are applied to engineering manufacturing industries, eg flow and temperature control of chemical and food products, monitoring work-in-progress so that workflow is always known and customers are kept informed of the progress of orders, maintaining stock levels for Just In Time (JIT) production, in plant and equipment safety systems, quality and inspection of manufactured products, in control of process plant and the movement of products and materials around the plant.</p> |
| LO.2 Be able to use computer-based systems to solve an engineering problem | <p>Learners will need to be able to use appropriate computer aided equipment to solve problems, eg to simulate the manufacture of a product, the control of an automated systems for the detection, conveyance and transfer of products from one process to another. They will need to work in a safe manner when using the equipment.</p> |
| LO.3 Understand microprocessor control applications in everyday consumer products | <p>Learners will need to research, handle, examine and analyse everyday consumer products that make use of microprocessor control technologies, eg domestic appliances such as washing machines and microwave ovens, TVs, motor vehicle ignition systems, security systems, smart cards, toys and games, communications devices.</p> |
| LO.4 Know about computer aided technology in maintenance operations | <p>Learners will need to investigate how computers are used to improve maintenance operations when used on typical engineering systems, eg for motor vehicle computer diagnostic testing, to schedule and record planned maintenance tasks on plant and equipment, and how new technologies such as vision systems aid process monitoring.</p> <p>Learners will also need to know about hand-held terminals that provide the maintenance engineer with essential, on the spot data/information, eg routine maintenance checklists, scanners that read bar code IDs of replacement parts, maintenance tasks for a particular piece of equipment, data collection and analysis.</p> |
-

How you will be assessed

This unit will focus on the applications of computers in engineering. As such you will be assessed through an assignment that will give you opportunities to demonstrate what you know about computer applications in process control and manufacturing, that you can use computer-based systems to solve engineering problems, what you know about computer aided technology in maintenance operations and computer communications systems.

This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given a number of tasks that will cover all of the material you have studied. Your tutor will give you opportunities to develop evidence and one or more tasks could be set in the laboratory or workshop, and may relate to your work experience. These opportunities might typically consist of four tasks.

The first task could cover what is required for assessment focus 1. This could use a written activity to describe how different industries use computers in process control and manufacturing. All of the evidence for this task will need to be in the form of a 'report'.

A second practical task, covering assessment focus 2 could use workshop activities and would involve setting up and using computer systems to solve engineering problems. Evidence for this task will be in the form of a 'process portfolio'.

A further task could cover assessment focus 3. This might use a written activity requiring you to describe microprocessor control systems and how they control consumer products. Evidence for this task will need to be in the form of a 'report'.

A fourth task to cover assessment focus 4, could be another task similar to that used for assessment focus 1. This would require you to describe computer applications in maintenance operations and use computer generated data. All of the evidence for this task will need to be in the form of a 'report'.

Marking grid

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|---|---|---|-------------------------|
| LO.1 Know about computer applications in process control and manufacturing | Describes an example of how two different industries use computers in process control and manufacturing. (0–6) | Describes and compares how two different industries use computers in process control and manufacturing. (7–10) | Describes, compares and evaluates how two different industries use computers in process control and manufacturing. (11–14) | 14 |
| LO.2 Be able to use computer-based systems to solve an engineering problem | Sets up and uses appropriate computer-based equipment to solve a given engineering problem. (0–8) | Sets up appropriate computer-based equipment to solve a given engineering problem in safe manner and presents a solution. (9–14) | Sets up appropriate computer-based equipment to solve a given engineering problem in a safe manner, presents a detailed solution, justifies the use of the equipment used and appraises the solution. (15–18) | 18 |
| LO.3 Understand microprocessor control applications in everyday consumer products | Describes how two different microprocessor systems control the features or actions of consumer products. (0–6) | Describes how two different microprocessor systems control the features or actions of consumer products and identifies the component parts of a microprocessor control system and explains how they work. (7–10) | Evaluates the use of a microprocessor control system in an consumer product, identify the component parts of a microprocessor control system, explain how they work and describe how the system might be applied to another product. (11–14) | 14 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|--|---|-------------------------|
| LO.4 Know about computer aided technology in maintenance operations | Describes two different computer applications in a given maintenance operation. (0–6) | Describes two different computer applications in a given maintenance operation and explains how computers enable detailed fault diagnosis in a product or piece of plant or equipment. (7–10) | Describes two different computer applications in a given maintenance operation, explains how computers enable detailed fault diagnosis in a product or piece of plant or equipment and interprets computer generated data from an engineering maintenance/diagnostic operation and proposes an appropriate course of action. (11–14) | 14 |
| | | | Total marks | 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

| Assessment focus LO.1 | |
|-------------------------------|---|
| Mark Band 1–3 (0–14 marks) | <p>Each of the two descriptions should be based on details of the use in process control and manufacturing industries, eg chemical, polymer, electronic, automotive, aerospace, etc. There are typically up to 3 marks for each of the two descriptions, but could go to 4 if one aspect is answered well and above that required for this mark, up to a maximum of 6 marks.</p> <p>Award up to 4 marks for the comparison of the two industry uses. Typically the comparison will probably in the form of advantages and disadvantages.</p> <p>Award up to 4 marks for the evaluation of the two different industries, eg the value to the industries of computers in the chosen applications and why they are used. Typically each evaluation could be awarded up to 2 marks.</p> |

| Assessment focus LO.2 | |
|-------------------------------|--|
| Mark Band 1–3 (0–18 marks) | <p>Presented with an engineering problem the learner can be awarded up to 2 marks for choosing an appropriate piece of computer-based equipment, based on its suitability to solve the problem. Up to 3 marks can be awarded for setting it up, based on its ability to be used, and up to 3 marks for using it correctly.</p> <p>Typically the safe use of the equipment can be awarded up to 2 marks. Up to 4 marks can be awarded for presenting a solution to the problem. The marks awarded should be based on how well the solution solves the problem and how well it can be seen to be a solution by a third party.</p> <p>Up to 2 marks are available for a justification of the decision to use appropriate computer aided equipment and 2 further marks are available for an appraisal of the solution.</p> |

| Assessment focus LO.3 | |
|-------------------------------|--|
| Mark Band 1–3 (0–14 marks) | <p>There are typically up to 3 marks for each of the two descriptions, although this could go to 4 if one aspect is answered well and above that required for this band, up to a maximum of 6 marks. Marks should be based on how well each answer describes how the microprocessor control system controls the features or actions of consumer products.</p> <p>Up to 2 marks can be awarded for the proper identification of the component parts of a microprocessor control system and up to 2 marks for an explanation of how the system works.</p> <p>Award 2 marks for the evaluation of the use of a microprocessor control system in an everyday consumer product. Similarly, up to 2 marks are available for an appropriate suggestion of how it might be applied to another product.</p> |

| Assessment focus LO.4 | |
|---------------------------------------|---|
| <p>Mark Band 1–3 (0–14 marks)</p> | <p>There are typically up to 3 marks for each of the two descriptions, but could go to 4 if one aspect is answered well and above that required for this mark, up to a maximum of 6 marks. Marks should be based on how well the answer describes their application to given maintenance operations.</p> <p>Up to 4 marks can be awarded for an explanation of how computers enable detailed fault diagnosis in the subject. Reference should be made to the product, plant or equipment under diagnosis and the way data is provided and used.</p> <p>Up to 2 marks can be awarded for the proper interpretation of computer generated data and up to 2 marks for proposing an appropriate course of action. The course of action suggested should come from the interpretation of the data.</p> |

Approaches to assessment

An overall assignment with four tasks would be appropriate for this unit. At least two of these tasks could be completed on placement in suitable industries.

Task 1 could be designed to cover assessment focus 1 and would require the learner to investigate how two different industries use computers in process control and manufacturing. At this level it would be sufficient for the learner to identify and describe just two similar and quite specific applications in each industry, one for process control and one for manufacturing. They could then compare and evaluate their use to achieve the higher mark bands. The evidence will need to be submitted in a 'report'.

Task 2 could provide learners with an opportunity to carry out a practical activity to satisfy assessment focus 2. Learners will need to be presented with an engineering problem to solve. This could originate from an external industrial partner, eg an industrial partner requests a product prototype manufactured using a rapid prototype machine tool. The centre must be certain that learners will know about and have access to appropriate computer aided equipment. Care must be taken to ensure the practical activity and safe working is captured properly, probably in the form of learner observation record sheets supported by annotated photographs and copies of documentation used/processes followed etc. Evidence for this task will need to be submitted in a 'process portfolio'.

Task 3 could involve an investigation and analysis of two microprocessor control systems in consumer products to meet the needs of assessment focus 3. Opportunities need to be given to enable learners to identify component parts during their evaluation and description of the microprocessor control system, and be able to show how the system might have another use. As such, the evidence will need to be submitted in a 'report'.

Task 4 could give require learners to investigate computer applications in maintenance operations 4. Centres may wish to collect a variety of products for learners to work with, perhaps a number of different systems taken out of redundant plant and equipment or a scrap motor vehicle. Alternatively, the focus could be on motor vehicle maintenance and repair or the engineering maintenance activities within one of the energy utility industries, gas, water or electricity.

The data required for mark band 3 should be straightforward, for example furnace temperature readings for a heat treatment plant or fuel pump rate on a motor vehicle with appropriate parameters for each. This would also ensure learners have an opportunity to make a suggested alternative use.

The evidence for this task will need to be submitted in a 'report'.

It is important that learners are able to handle and examine system boards safely and it may be beneficial if learners have completed the Level 1 unit *Electronic Circuit Construction and Testing* or something similar.

Guidance for teaching this unit

Delivery guidance

This unit is 60 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 20 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

The purpose of this unit is to provide learners with an understanding of how computers are an essential element in modern engineering. It is therefore important that learners have the opportunity to see first-hand how engineering manufacturing industries use computers in process control and manufacturing applications, maintenance and communications. They will need to access at least two different industries and know about the wider use of computers and microprocessor control systems in modern consumer products.

Assessment focus 1 is intended to introduce the learners to real world computer applications. This could be achieved through a series of visits at the start of the unit or during a scheduled placement. As suggested, these opportunities could also be used to address the needs of assessment focus 4, as every engineering manufacturing organisation will have a maintenance function. An alternative for this however may be by linking with a local car dealership to see how they use computer diagnostics in their service areas or with utility companies such as British Gas or Powergen. It may be possible to have maintenance engineers visit the centre to demonstrate how they use mobile computer technology for maintenance and fault diagnosis procedures. Any of these external partners could provide essential support and information to the learner, eg the data required for assessment focus 4 mark band 3.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | <p>Researching into how different industries use computers in process control and manufacturing. Assessment focus 1.</p> <p>Setting up and using appropriate computer-based equipment to solve a given engineering problem. Assessment focus 2</p> <p>Evaluating the use of microprocessor control systems in everyday consumer products. Assessment focus 3.</p> <p>Interpreting computer generated data from an engineering maintenance/diagnostic system and proposing an appropriate course of action. Assessment focus 4.</p> |
| Creative thinkers | <p>Setting up and using appropriate computer aided equipment to solve a given engineering problem. Assessment focus 2.</p> <p>Evaluating the use of a microprocessor control system in an everyday product and suggesting how it might be applied to another product. Assessment focus 3.</p> <p>Interpreting computer generated data from and engineering maintenance/diagnostic system and proposing an appropriate course of action. Assessment focus 4.</p> |
| Reflective learners | <p>Setting goals for the development of each of their assignments.</p> <p>Reviewing their progress against the completion of their assignments.</p> <p>Setting up, using, justifying the use of computer aided equipment for solving a given engineering problem and appraising the solution. Assessment focus 2.</p> |
| Team workers | Not present in this unit. |
| Self-managers | <p>Planning and organising the creation of their assignments for this unit.</p> <p>Dealing with time pressures and deadlines for the production of their assignments.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> <p>Setting up and using appropriate computer-based equipment to solve a given engineering problem. Assessment focus 2.</p> |
| Effective participators | Not present in this unit. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---|
| ICT – Use ICT systems | |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | Setting up and using appropriate computer aided equipment to solve a given engineering problem. Transmitting data successfully in an appropriate format to a remote industrial partner on three occasions. |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | Justifying the use of computer aided equipment for solving a given engineering problem and appraising the solution. Evaluating the effectiveness of communication activities used, identifying weaknesses and explaining how the system could be improved. |
| Manage information storage to enable efficient retrieval | Presenting a detailed solution to a given engineering problem using computer aided equipment. |
| Follow and understand the need for safety and security practices | Establishing computer communication links with a remote, industrial partner for the exchange of data in an appropriate format. |
| Troubleshoot | Setting up and using appropriate computer aided equipment to solve a given engineering problem. |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently for a complex task | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | Setting up and using appropriate computer aided equipment to solve a given engineering problem. Transmitting data successfully in an appropriate format to a remote industrial partner on three occasions. Evaluating the effectiveness of communication activities used, identifying weaknesses and explaining how the system could be improved. |
| ICT – Develop, present and communicate information | |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | Setting up and using appropriate computer aided equipment to solve a given engineering problem. Presenting a detailed solution to a given engineering problem using computer aided equipment. |
| Bring together information to suit content and purpose | Presenting a detailed solution to a given engineering problem using computer aided equipment. |

| Skill | When learners are ... |
|--|--|
| Present information in ways that are fit for purpose and audience | Presenting a detailed solution to a given engineering problem using computer aided equipment. |
| Evaluate the selection and use of ICT tools and facilities used to present information | Evaluating the effectiveness of communication activities used, identifying weaknesses and explaining how the system could be improved. |
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | Establishing computer communication links with a remote, industrial partner for the exchange of data in an appropriate format. |
| Mathematics | Not present in this unit. |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | |
| Identify the situation or problem and the mathematical methods needed to tackle it | |
| Select and apply a range of skills to find solutions | |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | |
| Draw conclusions and provide mathematical justifications | |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Establishing computer communication links with a remote, industrial partner for the exchange of data in an appropriate format. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | <p>Describing an example of how two different industries use computers in process control and manufacturing.</p> <p>Describing how two different microprocessor systems control the features or actions of consumer products.</p> <p>Describing two different computer applications in a given maintenance system.</p> |

Work experience

This unit provides numerous opportunities for learners to gather evidence through work experience. For example assessment focus 3.1 would be ideally covered during placements at two different engineering industries, so that learners can gain first-hand experience of research and information gathering.

In some circumstances the activities used for assessment focus 3.2 could be organised and carried out whilst on a placement, for example at a work-based learning provider or in the training centre of an engineering company.

For assessment focus 3.4 a work experience placement would be an ideal opportunity for learners to experience how industries use computers in support of maintenance operations. For example, a one day placement at an automotive service centre would enable learners to see and experience computer diagnostic testing.

Reference material

Kalpakjian S and Schmid S – *Manufacturing Engineering and Technology* (Prentice Hall, 2005) 0131489658

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Tooley M – *Engineering A Level* (Newnes, 2005) ISBN 0750666927

The Institution of Engineering and Technology – www.theiet.org

Unit 4: Producing Engineering Solutions

Principal Learning unit

Level 2

Guided Learning Hours: 60

Internally assessed

About this unit

Engineering is an extremely diverse sector and to help you understand some of the many things that engineers do, you will need to practise a variety of skills and processes in order to become familiar with them.

This unit will give you the opportunity to undertake your own project, producing an engineered product or carrying out an engineering service such as maintenance, installation or commissioning. As part of your duties, you will have to identify what you need to do, plan the process, taking into account the machinery or tools needed, select the materials required, then, when you have finished, carry out an inspection to help you identify what is right and which areas can be improved. This logical and structured approach to problem solving will enable you to develop some of the skills used across the engineering sector.

You will gain the practical experience required at this level and will develop an understanding of the theory behind the selection of materials, tools and equipment in engineering manufacturing or service. You will also develop your knowledge of the health and safety implications of working on industrial standard machines.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Understand health and safety procedures, standards and risk assessment in engineering activities
 - LO.2. Be able to plan for an engineering product or service
 - LO.3. Be able to select suitable materials, parts or components for an engineered product or service
 - LO.4. Be able to use processes, tools and equipment to make an engineered product or carry out a service
 - LO.5. Be able to apply inspection techniques to the engineered product or service.
-

What you need to cover

- | | |
|--|--|
| LO.1 Understand health and safety procedures, standards and risk assessment in engineering activities | Learners will need to know about their responsibilities under health and safety and follow standards and procedures when working in an engineering environment. They will learn about wearing appropriate clothing, using safety equipment as appropriate, carrying out risk assessments, ensuring that tools, equipment and machinery are safe and fit for use and applying good housekeeping practice throughout. |
| LO.2 Be able to plan for an engineering product or service | <p>Learners will need to plan for a given engineered product/service making use of different sources of information, eg job cards, engineering drawings, manuals, stock lists recognising size, shape, form and type of material, parts and components.</p> <p>Learners will also identify the tools, type of equipment and machinery to be used, the sequence of operations, the quality control points and how quality will be checked through inspection.</p> |
| LO.3 Be able to select suitable materials, parts or components for an engineered product or service | <p>Learners will need to select suitable materials, eg ferrous, non-ferrous metals and alloys, polymers such as thermosetting and thermoplastic, ceramic composites which combine the properties of different materials, eg bi-metal strips, carbon composites and sintered metals, adhesives.</p> <p>Learners will need to identify a material's properties in relation to the engineering task, eg the ability to be shaped, formed, machined, cast or forged, strength, toughness, elasticity, plasticity, malleability, ductility, hardness, the ability to be heat or chemically treated, painted or surface plated and corrosion resistant.</p> <p>Learners will need to identify electrical components for use in manufacturing or servicing, eg resistors, capacitors, diodes, LEDs, bulbs, wire, cable, types of solders, insulators, batteries, motors, buzzers, variable resistors, thermistors, transistors and integrated circuits; and recognise their properties, eg electrical conductivity/insulation, thermal conductivity/insulation.</p> <p>Learners will also need to identify mechanical components for use in manufacturing or servicing, eg nuts, bolts, screws, springs, rivets, pins, clips, keys and drive mechanisms including gear trains, parts or components in standard or non-standard sizes or values.</p> |

- LO.4. Be able to use processes, tools and equipment to make an engineered product or carry out a service**
- Learners will need to produce a given engineered product or carry out a service using suitable processes, tools and equipment, eg fabrication and welding, mechanical production, composite materials or electrical/electronic techniques or similar. They will need to apply a suitable finishing treatment processes, eg blueing, etching, plating, passivation, case hardening or painting.
- Learners will also need to know about the details that should be followed when making an engineered product or carrying out a service, eg plan, schedule.
- LO.5. Be able to apply inspection techniques to the engineered product or service**
- Learners will need to produce an inspection plan to assess the quality of the engineered product or service to ensure it conforms to specification, with an emphasis on, for example, shape and form, dimensional accuracy, tolerance, fit, finish, performance and comparison to product specification or output.
-

How you will be assessed

You are likely to be given a number of tasks that will cover the material you have studied. Your tutor will give you opportunities to develop the necessary skills and knowledge. One or more tasks will be set in the workshop and may relate to your work experience.

These opportunities could typically consist of 2 tasks. Task 1 could cover the requirement of assessment focus 1 as combined practical and written work. The preparation and execution of the actual risk assessment should be based on the intended production activities of task 2. The evidence will need to be submitted in a 'process portfolio'.

Task 2 could bring together assessment foci 2, 3, 4, and 4.5. This could be a combined practical and written work with the production and implementation of a plan for assessment focus 2, identifying materials for assessment focus 3, production of the actual engineered product or carrying out the service for assessment focus 4 and planning and inspection documentation for focus 5. Also as part of assessment focus 5 you will review the process and consider what you have learned and might do differently the next time. Again, the evidence will need to be submitted in a 'process portfolio'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|---|---|-------------------------|
| LO.1 Understand health and safety procedures, standards and risk assessment in engineering activities | Identifies health and safety procedures and standards appropriate for a given engineering activity and identifies why a risk assessment could be necessary during the activity. (0–4) | Describes responsibilities of self and others when working on a given engineering activity and identifies substances or processes where a risk assessment would be necessary during the activity and states why it is. (5–7) | Compares the health and safety responsibilities of self and others when working on a given engineering activity. Carries out a risk assessment identifying hazards and risks and states whether the risk is acceptable or not and how it can be controlled. (8–10) | 10 |
| LO.2 Be able to plan for an engineering product or service | Produces a plan to include materials or components, tools and equipment and sequence of events for the manufacture of an engineered product or to carry out a service. (0–4) | Produces a detailed plan for the manufacture of an engineered product or service, and justifies the sequence of operations and reasons behind choice of tools and equipment chosen. (5–7) | Applies plan and proposes improvements based on application. Records all suggested improvements and justifies why the improvements have been suggested and the intended result of improvements. (8–10) | 10 |
| LO.3 Be able to select suitable materials, parts or components for an engineered product or service | Uses information given on own plan to identify and select materials, parts or components for the production of an engineered product or the carrying out of a service. (0–4) | Uses information given on own plan to identify, select and prepare materials parts or components for the production of an engineered product or the carrying out of a service. (5–7) | Justifies the selection and preparation of materials, parts or components for the production of an engineered product or the carrying out of a service, based on the use of own plan. (8–10) | 10 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|---|-------------------------|
| LO.5 Be able to apply inspection techniques to the engineered product or service | Performs inspection techniques and checks on an engineered product or service to check compliance with plan. (0–4) | Performs inspection techniques and checks on an engineered product or service to check compliance with plan and records the key measurements and assesses compliance with initial plan. (5–7) | Evaluates the inspection techniques employed and the results obtained as a result. Summarises what has been learnt during the process and what might be carried out differently next time to ensure compliance. (8–10) | 10 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|---|--|--|------------------------------|
| LO.4 Be able to use processes, tools and equipment to make an engineered product or carry out a service | Produces with guidance, an engineered product or carries out a service following own plan and uses processes, tools and equipment in a correct and safe manner. (0–10) | Produces with limited guidance, an engineered product or carries out a service following own plan and correctly selects all processes, tools and equipment in a correct and safe manner, considering self and others. (11–15) | Independently, produces an engineered product or carries out a service following own plan and self-selects and uses additional drawings or documentation, process, tools or equipment in an effective and safe manner, considering self and others. (16–20) | 20 (10+10+10+20) = 60 |
| Total marks | | | | |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

Examples of ‘*guidance*’ might include (but are not limited to):

- instructions given verbally telling learners what to do and how to do it, how to follow their own plan and use tools and equipment in a correct manner for assessment focus LO.4
- when carrying out these tasks the learner consistently needs reminding what to do
- constant demonstration about what to do
- if they were not guided through each stage of the use of the plan and use of processes, tools and equipment the learner would not be able to complete the manufacture of the engineered product or carry out the service safely for assessment focus LO.4.

Examples of ‘*limited guidance*’ might include (but are not limited to):

- the tutor gives a variety of options that learners decide upon, they discuss how to follow the plan, select and use processes, tools and equipment for assessment focus LO.4, the learner will then confirm how to use the plan and what are the correct processes, tools and equipment to select and what is the correct and safe way to use appropriate them before they commence the activity
- after this initial support to, in the main, start the processes and ensure the learner is safe to do so, the tutor is likely to react only to questions the learner asks
- the learner checks matters of detail to ensure they are progressing as needed, this may be on a regular basis but would be checking for confirmation that they are progressing satisfactory and doing things correctly
- in some cases the tutor may have to assist and intervene to ensure actions are progressing satisfactory and correctly.

Examples of ‘*independence*’ might include (but are not limited to):

- the learner feels comfortable to carry out the tasks and follow their plan without support, the additional drawings or documentation, processes, tools and equipment they select and use will be those that are most suitable for the task and they will always show due regard to safety
- initially, the tutor will support the learner to ensure they are able and know what they need to do when carrying out the required tasks
- the tutor will monitor and recognise that the learner can carry out the tasks but may on occasions have to assist
- learners may seek confirmation that they are doing things right before they carry out stages of the tasks required.

Assessment focus 4 will require practical work and as such will need a witness statement/observation record supplemented by annotated photographs and other forms of evidence such as copies of learner’s production plan and other documentation. This evidence should clearly state the level of support given to the learner and be detailed enough for the Assessor to make a judgement whether the response falls into mark band 1, 2 or 3.

Marking grid A

| Assessment focus LO.1 | |
|---------------------------------------|--|
| <p>Mark Band 1–3 (0–10 marks)</p> | <p>At mark band 1, 3 marks can be awarded for identifying appropriate health and safety procedures and standards relevant to the activity being carried out. This band would also be appropriate for responses which only cover one procedure, even if well described. 1 mark can be awarded for identifying why a risk assessment may be necessary during the activity.</p> <p>Up to 3 marks can be awarded for descriptions that show some understanding of health and safety. 1 mark can be awarded for describing the health and safety responsibilities of self and others when working on a given engineering activity. 1 mark can be awarded for identifying substances or processes that require risk assessment and one mark for stating why.</p> <p>At mark band 3, 1 mark can be awarded if the learner correctly draws a comparison between the duties of self and others. They must realise that they are both important when working in an engineering work area. 1 mark can be awarded for carrying out a risk assessment and identifying hazards and risks. 1 mark can be awarded for deciding if the risk is acceptable and if not suggesting methods of control. To achieve marks in this mark band, learners should demonstrate they understand the requirements of a risk assessment and how the data is recorded in the correct manner.</p> |

| Assessment focus LO.2 | |
|---------------------------------------|---|
| <p>Mark Band 1–3 (0–10 marks)</p> | <p>At mark band 1, 4 marks can be awarded for devising a written plan of operation to produce an engineered product or system. The plan would be basic, but should contain materials or components, tools and equipment and sequence of events.</p> <p>At mark band 2, the plan is likely to be more detailed than that for mark band 1 to allow the justification to be clear. 3 marks can be awarded for a justification of the sequence of operations included in the plan (devised in band 1) and giving the reasons behind the choice of tools and equipment to use. It is important that the justification has some reasoning behind the sequence of events and takes account the process to be carried out (for example a component should be drilled before being bent as it will not fit on the drill bed after being bent.)</p> <p>1 mark can be awarded for reviewing the success of the plan and 2 marks for making suggestions for improvements where necessary.</p> |

| Assessment focus LO.3 | |
|-------------------------------|--|
| Mark Band 1–3 (0–10 marks) | <p>2 marks can be awarded for correctly identifying materials, parts or components suitable for task. The identification should relate to the plan developed in assessment focus 2 and 2 marks can be given for selecting the materials, parts or components (ie as part of the plan in assessment focus 2). For example the colours and values of resistors as a means of identification.</p> <p>3 marks can be awarded for the preparation of the materials, parts or components (from mark band one) suitable for task. Preparation can be simply deburring and cleaning metals, or laying out a number of electronic components in the correct order prior to assembly. This should be reflected in the plan from assessment focus 2.</p> <p>3 marks can be awarded for justifying why the materials, parts or components were chosen. This should relate to the properties and features of the materials, parts or component that relate to the intended engineered product or service being carried out.</p> |

| Assessment focus LO.5 | |
|-------------------------------|--|
| Mark Band 1–3 (0–10 marks) | <p>3 marks can be awarded for using basic inspection techniques appropriate to the engineering task. 1 mark can be awarded for demonstrating that the checking was relevant to the drawing specification.</p> <p>1 mark can be awarded if the method used to record inspection results is appropriate to the product or service requirement. 2 marks can be awarded for comparing the results with the initial plan and producing a comparison that clearly shows if compliance has been achieved.</p> <p>1 mark can be awarded for reviewing the inspection techniques and 2 marks for suggesting where improvements could be made. To achieve all 3 marks learners must consider all aspects of the inspection process. They must mention how the inspection was carried out and if they thought they carried it out correctly and what might be done differently next time.</p> |

Marking grid B

| Assessment focus LO.4 | |
|-------------------------------|---|
| Mark Band 1–3 (0–20 marks) | <p>Up to 3 marks can be awarded for producing the engineered product or carrying out the service, based on the relevance of how it was done in terms of quality of finished product or success of the service. Up to 2 marks can be awarded for following the learner’s own plan based on how well it is followed and the reasoning behind any amendments made. 3 marks can be awarded if the learner adheres to the safety considerations when carrying out the engineering task. These should include personal protective clothing, general duties, safe use of tools and equipment and leaving the work area in a safe and clean state when the task is completed. Typically 1 mark can be awarded for the consideration of each up to the maximum of 3 marks for this part of the mark band. Up to 2 marks can be awarded for the use of given tools and equipment based on the care taken and correct use. At mark band 1 the learner has to be guided and advised throughout to ensure that progress is made. The learner relies on the support of the tutor, who has to assist in most aspects of the work. This level of support restricts the learner’s mark to mark band 1, irrespective of the quality of the outcomes.</p> <p>2 marks can be awarded if the learner has completed the engineering task (manufactured the product or carried out the service) with limited support and 1 mark for the selection of their own process, tools and equipment to use. Up to another 2 marks can be awarded for consideration of safety of self and others. The tutor supports the learner initially in carrying out the task and following the schedule. Thereafter the tutor reacts to questions from the learner and suggests a range of ideas/activities that the learner acts on. The learner frequently checks matters of detail. The tutor needs to assist in some aspects of the work. This level of support restricts the learner’s mark to bands 1 or 2, irrespective of the quality of the outcomes.</p> <p>At mark band 3, 2 marks can be awarded if the learner has independently completed the engineering task (manufactured the product or carried out the service) without any significant support and 1 mark for independently following their plan. Up to another 2 marks can be awarded for the selection and use of additional supporting drawings and/or documentation that was instigated and used by the learner independently. The tutor supports the learner initially in carrying out the task and following the schedule. Thereafter the tutor occasionally assists the learner, and only when asked, but monitors progress throughout. This level of support gives access to all three mark bands.</p> |

Tutors will need to exercise judgement in respect of an appropriate engineered product. A possible scenario could be to produce a product brief, including drawings and a specification from an external source, perhaps a partner company. A more complex product than Level 1 is required and should provide opportunities for each learner to address each of the assessment foci. Levels of guidance given during the activity may be recorded on a witness testimony sheet that details the activity undertaken and is signed by the tutor.

The bulk of the work is likely to be delivered through practical activities with integrated theory. Therefore the task needs to encompass all aspects of the foci and be challenging yet readily achievable by the learner at Level 2.

The specification may require the use of production engineering machinery, fabrication and welding equipment and specialist hand tools at some point in the production process and servicing activity. Centres will need to consider this when producing or negotiating a product or servicing requirement brief.

Approaches to assessment

The assignment for this unit could consist of two tasks.

Task 1 could cover the requirements of assessment focus 1 as combined practical and written activities. The written activity should require a description of how to work safely, with reference to the health and safety responsibilities of the learner, including the correct use and storage of PPE. The task should also offer the opportunity for learners to identify both key safety points when working in a workshop and substances that could be hazardous. Once these safety points and substances have been identified learners could be asked to carry out a practical activity in the form of risk assessment on them. This task will allow and encourage movement across each mark band appropriately for assessment focus 1. The evidence for this task will be in the form of written responses complete with learner observation record sheets supplemented by annotated photographs of the practical elements. As such this will need to be submitted in a 'process portfolio'.

Task 2 could be based around the actual production of an engineered component or product or the carrying out of a service. This task should be a mix of practical and written activities. Learners should be given a suitable engineered product brief or service requirement and from it produce a plan of how they intend to make the product or carry out the service (assessment focus 2). Movement across the mark bands given for assessment foci 2 and 3 is based around the level of detail given in the planning and the level of autonomy shown by the learner. Other activities will need to be given, asking learners to apply and justify their plan and suggest improvements. Learners will then produce the product or carry out the service and devise an inspection methodology recorded on an inspection sheet. Movement across the mark bands for assessment foci 4 and 5 is based on the level of compliance with both the plan and inspection plan. The evidence for this task will need to be submitted in a 'process portfolio'. Learner observation record sheets, annotated photographs, planning documents and written response are all likely to be included within this evidence for this task.

The outcome of task 2 is the production of an engineered product or a successful service (that encompasses learning outcomes 2, 3, 4 and 5 to the required standards) and centres should think how they are going to demonstrate that this actually took place. As already mentioned an annotated photographic record would be one method that shows the stages of development of the product, service activity, the plan and the inspection process. Activities should be structured appropriately to allow learners to achieve across the mark bands.

Guidance for teaching this unit

Delivery guidance

This unit is 60 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 20 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

The majority of the unit content is likely to be delivered through practical activities with integrated theory.

For the health and safety elements, it is suggested that learners use a college or school workshop that is fitted out to industry standards to enable them to understand the need for PPE, identify hazards under PUWER and COSHH, identify specific safety signs applicable to the processes used and then carry out a risk assessment. It would also be beneficial, for assessment purposes, for health and safety to be covered during workshop sessions.

‘Cartoon’ safety sheets, where the learner is asked to identify hazards and non safe working practices may be used to get the message across. The knowledge gained from this exercise would then be employed within the workshop prior to practical activities taking place.

It is essential for health and safety purposes that the learner fully understands the workings of the machines to be used or worked on so that they feel comfortable when carrying out practical engineering work. For this reason, it is suggested that an investigative approach be used when identifying the component parts of the machines and their function. This could be in the form of a multiple choice type handout where learners select the correct name of the component from a list and add the name against a drawing or picture of the component.

It is envisaged that the learner will develop skills through a progressive approach, firstly carrying out simple engineering activities and then building up to a level where they are capable of undertaking the complete task for the purposes of assessment.

The actual product can be of a simple nature at this level as the product is only part of the task and the emphasis is on the planning and selection of suitable tools and equipment. If a service is to be used then again this should be fairly simple with emphasis on the planning and selection of suitable tools and equipment. In all events the learner should be taught how to look for improvements in a plan.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|---|
| Independent enquirers | Identifying coursework questions and problems to resolve. Identifying health and safety procedures and standards appropriate to a given engineering activity and identifying why a risk assessment would be necessary during the activity. Assessment focus 1. |
| Creative thinkers | Producing a production plan to include materials or components, tools and equipment and sequence of events for the manufacture of an engineered product or system. Assessment focus 2. |
| Reflective learners | Setting goals for the development of each of their assignments. Reviewing their progress against the completion of their assignments. Performing inspection techniques and checking on an engineered product or service to check compliance with plan. Assessment focus 5. |
| Team workers | Not present in this unit. |
| Self-managers | Dealing with time pressures and deadlines for the production of their assignments. Organise time and resources, prioritising actions. Seeking advice and support from their peers and tutors when needed. Producing an engineered product or carry out a service following own plan and using processes, tools and equipment in a correct and safe manner. Assessment focus 4. |
| Effective participators | Producing a plan to include materials or components, tools and equipment and sequence of events for the manufacture of an engineered product or to carry out a service. Assessment focus 2. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently for a complex task | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |

| Skill | When learners are ... |
|--|--|
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | Comparing dimensions of completed work with those given on engineering drawings. |
| Identify the situation or problem and the mathematical methods needed to tackle it | Carrying out measuring tasks. |
| Select and apply a range of skills to find solutions | Comparing results and establish variance. |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | Checking of dimensions whilst work is in progress. |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | Recording numerical results of inspection and producing a plan of action. |
| Draw conclusions and provide mathematical justifications | |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Taking part in formal and informal discussions/exchanges with a supervisor when they are describing different types of engineering drawings and different sorts of documentation used when planning a production task. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | Reading and understand a range of engineering drawings and recording sheets. |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | Devising a written plan of engineering operation to produce an engineered product. Producing an inspection report. |

Work experience

This unit lends itself to delivery and assessment within a vocational environment in local industry where work experience is taking place. Learning outcomes may be achieved in a variety of placements where the necessary vocational skills and equipment are available.

Specialist resources

When delivering this unit, centres need to ensure that learners have access to the necessary equipment required.

Where possible, the equipment should be of industry standard to enable learners to fully appreciate the types of machines available and develop a genuine feel for the process, simulation will not be permitted.

The engineered product or system should be of substantial enough to permit learners to cover all aspects of the learning outcomes. Reference materials should be available to enable the learner to follow prescribed procedures. Again, a range of hand tools should be available that are fit for purpose.

The working environment should be one that gives learners access to health and safety information and signage with procedures already in place that will guide the learning process.

Reference material

Godfrey N and Wallis S – *GCSE Engineering* (Nelson Thornes, 2004) ISBN 9780748785513

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Unit 5: Electrical and Electronic Circuits and Systems

Principal Learning unit

Level 2

Guided Learning Hours: 30

Internally assessed

About this unit

Have you ever wondered how the electrical and electronic goods that you use every day actually work and what goes on inside them? This unit will help you learn the basis of electronic circuits, how they are built and how they work. You will also learn how to recognise the components that make up electrical and electronic circuits and understand how they work together.

This unit will provide you with an opportunity to understand how a prototype electronic circuit is constructed and tested. The unit will focus on practical skills and will allow you to undertake the identification and selection of a variety of basic electronic components as well as the assembly and testing of a working electronic circuit. You will also use a variety of different electrical and electronic test instruments to check components and circuits and also how to locate faults on simple electronic circuits. This is a fun and exciting unit that will provide you with an introduction to electronics as a potential and very rewarding future career.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Understand safe working practices in the workshop/ laboratory and understand relevant electrical and electronic principles
 - LO.2. Be able to recognise and select components used in electrical and electronic circuits
 - LO.3. Be able to construct an electronic circuit and understand its basic operating principles
 - LO.4. Be able to test and find faults on electronic circuits.
-

What you need to cover

- LO.1 Understand safe working practices in the workshop/laboratory and understand relevant electrical and electronic principles**
- Learners will need to understand and be able to apply relevant safe working practices when working with electrical and electronic systems such as identifying electrical hazards, electric shock prevention, the need for isolation using appropriate devices (eg miniature circuit breakers (MCB), residual current devices (RCD) and earth leakage circuit breakers (ELCB)). They will also need to understand how to inspect electrical equipment, cables and connectors, inspect and replace mains connectors and fuses and understand the need for portable appliance testing (PAT) and compliance with electrical safety legislation and associated regulations.
- Learners will need to know about the effective grounding and earthing of non-insulated equipment (eg equipment with a metal enclosure or with an exposed metal chassis), the safe use of hand tools (eg screwdriver, pliers, cutters, etc); safe use of soldering equipment (eg soldering iron, soldering and desoldering tools); safe use of PCB manufacturing tools and equipment (eg etching equipment, PCB drills, etc); safe use of measurement and test equipment (eg multimeter, oscilloscope, power supply, signal generator, logic probe) including use of appropriately insulated test leads and probes.
- Learners will also need to cover the main electrical and electronic principles that are relevant to electrical systems such as electrical units and the relationship between them (eg calculation of voltage, current, resistance and power, calculation of supply current and fuse ratings; relationship between RMS and peak voltage).
- LO.2 Be able to recognise and select components used in electrical and electronic circuits**
- Learners will need to know about and be able to recognise a range of electrical and electronic components such as fixed resistors (eg carbon and metal film types, wirewound, ceramic and metal clad types), variable and pre-set resistors and potentiometers (eg carbon and wirewound types, multi-turn, open skeleton preset, ceramic metal types); fixed capacitors (eg polyester, polystyrene, mica, ceramic and electrolytic types); variable and pre-set capacitors (eg air-spaced, solid-dielectric and ceramic types); fixed inductors (eg air, iron and ferrite-cored types); pre-set inductors (eg with adjustable ferrite cores); transformers (eg iron and ferrite cored types, power and signal types); diodes (eg silicon power rectifiers, bridge rectifiers, switching diodes, signal diodes, zener diodes, variable capacitance diodes; silicon controlled rectifiers (thyristors); optoelectronic devices (eg light emitting diodes, light dependent resistors, seven-segment displays, LED bar graph displays); transistors (eg NPN and PNP bipolar junction transistors, P-channel and N-channel junction and insulated gate field effect transistors); integrated circuits (eg operational amplifiers, comparators, timers, logic gates); switches (eg toggle, slide and rotary types); cells and batteries; loudspeakers, buzzers and

microphones; connectors (eg single and multipole types, DIN, phono, IDC types); component markings and colour codes (eg value, tolerance, voltage rating, etc); component symbols (to BS 3939 and BS 8888).

Learners will also need to be able to correctly select components for use in electrical and electronic circuits based on calculation of resistance, voltage, current and power rating (as appropriate); component type, outline and physical encapsulation (eg axial or radial leads, pin-spacing, etc).

LO.3 Be able to construct an electronic circuit and understand its basic operating principles

Learners will need to gain a practical knowledge of the different techniques used to construct circuits, such as bread-boarding (using solderless prototype boards), soldering, matrix boards, printed circuit boards, interconnection techniques (eg PCB headers, DIN and other multi-way connectors, IDC connectors, jack, phono and RF coaxial connectors).

Learners will need to know about electronic circuits such as rectifiers and smoothing circuits, unregulated and regulated power supplies, transistor amplifiers.

Learners will have to understand the main operating principles of electronic circuits such as the basic principles of rectification, amplification and oscillation, calculation of voltage gain, calculation of time constant, relationship between frequency and period.

LO.4. Be able to test and find faults on electronic circuits

You will need to be able to carry out testing on electronic circuits and use electronic test equipment (eg multimeter, oscilloscope, signal generator, logic probe, as appropriate), and measure circuit parameters (eg voltage, current, resistance, voltage gain, frequency, period, as appropriate to the circuit concerned).

The circuits that you will test will be simple electronic circuits (eg light sensor, temperature sensor, light flasher, test oscillator).

You will also need to be able to use fault finding techniques such as test-point voltage and current measurement (ie comparison with tables of test voltages and test currents, as appropriate; signal tracing (eg input to output, output to input and half-split methods).

How you will be assessed

The key focus of this unit is your ability to be able to select electronic components and use them to construct, test and fault-find on a simple electronic circuit. As part of the assessment you will also be expected to provide evidence that you have used safe working practices. You should receive a full briefing concerning the work well in advance of the due date for completion. This will allow you to carry out any preparatory work. The theme of your assessment will therefore be based on the construction (including selection of components), testing and fault-finding of a simple electronic circuit such as a light sensor, temperature sensor, light flasher, or test oscillator.

You will be expected to complete the individual tasks under controlled conditions (usually during normal class teaching periods). This unit will be assessed by your tutor who will set an assignment for you to complete. You are likely to be given one or more tasks which will cover all the material you have studied. Most of these tasks will be set in the workshop and may relate to your work experience. Your tutor will give you opportunities to develop evidence. These opportunities could typically consist of four tasks.

Task 1 could cover some of the requirements of assessment focus 5.1 with written activities including some calculations. For this task you would need to submit your work in the form of a 'report'.

Task 2 could cover the requirements for assessment focus 5.2 as a practical task. It will therefore give you an opportunity to develop and use your practical skills applied to electronic componentry. For this task you would need to submit your own work in the form of a 'process portfolio'.

Task 3 could cover assessment focus 5.3 and some of the requirements of assessment focus 5.1 as a mixture of practical and written activities and as such you would again need to submit your own work in the form of a 'process portfolio'.

The fourth and final task could cover the requirements for assessment focus 5.4 and would again be mainly a practical exercise for you to do. Again for this task you would need to submit your own work in the form of a 'process portfolio'. It will be the main assessment in this unit and thus carries a higher weighting of marks and gives you an opportunity to develop and use your practical skills applied to electronic fault finding.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|---|-------------------------|
| LO.1 Be able to demonstrate safe working practices in the workshop/laboratory and understand relevant electrical and electronic principles | Demonstrates safe working practices when constructing, testing and fault-finding on electronic circuits. (0–6) | Demonstrates safe working practices when constructing, testing and fault-finding on electronic circuits, and determines current, voltage and power in a simple DC circuit. (7–11) | Demonstrates safe working practices when constructing, testing and fault-finding on electronic circuits, determines current, voltage and power in a simple DC circuit, and calculates appropriate ratings for fuses or other protection devices in an AC circuit stating any assumptions made. (12–15) | 15 |
| LO.2 Be able to recognise and select components used in electrical and electronic circuits | Identifies six different components used in electrical and electronic circuits. (0–4) | Identifies nine different components used in electrical and electronic circuits and selects an appropriate component for an electrical/electronic circuit application. (5–7) | Identifies 12 different components used in electrical and electronic circuits and selects appropriate components for two different electrical/electronic applications. (8–10) | 10 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|--|---|-------------------------|
| LO.3 Be able to construct an electronic circuit and understand its basic operating principles | Describes the overall function of the circuit that they have constructed. (0–2) | Describes the overall function of the circuit that they have constructed, and explains the function of each individual component. (3–4) | Describes the overall function of the circuit that they have constructed, explains the operation of the circuit with reference to the function of each individual component, and explains the overall operation/action of the circuit. (5–6) | 6 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|---|---|----------------------------|
| LO.3 Be able to construct an electronic circuit and understand its basic operating principles | Uses appropriate techniques to construct an electronic circuit from a given circuit diagram, with assistance (0–4) | Uses appropriate techniques to construct an electronic circuit from a given circuit diagram, with limited assistance (5–7) | Uses appropriate techniques to construct an electronic circuit from a given circuit diagram, independently (8–9) | 9 |
| LO.4 Be able to test and find faults on electronic circuits | Uses appropriate techniques and test instruments to carry out basic voltage, current and signal tests on given working circuits in order to verify that it is functioning correctly. | Uses appropriate techniques and test instruments to carry out basic voltage, current and signal tests on given working circuits in order to verify that it is functioning correctly and uses appropriate fault-finding techniques and test instruments to locate and identify a fault on a similar circuit. (9–15) | Uses appropriate techniques and test instruments to carry out basic voltage, current and signal tests on given working circuits in order to verify that it is functioning correctly, use appropriate fault-finding techniques and test instruments to locate and identify two different faults on a similar circuit. (16–20) | 20 |
| Total marks | | | | (15+10+6+9+20) = 60 |

Assessment guidance

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

Examples of ‘*guidance*’ might include (but not limited to):

- instructions given verbally telling learners what to do and how to do it, what technique to use and how to use the circuit diagram and construct the electronic circuit for assessment focus LO.3 in mark grid B.
- when carrying out these tasks the learner consistently needs reminding of what to do
- constant demonstration of what to do
- if they were not guided through each stage of the construction the learner would not be able to build an appropriate circuit from the diagram for assessment focus LO.3 in mark grid B.

Examples of ‘*limited guidance*’ might include (but not limited to):

- the tutor gives a variety of options upon which learners decide. They discuss what to do and how to do it, what technique to use and how to use the circuit diagram and construct the electronic circuit for assessment focus LO.3 in mark grid B. The learner will then confirm how to use the diagram and construct the circuit before they commence the activity
- after this initial support to start the processes and ensure the learner is safe to do so, the tutor is likely to only react to questions the learner asks
- the learner checks matters of detail to ensure they are progressing as needed, this may be on a regular basis but would be checking for confirmation that they are progressing satisfactory and doing things correctly
- in some cases the tutor may have to assist and intervene to ensure actions are progressing satisfactory and correctly.

Examples of ‘*independence*’ might include (but not limited to):

- the learner feels comfortable to carry out the tasks without support, they will be able to use the diagram and construct the circuit using the correct technique most suitable for the task and they will always show due regard to safety
- initially the tutor will support the learner to ensure they are able and know what they need to do when carrying out the required tasks, although this may be more apparent during the formative assessment stages than with the summative assessment
- the tutor will monitor and recognise that the learner can carry out the tasks but may on occasions have to assist
- learners may seek confirmation that they are doing things right before they carry out stages of the tasks required.

Tasks that involve learners working independently or with guidance should not be attempted until it is clear that they have been taught and have practised the relevant knowledge and skills and are suitably ready to generate and gather evidence.

Marking grid A

| Assessment focus LO.1 | |
|-------------------------------|--|
| Mark Band 1–3 (0–15 marks) | <p>1 mark is available for demonstrating each of up to six different safe working practices used when constructing, testing and fault finding on circuits. The working practices used are likely to be from a range that could include identifying electrical hazards, shock prevention, need for isolation, inspection procedures/requirements, safe use of tools, safe soldering and compliance with electrical safety legislation and associated regulations.</p> <p>Up to 5 further marks can be awarded for determining current (1 mark), voltage (1 mark), resistance (1 mark), and power (2 marks) present in a given DC or AC circuit. Marks should only be awarded where learners supply fully worked answers.</p> <p>Up to 4 marks can be awarded for calculating appropriate ratings for a fuse or other protection device. Fully worked calculations, together with a statement of any assumptions made (eg nominal supply voltage) will be required for the full 4 marks.</p> |

| Assessment focus LO.2 | |
|-------------------------------|--|
| Mark Band 1–3 (0–10 marks) | <p>Marks are awarded for identifying a range of components used in electrical and electronic circuits. 6 marks for identifying 12 different components; 5 marks for identifying nine different components; 4 marks for identifying six different components; 3 marks for identifying five different components; 2 marks for identifying four different components; 1 mark for identifying three different components.</p> <p>Up to 2 marks for selecting appropriate components for the given circuit application and up to 2 marks for selecting appropriate components for a second given circuit application.</p> |

| Assessment focus LO.3 | |
|--------------------------------------|--|
| <p>Mark Band 1–3 (0–6 marks)</p> | <p>Up to 2 marks can be awarded for a written description of the overall function of the circuit.</p> <p>Up to 4 marks can be awarded for the explanation of the function of the individual components. 1 mark is available for each explanation, such as single-pole single-throw (SPST) on/off switches as a means of interrupting the supply; operation of two resistors as a potential divider; operation of input sensors/transducers as a means of converting light, temperature, sound, etc to an electrical signal; operation of indicators or output transducers as a means of converting electrical signals to light, sound, motion, etc; operation of a transistor as a current amplifier; operation of an operational amplifier as a voltage amplifier respectively; operation of an operational amplifier as a comparator.</p> <p>Up to 6 marks are available for an explanation of the overall operation of the circuit (ie an overall conceptual understanding of how the components work together in order to provide the required circuit function). This explanation should refer to essential electronic concepts, with marks allocated to specific operational aspects of the circuit. For example, a response could include, where appropriate, the need for a series resistor of appropriate value to limit the current supplied to an LED indicating device; the action of a potential divider to produce a reference voltage; the switching action of a transistor with base current required to turn the device on; the switching action of an operational amplifier when connected as a comparator; the action of an operational amplifier when connected as a linear amplifier with feedback defined voltage gain; the logical state of the inputs of a logic gate required for the output to go high or low.</p> |

Marking grid B

| Assessment focus LO.3 | |
|--------------------------------------|---|
| <p>Mark Band 1–3 (0–9 marks)</p> | <p>Marks can be awarded for quality of construction, on the basis of component location and orientation, quality of soldering, component preparation and correct use of hand tools, and not causing damage to components. Within mark band 1, learners will have received assistance and guidance throughout the task to ensure progress is made. To be eligible for mark band 2, learners will have received limited assistance. Learners who work independently will be eligible for mark band 3.</p> |

| Assessment focus LO.4 | |
|---------------------------------------|---|
| <p>Mark Band 1–3 (0–20 marks)</p> | <p>Up to 8 marks can be awarded for the use of appropriate test equipment to carry out basic functional tests which should include static voltage measurement at given tests points (up to 2 marks), supply current measurement (up to 2 marks), input/output signal tests or equivalent stimulus as a means of testing dynamic operation (up to 4 marks). The techniques used should include the correct use of electronic test equipment.</p> <p>Up to 7 marks can be awarded for using appropriate fault finding techniques (up to 3 marks) to locate (up to 2 marks) and correctly identify (up to 2 marks) a given fault condition. Again, the techniques used should include the correct use of electronic test equipment.</p> <p>Up to 5 marks for using appropriate fault finding techniques (up to 2 marks) to locate (1 mark) and correctly identify (up to 2 marks) a further (ie second) fault condition.</p> |

Approaches to assessment

For the assessment of this unit it might be appropriate to devise an assignment based on the construction (including selection of components), testing and fault-finding of a simple electronic circuit such as a light sensor, temperature sensor, light flasher, or test oscillator. Note that learners are not required to design the circuit from scratch nor are they required to design and manufacture the printed circuit board. Learners are however required to understand the processes involved and they should be able to relate the circuit schematic to the physical layout of components on a printed circuit board.

The assignment could comprise four inter-related tasks in which each task contributes evidence in support of a different learning outcome and assessment foci.

Task 1 could contribute to assessment focus 1 and require learners to identify six hazards associated with the construction and testing of the given electronic circuit. In connection with some or all of the hazards identified, learners could be asked to describe and explain at least four safe working practice and why these precautions are needed. Examples of these hazards and associated safety precautions might be:

- 1 the need to ensure that the soldering iron or soldering station has a correctly fitted mains lead and plug
- 2 the need to ensure that ventilation/fume extraction and eye protection is used when soldering
- 3 the need to use a bench mat and soldering iron stand
- 4 the need to be aware of others working in the near vicinity and to observe general workshop/laboratory working practices
- 5 the need to ensure that any item of test equipment used has been recently PAT tested
- 6 the need to ensure that the workbench is tidy and that trailing leads are avoided
- 7 the need to ensure that mains powered equipment is fitted with a correctly rated fuse
- 8 the need to know the location of the bench mains isolating switch so that the supply can be disconnected in an emergency
- 9 the need to ensure that equipment is switched off and isolated from the supply before dismantling prior to any internal inspection
- 10 the need to ensure that only suitably rated components are used to replace any components that may have failed
- 11 the need to use insulated test leads and probes when connecting test instruments to circuit test points and to avoid contact with the circuit under investigation when making measurements
- 12 the need to ensure that capacitors are given time to lose any residual charge before measurements are made
- 13 the need to ensure that any exposed metal parts (such as a metal chassis or enclosure) are effectively grounded
- 14 the need to ensure that any static sensitive (ESD) components are handled and stored correctly.

The demonstration of safe working practices could be assessed in task 3 of this assignment.

For the requirements of mark band 2 learners could then be given a simple DC circuit comprising, for example, a battery and two series-connected resistors) and asked to calculate the effective resistance, current supplied, voltage drop across each resistor and power dissipated in

each resistor. Finally, learners could be given for mark band 3 the voltage and current ratings for an AC mains-operated electrical or electronic appliance and then be asked to determine a suitable fuse rating for the appliance. The evidence for this task will be submitted in a 'report'.

Task 2, addressing assessment focus 2, could require learners to identify a selection of twelve given electronic components from their markings and physical appearance. An example of an appropriate selection of 12 components might be:

- 1 a carbon film fixed resistor with colour code markings
- 2 a wirewound variable potentiometer
- 3 a polarised electrolytic capacitor
- 4 a polyester capacitor
- 5 a ceramic disk capacitor
- 6 a preset potentiometer
- 7 a silicon rectifier diode
- 8 a small-signal transistor
- 9 an operational amplifier
- 10 a standard light emitting diode
- 11 a light dependent resistor
- 12 a 9V battery
- 13 a miniature mains transformer
- 14 a miniature loudspeaker
- 15 a miniature toggle switch
- 16 a dual-in-line (DIL) integrated circuit.

Note that not all of these components may be present in the electronic circuit used in tasks 3 and 4 for construction, testing and fault-finding.

The components could be supplied in the form of real samples, good quality illustrations, schematic symbols, or a selection of all three. Where colour codes are used to indicate values (as in the case of a carbon film resistor) these should be clearly displayed or indicated as supplementary text in the case of a grey-scale illustration.

Learners could then be asked to select from a catalogue extract or from a set of component data sheets specific components for two given circuit applications.

Examples of component selection for two different applications might be:

- 1 selecting an appropriate small-signal transistor for use in a potential-divider driven light sensor circuit from four alternative transistor types, each having different characteristics and ratings
- 2 selecting an appropriate optical transducer for use in a potential-divider driven light sensor circuit from four alternative light sensitive devices, each having different characteristics and ratings.

The evidence for task 2 will be submitted in a 'process portfolio' as it could contain annotated templates, annotated photographs, learner observation record sheets etc.

Task 3, addressing assessment focus 3 and some of assessment focus 1. A practical activity could require learners to construct and test a given electronic circuit (the circuit should have a least five different individual components) demonstrating safe working practices (eg a light sensor, temperature sensor, light flasher or test oscillator) using a pre-built printed circuit board

and a supplied set of components. The circuit should be assembled with components correctly located, orientated and neatly soldered into place. Once complete, the circuit should be tested for correct operation and circuit voltages and supply current measured and compared with a tabulated set of design values (supplied by the tutor). A written activity needs to be set to allow learners to firstly describe what the circuit is for and then explain the function of the individual components and then explain the function of the overall circuit. The evidence for task 3 will be submitted in a 'process portfolio' as it could contain written descriptions and explanations, checklists, annotated photographs, learner observation record sheets etc.

Task 4, addressing assessment focus 4 could require a practical activity allowing learners to investigate at least two circuit boards which are in good working order. A further practical activity needs to be set to allow learners to fault find on a circuit that has a least two faults, alternatively two separate circuit boards with different faults could be used. These boards should be similar to those that learners have constructed so that learners are already familiar with their function and operation. Examples of faults that could be present include:

- 1 an open-circuit switch
- 2 an open-circuit resistor
- 3 an incorrect population of a component or value error
- 4 an open-circuit transistor (base or collector open-circuit)
- 5 a short-circuit transistor (collector to emitter short-circuit)
- 6 a physical PCB fault (eg broken track, short-circuit between tracks, dry joint)
- 7 an incorrectly orientated transistor, diode or integrated circuit.

Learners could be given, where possible, a random selection of up to four of these boards together with and a selection of appropriate test equipment. They should also be given a circuit diagram, PCB component layout and a table of test voltages taken under normal working conditions. Learners should be instructed to use appropriate fault-finding techniques to identify and locate the fault on each board and, in connection with this, they should be expected to carry out a number of prescribed activities (carrying out a visual inspection of the board prior to connection to the supply, initial checking of supply voltage and current, observing the general nature of the fault (eg are any power or signal indications present?), measurement of test point voltages, etc).

Fault-finding techniques should include close visual examination as well as deductions made from test voltages and signal observations (as appropriate). In each case, learners should fully document their findings and describe the fault-finding method used as well as any deductions made. For example, a typical learner response might be:

- 1 Carried out a visual inspection of the board before applying power – no obvious defect noted
- 2 Applied power and measured the supply current using a digital multimeter on the DC current range – noted that this was abnormally large at 25 mA instead of the expected 15 mA
- 3 Used a digital multimeter to check the test point voltages – found that the collector and emitter voltages of TR1 were identical (both were 2.5 V instead of 4.5 V and 1.2 V respectively)
- 4 Removed the power and carried out a resistance check between the collector and emitter of TR1 – resistance indicated was zero ohms
- 5 Suspected fault is TR1 failed short-circuit between collector and base.

The evidence for task 4 will be submitted in a 'process portfolio' as it could contain checklists, annotated photographs, learner observation record sheets etc.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

Wherever possible, this unit is best taught using practical investigations. Health and safety should be stressed throughout the unit, especially the hazards of working with electricity. Learners should be given ample opportunity to work with real components and to make use of catalogues and data sheets. They should be introduced to practical construction techniques through simple wiring and assembly exercises and to a variety of basic electrical and electronic measurements through structured laboratory work. As part of this process learners should be introduced to the use of hand tools, soldering equipment, multimeters, oscilloscopes, power supplies and signal generators at an early stage in the course. An introduction to fault-finding technique could be based on a progressive series of fault location exercises using switched faults on circuit of increasing complexity.

It should be noted that a detailed understanding of the operation of a wide range of electronic components and circuits is not required in order to satisfy the learning outcomes for this unit. Instead, the emphasis should be on sufficient understanding to interpret a simple electronic circuit and identify the function of the components used in it. There is no need to understand, for example, the physics of semiconductors or the detailed operation of transistor amplifiers or logic circuits.

In order to minimise the risk of electric shock, learners should only be expected to undertake work on low-voltage circuits supplied from current-limited DC power units. The maximum voltage that should be present in the circuits on which learners work and take measurement should be limited to no more than 20 V (DC or peak AC) and the maximum current limited to no more than 1 A (DC or peak AC). Soldering stations should ideally be low-voltage ESD-protected and the leads fitted to soldering irons should be of the heat-proof variety. All electrical and electronic test equipment should be regularly PAT tested and bench supplies should be fitted with appropriate isolating circuit breakers. Protective soldering mats and soldering iron stands should be provided together with eye protection and adequate provision for ventilation/fume extraction should be provided. Finally, it is absolutely essential that learners are supplied with basic electrical and workshop safety information before they undertake *any* practical work.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | Identifying and selecting components for use in electronic circuits (assessment focus 2), using appropriate techniques in the construction and testing of electronic circuits (assessment focus 3), and when describing, explaining and demonstrating safe working practices (assessment focus 1). |
| Creative thinkers | Using appropriate techniques and test instruments to carry out basic voltage, current and signal tests on a working circuit in order to verify that it is functioning correctly. Assessment focus 4. |
| Reflective learners | Not present in this unit. |
| Team workers | Not present in this unit. |
| Self-managers | Using appropriate techniques to construct an electronic circuit from a given circuit diagram and describe the overall function of the circuit. Assessment focus 3. Using appropriate techniques and test instruments to carry out basic voltage, current and signal tests on a working circuit in order to verify that it is functioning correctly. Assessment focus 4. |
| Effective participators | Not present in this unit. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---|
| ICT – Use ICT systems | |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | Using CD ROM and online catalogues and component reference sources. |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently for a complex task | Using CD ROM and online catalogues and component reference sources. |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | Using CD ROM and online catalogues and component reference sources. |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |

| Skill | When learners are ... |
|--|--|
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | Calculating values of components, circuit parameters and fuse ratings. |
| Identify the situation or problem and the mathematical methods needed to tackle it | Calculating values of components, circuit parameters and fuse ratings. |
| Select and apply a range of skills to find solutions | Calculating values of components, circuit parameters and fuse ratings. |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | Checking calculations against an expected range of values. |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | Producing results from measurements and comparing these with given values. |
| Draw conclusions and provide mathematical justifications | Finding results and solutions and drawing conclusions in the light of the situation when they are calculating resistance, voltages, currents and power in circuits and with the aid of calculations justifying given component values. |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Discussing results with tutor. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | Reading and understanding task requirements, test equipment manuals and user guides, component and circuit data. |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | Recording and interpreting measurements and test results and summarising deductions made when carrying out fault-finding tasks. |

Work experience

Some parts of this unit can be delivered in the workplace. Learning about circuit diagrams and component recognition when applied to real engineering solutions would give learners opportunities to maximise their potential. Engineering companies are likely to have sets of components and drawings (hard copies or computer copies) that learners could study. They will also have circuit testing facilities. Learners could also become involved in taking measurements and testing circuits.

All assessment foci lend themselves to the gaining of evidence within the workplace. The practical activity to determine different parameters in circuits, recognition of components and the testing and fault finding of circuits could be exercised on a workplace visit. Staff at any organisation helping in this manner would however need careful guidance on expectations and the need to ensure that learners are able to gather the required evidence in support of the learning outcomes for this unit.

Specialist resources

The following specialist resources (in appropriate quantities to suit the number of learners) will typically be required for delivering this unit:

- multimeter (digital or analogue type)
- signal generator
- power supply
- oscilloscope
- logic probe
- constructed circuits (with switched faults)
- manufacturers' and suppliers' catalogues
- component symbols reference data (BS3939, BS8888)
- a supply of electronic components (resistors, capacitors, diodes, transistors, etc) and printed circuit boards (etched and pre-drilled).

Reference material

Bishop O – *Electronics: A First Course* (Newnes, 2006) ISBN 0750669608

Bishop O – *Electronics: Circuits and Systems* (Newnes, 2003) ISBN 0750658452

Duncan T – *Success in Electronics* (Hodder Murray, 1997) ISBN 0719572053

Tooley M – *Electronic Circuits: Fundamentals and Applications* (Newnes, 2006) ISBN 0750669233

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Unit 6: Application of Manufacturing Techniques in Engineering

Principal Learning unit

Level 2

Guided Learning Hours: 60

Internally assessed

About this unit

All the products that you use on a daily basis, from computers to coffee pots, are engineered and many are manufactured in the UK in a vibrant sector that contributes a great deal to the national economy.

Most UK manufacturers have turned to modern technology and manufacturing methods to try to gain an advantage over their global competitors and more often than not now produce high quality, high value added goods and services.

In this unit you are going to get involved in engineering manufacturing activities, producing, as part of a team, a quantity of the same product. You will learn about production planning and scheduling and be responsible for setting up tools and equipment including computer numerical control (CNC) and preparing materials ready for production. In line with modern industrial practice you will learn how to apply quality control during production and be able to record and interpret the resulting data.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Be able to work effectively in a production team and reflect on their performance
 - LO.2. Know about production information and how this is used to plan and schedule for manufacturing
 - LO.3. Be able to set up and use tools and CNC equipment safely to process materials
 - LO.4. Be able to apply appropriate quality control techniques and interpret quality data.
-

What you need to cover

| | |
|---|--|
| LO.1 Be able to work effectively in a production team and reflect on their performance | <p>Learners will need to work as part of a team that manufactures a quantity of engineered products. Learners will learn about their strengths and weaknesses, how to co-operate with others to plan and work towards production goals, allocate roles and responsibilities, ensure good communication between team members and take responsibility.</p> |
| LO.2 Know about production information and how this is used to plan and schedule for manufacturing | <p>Learners will need to be able to recognise and interpret essential production information from drawings and specifications, eg size, shape, form, materials, quantity, process methods, quality, where these are specified.</p> <p>Learners will need to be able to produce a production plan for a quantity of the same product, eg sequence of operations, materials, process methods, tools, equipment and machinery to be used, critical production and quality control points, inspection and quality checks, health and safety requirements.</p> <p>Learners will also need to know about production scheduling and setting realistic deadlines involving the production of a quantity of the same product, eg batch, high volume production.</p> |
| LO.3 Be able to set up and use tools and CNC equipment safely to process materials | <p>Learners will need to be able to set up and use appropriate tools and equipment including CNC to manufacture a quantity of products safely, eg turning, milling, grinding, presswork.</p> <p>Learners will prepare and process suitable materials, eg metals, alloys, polymers.</p> <p>Learners will also need to demonstrate that they can work safely and maintain a safe, clean and tidy working environment.</p> |
| LO.4 Be able to apply appropriate quality control techniques and interpret quality data | <p>Learners will need to check the quality of their work to ensure that products conform to specification using appropriate techniques, eg inspect, test, measure, compare. They will check dimensions, tolerances, fit, finish and performance.</p> <p>Learners will examine quality sampling, through the use of statistical methods for testing, in volume production and the recording and interpreting of quality data to maintain conformance to standards.</p> |

How you will be assessed

This unit will be assessed by your tutor who will set an assignment for you to complete. Because of the nature of this unit you will need to work as part of a production team to manufacture a quantity of the same engineered product. As such you will be assessed through the theme of the work of a manufacturing engineer including planning, scheduling, setting machines and quality control. Although working in a team, the evidence that you produce for assessment must always be your own work. Each assessment focus is a stage in the production of a quantity of the same, engineered product and it could be that your tutor splits the assignment into tasks that relate to each assessment focus.

The task used to cover the requirements of assessment focus 3 should have practical activities and will be the main assessment for this unit, and thus carries a higher weighting of marks. It will therefore give you an opportunity to develop and use your practical skills applied to tasks associated with the use of a CNC machine.

Your team will be asked to produce sufficient numbers of the product to enable you to fulfil each assessment focus and production may take place on a number of occasions. Most of the work you will be required to undertake should take place in a workshop or production facility and will involve both practical and written activities.

All of the evidence you generate during this assignment will need to be submitted in a 'process portfolio'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|--|-------------------------|
| LO.1 Be able to work effectively in a production team and reflect on their performance | Participate effectively in a production team and describes own role in the team, with an indication of own strengths and weaknesses. (0–3) | Participates effectively in a production team and explains how own role was part of the overall team and gives an indication of own strengths and weaknesses. (4–5) | Participate effectively in a production team and analyses own contribution to team, recognising strengths and weaknesses, and suggests how it could have been improved. (6–7) | 7 |
| LO.2.1 Know about production information | Describes essential production information found in product drawings and a specification for a given engineered product. (0–4) | Describes the essential production information found in product drawings and a specification for a given engineered product with interpretation. (5–7) | Describes the essential production information from product drawings and a specification for a given engineered product with correct interpretation. (8–10) | 10 |
| LO2.2 Production plans and schedules | Produces a production plan and schedule for the manufacture of a quantity of the same engineered product. (0–4) | Produces a detailed production plan and realistic schedule for the manufacture of a quantity of the same engineered product. (5–7) | Produces a detailed production plan and realistic schedule for the manufacture of a quantity of the same engineered product and justifies the sequence of operations and schedule. (8–10) | 10 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|--|---|-------------------------|
| <p>LO.4 Be able to apply appropriate quality control techniques and interpret quality data</p> | <p>Uses quality control techniques correctly, including statistical methods, to establish whether a sample of engineered products conforms to the standards specified.</p> <p>(0–4)</p> | <p>Records quality control and statistical data obtained by using appropriate techniques, including statistical methods, in an accurate and appropriate format and establishes the extent to which a sample of engineered products conforms to the standards specified.</p> <p>(5–7)</p> | <p>Records quality control and statistical data obtained by using appropriate techniques, including statistical methods, in an accurate and appropriate format and establishes the extent to which a sample of engineered products conforms to the standards specified. Analyses reasons for success/failure of production, with a suggestion for improvement where appropriate.</p> <p>(8–9)</p> | <p>9</p> |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|---|---|----------------------------|
| LO.3 Be able to set up and use tools and CNC equipment safely to process materials | With guidance sets up and uses CNC tools and equipment to manufacture a quantity of the same simple engineered product safely, maintaining a clean and tidy working environment. Comments on the success of this activity. (0–10) | With limited guidance prepares given material, sets up and uses CNC tools and equipment to manufacture a quantity of the same simple engineered product safely, maintaining a clean and tidy working environment. Reviews the success of this activity. (11–17) | Independently selects and prepares material, sets up and uses CNC tools and equipment to manufacture a quantity of the same simple engineered product safely, maintaining a clean and tidy working environment. Evaluates the success of this activity. (18–24) | |
| Total marks | | | | (7+10+10+9+24) = 60 |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the best fit approach. This section should be referred to only once the preliminary judgement has been made by the assessor and is used to guide the assessor as to placement within the mark band.

For assessment focus 3 the learner is asked to demonstrate whether they can work independently with CNC tools and equipment, or whether they need some guidance.

Examples of ‘*guidance*’ might include (but are not limited to):

- instructions given verbally telling learners what to do and how to do it
- when carrying out these tasks the learner **frequently** needs reminding what to do
- **repeated** demonstration of what to do
- if they were not guided through each relevant stage the learner would probably not be able to complete the task.

Examples of ‘*limited guidance*’ might include (but are not limited to):

- the tutor gives a variety of options that the learner decides upon, they discuss how to take the task forward, the learner will then confirm their approach before they commence the activity
- after initial support to start the processes and ensure the learner is safe to do so, the tutor is likely to react only to questions the learner asks
- the learner checks matters of detail to ensure they are progressing as needed, possibly on a regular basis, but would be checking for confirmation that they are progressing satisfactorily and doing things correctly rather than asking for assistance
- **occasionally** the tutor may have to assist and intervene to ensure actions are progressing satisfactorily and correctly.

Examples of ‘*independence*’ might include (but are not limited to):

- initially, the tutor will support the learner to ensure they are able and know what they need to do when carrying out the required tasks, although this may be more apparent during the formative assessment stages than with the summative assessment
- the learner feels comfortable to carry out the tasks without support, the tools, equipment and documentation they select and use will be those that are most suitable for the task and they will always show due regard to safety
- the tutor will monitor and recognise that the learner can carry out the tasks but may on **very few** occasions have to assist
- learners may **occasionally** seek confirmation that they are doing things right before they carry out stages of the tasks required.

Marking grid A

| Assessment focus LO.1 | |
|------------------------------|--|
| Mark Band 1 (0–3 marks) | The learner participates effectively in a production team and gives a clear description of their own role which shows how they fitted into the overall make-up of the team. For example, their contribution during developing a production plan, setting and using a CNC machine, and applying quality control techniques. The learner describes at least one strength and one weakness, with an example of how each was evident in the activity. A simple list of strengths and weaknesses is not sufficient. Up to 3 marks are available, but a well-described strength could offset a simply stated weakness. |
| Mark Band 2 (4–5 marks) | The learner participates effectively in a production team and explains the nature of their role and how it contributed to a balanced team. They describe at least one strength and one weakness with an example of how each was evident in the activity. A simple list of strengths and weaknesses is not sufficient. Marks for either aspect of the answer (role, strength/weakness) can go to 3, with a maximum of 5 overall. |
| Mark Band 3 (6–7 marks) | The learner participates effectively in a production team and explains the nature of their role and how they contributed to a balanced team for the purpose of the activity. The description of own weaknesses and strengths is developed to include at least one justified suggestion for how the learner could have contributed more effectively to the team’s performance. |

| Assessment focus LO.2.1 | |
|--------------------------------|--|
| Mark Band 1 (0–4 marks) | Given product drawings and a specification the learner describes at least four essential pieces of production information for a given engineered product, up to a maximum of 4 marks. |
| Mark Band 2 (5–7 marks) | For full marks the learner not only describes the essential production information contained in the drawings and specification, but also interprets at least one of those pieces of information. There is a maximum of 6 marks for detailed description alone. |
| Mark Band 3 (8–10 marks) | The feature of this band is the confident interpretation as well as the description. At the bottom end of the band there are likely to be 2 or 3 pieces of information interpreted, while at the top of the band all can be expected to have some interpretation at least. |

| Assessment focus LO.2.2 | |
|--------------------------------|--|
| Mark Band 1 (0–4 marks) | For full marks the learner produces a production plan that is basic but includes most of the essential information appropriate for the chosen product and a schedule with key milestones identified. Without a schedule the maximum mark is 3. The plan and schedule should be considered together – a plan missing some essential information, and a schedule with only some of the milestones might be worth 2 marks overall, but this is a holistic judgment and does not represent 1 for the plan and 1 for the schedule. |
| Mark Band 2 (5–7 marks) | For full marks the learner produces a detailed production plan that has all the expected information to enable the chosen product to be manufactured, and a schedule with key milestones which are judged to be achievable. Again, these must be looked at holistically. At the bottom end of the band there are likely to be a few items of detail missing and one or two milestones might be deemed to be unrealistic. |
| Mark Band 3 (8–10 marks) | The learner produces a detailed production plan that has all the expected information to enable the chosen product to be manufactured, and a schedule with key milestones which are judged to be achievable. The plan is justified (for example by explaining why the operations have to be carried out in a particular sequence) as is the schedule (for example by explaining how the dates for milestones were calculated). There must be some justification for the learner to be considered for this band, but at the bottom end of this range it might only be found weakly and against only the plan or the schedule. This would be valid for 8 marks if the plan and schedule themselves were strong, and so the learner’s best fit was against band 3 rather than band 2. Weak justification with a patchy plan is not acceptable for band 3. |

| Assessment focus LO.4 | |
|------------------------------|--|
| Mark Band 1 (0–4 marks) | <p>For full marks the learner applies at least three quality control techniques correctly, one of which must be a statistical method, to test the sample. A simple outcome is determined that states whether the sample does or does not meet the specified standard.</p> <p>The learner cannot achieve full marks without a statement indicating correctly that the sample does or does not meet the standard, but can get up to 3 marks for carrying out the tests. At the lower end of the band only some of the techniques may be correctly applied.</p> |
| Mark Band 2 (5–7 marks) | <p>For full marks the learner correctly and successfully applies appropriate techniques, with at least one statistical method included, to test the sample. Data is recorded clearly and accurately, and the learner states clearly the extent to which the sample has met (or not met) the standard, for example by indicating the percentage pass/fail, and/or expresses how much the items were within or outside tolerance.</p> <p>Learners at the lower end of the band are likely to have offered a simpler judgement of quality, or have an inconsistent quality of records, or perhaps have completed one of the techniques incorrectly.</p> |

| Assessment focus LO.4 (continued) | |
|--|--|
| Mark Band 3 (8–9 marks) | <p>The top of this band is characterised by fuller reporting on the quality of the sample, with the good band 2 outcome enhanced by some comment about the production process that might explain why the products were within or outside tolerance. The learner is not necessarily expected to know about the relevant production process, so generic but appropriate comments about maintenance of quality during manufacture are quite acceptable.</p> <p>Work achieving marks lower in the band must have at least some such comment. A simple comment added to a good band 2 response is worth 8, and two such comments or one well-developed one will quickly get full marks.</p> |

Marking grid B

| Assessment focus LO.3 | |
|------------------------------|---|
| Mark Band 1 (0–10 marks) | <p>For full marks, the learner successfully manufactures a quantity of the product using the machine and equipment in a correct and safe manner, maintaining a clean and tidy work environment having set up the tools and equipment under the guidance of the assessor/tutor. For this band the learner does not have to prepare the materials themselves, but they should demonstrate that they can handle them correctly. There should be some evaluative comments about the success that recognise some aspects of what went well and/or badly, as appropriate.</p> <p>Marks lower in the band will be appropriate for learners who achieve some of these requirements but who perhaps produce only a few items of inconsistent quality, allow their working environment to become dirty or untidy, or for those who rely on the tutor to set up all aspects of the CNC equipment. However credit should be given to learners who recognise the shortcomings in carrying out the activity and this will help to move them up in the band.</p> <p>Irrespective of the quality of the outcome, if a learner completes the task ‘with guidance’, as defined above, they must be marked within this band.</p> |
| Mark Band 2 (11–17 marks) | <p>For full marks the learner successfully manufactures a quantity of the product using the machine and equipment in a correct and safe manner, having set up the tools and equipment with limited support from the assessor/tutor. The learner prepares the materials to be used in the manufacturing process and handles them correctly. The working environment is maintained in a clean and tidy state and the learner takes a balanced look back at how they carried out the activity, probably at the top of the band offering some suggestions for improvement in the future.</p> <p>At the lower end of this band the learner might carry out the manufacturing process successfully, but with some flaws in the products due to incompletely prepared materials, and carry out the work in an environment which is allowed to become dirty and untidy. The review of the activity is important, and the learner with this profile who shows an understanding of why some things went wrong and how to improve on them will move up the band.</p> |

| Assessment focus LO.3 (continued) | |
|---|---|
| <p>Mark Band 3 (8–9 marks)</p> | <p>For full marks the learner successfully manufactures a quantity of the product using the machine and equipment in a correct and safe manner, having set up the tools and equipment independently. The learner selects the materials they plan to use, and prepares them and handles them correctly. The working environment is maintained in a clean and tidy state and there are some insightful comments into the reasons for success and shortcomings in the activity, with some suggestions for improvement.</p> <p>At the lower end of this band the learner might carry out the manufacturing process successfully, but with some flaws in the products due to incompletely prepared materials and/or selection of a material that was not best suited to the product. The work may be carried out in an environment which is allowed to become dirty and untidy. The review is particularly important because the learner achieving in this band has carried out the work independently, and while a successful outcome is needed for marks at the top of the band, if they recognise how they might do things differently to improve performance in the future this should be given real credit.</p> |

Approaches to assessment

This unit could be assessed through a holistic piece of work in line with the marking grid. Given the importance of working safely with tools and equipment in the workshop, and the expectation that higher achieving learners should be showing a degree of independence, a programme of formative assessment is important to ensure that they are adequately prepared for the summative assessment.

Each learner could receive the same assignment either before or after they have been allocated to a production team. It is essential that tutors make appropriate arrangements for the collection of evidence as learners work together in teams. The type of evidence expected must differentiate between the performance of each team member during production activities. For example, evidence for assessment focus 1, could be a learner observation record sheet or tutor observation record to demonstrate that the learner did contribute to the organisation of a production team and did fulfil their own role within the team. Other supplementary evidence, such as minutes of team meetings would also help consolidate this evidence. A learner statement simply saying 'I contributed well to the team' would be insufficient to contribute towards the marking grid requirements. Mark band 3 may be best evidenced through a written outcome analysing their own performance, although it too should be supported by other evidence.

Tutors must provide assessment opportunities for each learner to achieve the assessment foci. The assignment should require the production of sufficient quantities of the same engineered product to make this possible.

If production activities are organised properly, each learner should be able to apply quality control techniques at one or more stages in production sufficient to meet the requirements of assessment focus 4. As above, each learner must produce their own evidence.

When learners are required to work together as a team to plan, set up and manufacture a quantity of the same product the tutor will need to carefully plan the assessment so that the team is able to carry out the activities without hindrance and each learner's contribution is identified.

The starting point for learners must be the provision of appropriate product information with the assignment, ie component drawings and product specification. These drawings and specifications should have enough information to enable learners to extract enough evidence to meet mark band 2 for assessment focus 2.1. As such it should typically have at least seven pieces of information that relate to production. This information is in its broadest sense and as ranged in the 'what you need to cover' section.

Centres may choose to assign learners to a production team or allow them to form their own teams. It is assumed that for assessment focus 1 teams have been formed and the evidence they are required to generate for this will occur before, during and after the production of a quantity of the same product. The quantity of products and the number of occasions production activities occur must be sufficient to allow each team member to achieve the requirements of the assessment focus. For mark band 1 a written description of strengths and weaknesses would suffice with perhaps minutes of meetings or peer statements that show that an individual learner has contributed to the organisation of the team to manufacture a quantity of the same engineered product. Evidence to support mark band 2 might be presented as a learner observation record sheet, a photographic record or a peer group assessment. Mark band 3 requires a written analysis of the learners own performance in the production of a quantity of the same engineered product with suggestions as to how this could be improved.

From the product drawings and specification, each learner should provide their own description of the essential production information for mark bands 1 and 2 of assessment focus 2.1 and an interpretation of this for mark band 3. Similarly, for assessment focus 2.2, each learner should produce their own production plan and schedule for the quantity of the same product. Depending on how many production runs a team makes it may be possible for each learner's production plan and schedule to be used, otherwise the team may select just one.

The actual production of a quantity of the same engineered product is dealt with in assessment focus 3. The learner will be responsible for setting up and using tools and equipment, including at least one CNC machine, although this may be with guidance. assessment focus 3 includes differentiation according to the degree of independence with which a learner can complete a task. Ahead of the assessment, learners should have been taught and practised the necessary skills to use CNC tools and equipment across a range of materials so that all of the content requirements have been covered. When they are being assessed on this activity support should be given, either if asked for or if the learner is at risk of working unsafely or inappropriately. This support should be recorded and form part of the evidence for the allocation of marks.

Assessment focus 4 is not necessarily addressed at the end of the production cycle but in line with modern manufacturing methods will certainly take place at each stage of production so that the each learner can be responsible for their own quality control. For mark band 1 the assessor will need to see some evidence that the learner has used the quality control techniques prescribed in the production plan to check that an appropriate sample of products conform to the standards required. This may be done using a learner observation record sheet. For mark band 2 the learner must keep records of quality control data in an accurate and appropriate format, possibly a table or record of the quality control outcomes and statistical records. Other supplementary evidence could be in the format of records of statistics used and the outcomes from the comparison against the standards found in the component drawings and product specification for example. For mark band 3 the learner will analyse these records to identify problems and modify production activities accordingly. The learner may themselves keep a log of activities so that they have an accurate record of what took place on each production run.

The outcome of this unit is the production of a quantity of engineered products to the required standards and centres should think how they are going to demonstrate that this actually took place. Learners will need to gather all their evidence and submit this in a 'process portfolio'.

Guidance for teaching this unit

Delivery guidance

This unit is 60 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 20 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

Whilst the learning outcomes are ordered in a logical way, teamwork may be best developed through practising skills required by the other outcomes. It may therefore be best to deliver outcomes 6.2 to 6.4 and draw out aspects of teamwork throughout.

Learners will need to find out about planning and scheduling before they practice the use of tools and CNC equipment. A good way to improve these planning and scheduling skills will be to reflect on those used during the development of the practical skills required for learning outcome 6.3. They will also need to be instructed in and practice the use of testing and measuring equipment along with the use of statistical methods deployed in volume production. Obviously a reflection on what makes good teamwork will need to be understood and carried out at regular intervals. Once learners have had these experiences each learner should be judged for their readiness for the summative assessment of this unit.

Tutors will need to exercise judgement in respect of an appropriate engineered product. The best scenario would be a product brief, including drawings and a specification from an external source, perhaps a partner company. A complex product is not required but one that provides a sufficient challenge to the team and an opportunity for each learner to address each of the assessment foci. The level of accuracy expected within the product should match that achievable by the resources available at the centre. As required by the assessment foci the product should have opportunities for learners to seek out and comment on a range of information that will affect production requirements. It is likely to have either a range of process requirements for a single part product or more than one part to enable schedules to be developed. The key message for a centre is to keep the product as simple as possible but select one that has opportunities for learners to each take part in a team producing a quantity of the product and have opportunities to plan and schedule the production.

The specification clearly requires the use of a CNC machine at some point in the production process and centres will need to consider this when producing or negotiating a product brief.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|--|
| Independent enquirers | <p>Describing own strengths and weaknesses, fulfilling own role within a team, analysing team's performance and suggesting how it could be improved. Assessment focus 1.</p> <p>Describing essential production information found in product drawings and a specification for a given engineered product. Assessment focus 2.1.</p> <p>Using quality control techniques correctly, including statistical methods, to establish whether a sample of engineered products conforms to the standards specified. Assessment focus 4.</p> |
| Creative thinkers | <p>Contributing to the organisation of a production team to manufacture a quantity of the same engineered product. Assessment focus 1.</p> |
| Reflective learners | <p>Setting goals for the development of each of their assignments.</p> <p>Reviewing their progress against the completion of their assignments.</p> <p>Participating effectively in a production team and describing own role in the team, with an indication of own strengths and weaknesses. Assessment focus 1.</p> <p>Setting up and using CNC tools and equipment to manufacture a quantity of the same simple engineered product safely, maintaining a clean and tidy working environment. Commenting on the success of this activity. Assessment focus 3.</p> |
| Team workers | <p>Participating effectively in a production team and describing own role in the team, with an indication of own strengths and weaknesses. Assessment focus 1.</p> |
| Self-managers | <p>Planning and organising the creation of their assignments for this unit.</p> <p>Dealing with time pressures and deadlines for the production of their assignments.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> <p>Producing a production plan and schedule for the manufacture of a quantity of the same engineered product. Assessment focus 2.2.</p> <p>Setting up and using CNC tools and equipment to manufacture a quantity of the same simple engineered product safely, maintaining a clean and tidy working environment. Commenting on the success of this activity. Assessment focus 3.</p> <p>Using quality control techniques correctly, including statistical methods, to establish whether a sample of engineered products conforms to the standards specified. Assessment focus 4.</p> |
| Effective participators | <p>Not present in this unit.</p> |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---|
| ICT – Use ICT systems | |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | Following a production plan to set up and use tools and equipment utilising CNC to manufacture a quantity of the same engineered product safely, maintaining a clean and tidy working environment. Using quality control techniques, including statistical methods, correctly to establish whether a sample of engineered products conform to the standards specified. |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | Following a production plan to set up and use tools and equipment utilising CNC to manufacture a quantity of the same engineered product safely, maintaining a clean and tidy working environment. |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently for a complex task | Following a production plan to set up and use tools and equipment utilising CNC to manufacture a quantity of the same engineered product safely, maintaining a clean and tidy working environment. |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |

| Skill | When learners are ... |
|---|--|
| ICT – Develop, present and communicate information | |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | |
| Bring together information to suit content and purpose | Recording quality control and statistical data obtained by using quality control techniques, including statistical methods, in an accurate and appropriate format. |
| Present information in ways that are fit for purpose and audience | Recording quality control and statistical data obtained by using quality control techniques, including statistical methods, in an accurate and appropriate format. |
| Evaluate the selection and use of ICT tools and facilities used to present information | |
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | Using quality control techniques, including statistical methods, correctly to establish whether a sample of engineered products conform to the standards specified. Analysing quality control and statistical data to identify problems and modify production activities |
| Identify the situation or problem and the mathematical methods needed to tackle it | Using quality control techniques, including statistical methods, correctly to establish whether a sample of engineered products conform to the standards specified. Analysing quality control and statistical data to identify problems and modify production activities. |
| Select and apply a range of skills to find solutions | Using quality control techniques, including statistical methods, correctly to establish whether a sample of engineered products conform to the standards specified. |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |

| Skill | When learners are ... |
|---|--|
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | |
| Draw conclusions and provide mathematical justifications | Analysing quality control and statistical data to identify problems and modify production activities. |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Describing own strengths and weaknesses and contributing to the organisation of a production team to manufacture a quantity of the same engineered product. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | Describing all of the essential production information found in product drawings and a specification for a given engineered product. |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | Describing own strengths and weaknesses and contributing to the organisation of a production team to manufacture a quantity of the same engineered product. Producing a detailed production plan and realistic schedule for the manufacture of a quantity of the same engineered product. |

Work experience

Much of the knowledge, skills and understanding needed for this unit can be gained through work experience.

Focused work experience placements that give learners experience of production planning and scheduling, quality control techniques and data analysis in industry would be beneficial. The collection of examples of production plans and schedules and quality control data and statistical analysis, including charts from industry, should form the basis of teaching and learning for these learning outcomes. The use of quality control techniques in industry or on a work placement would be a good way for learners to understand the benefits of these techniques and requirements.

Specialist resources

Centres should have access to a range of drawings and specifications for suitable products that can be manufactured in quantity. Exemplar production plans and schedules will be required when explaining how these are developed and used. Centres should have access to a range of CNC equipment and a range of materials suitable for processing when making a quantity of products. They should also have access to a range of supporting safety equipment.

Reference material

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Shingo S – *Mistake Proofing for Operators, The ZQC System Shingo* (Productivity Press, 1997)
ISBN 1563271273

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Unit 7: Applications of Maintenance Techniques in Engineering

Principal Learning unit

Level 2

Guided Learning Hours: 30

Internally assessed

About this unit

Most engineered products, equipment and systems require regular adjustment and servicing during their lifetime to ensure that they continue to work properly. Maintenance engineers are responsible for ensuring such systems are properly maintained and we all depend on them at some time or other. For example if we lost our cash card in an ATM when trying to withdraw money or if the central heating system broke down in mid-winter because it had not been maintained we would not be very happy. Similarly in industry, manufacturers must have plant and equipment that works. This plant and equipment relies on products and systems. Breakdowns are non-productive and cost money and persistent breakdowns could also result in lost contracts and jobs.

In this unit you will be able to get involved with both maintenance procedures and carrying out of maintenance activities. This is a practical unit that will involve hands-on activities, putting knowledge and understanding into practice. The unit lends itself to support from local workplace providers so you may well receive an insight into maintenance activities within a real engineering environment.

You will find out about different types of maintenance, carry out routine tasks and discover the effects of improper maintenance. You will also carry out a risk assessment that is required for a maintenance activity.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Understand different types of maintenance for engineered products, plant or equipment including the use of statistical trends
 - LO.2. Be able to carry out routine maintenance tasks and devise a maintenance procedure
 - LO.3. Understand the effects of poor maintenance and the range of spares and replacement parts
 - LO.4. Be able to carry out a risk assessment in a maintenance environment.
-

What you need to cover

| | |
|---|--|
| LO.1 Understand different types of maintenance for engineered products, plant or equipment including the use of statistical trends | <p>Learners will need to investigate the following types of maintenance for engineered products, plant or equipment: planned, routine (servicing), preventative, front-line, unplanned (equipment failure), breakdown repair (run to failure).</p> <p>Learners will also appreciate the need and the use of statistical methods (mean-time-to-failure and mean-time-to-repair) for analysing trends.</p> |
| LO.2 Be able to carry out routine maintenance tasks and devise a maintenance procedure | <p>Learners will need to carry out routine maintenance tasks including service and adjustments following manufacturers' guidance for engineering assets, eg plant, equipment, engineered products, services, machinery.</p> <p>Learners will also devise a maintenance procedure for engineering assets, eg sequence to follow, timescales, tooling/resources required, documentation to use; adopting appropriate safety practices and applying relevant diagnostic routines.</p> |
| LO.3 Understand the effects of poor maintenance and the range of spares and replacement parts | <p>Learners will need to find out about the implications for the user and manufacturer if products, plant or equipment are not properly maintained. They will investigate and appreciate the consequences of not maintaining optimum stock levels of spares and replacement parts.</p> <p>Learners will also examine the role statistical data plays when considering stock levels for spares and replacement parts.</p> |
| LO.4 Be able to carry out a risk assessment in a maintenance environment | <p>Learners will carry out a risk assessment for an engineering maintenance task taking into account correct use and storage of Personal Protective Equipment (PPE), health and safety regulations, warning signs.</p> |

How you will be assessed

This unit will focus on the work of a maintenance engineer and as such you will be assessed through an assignment giving opportunities, through a theme of maintenance, to demonstrate that you know about maintenance and the use of statistical trends. You will be expected to show that you can carry out maintenance tasks, including a risk assessment and devising a maintenance procedure, similar to those that a maintenance engineer working in industry is likely to come across. The maintenance engineer will also understand what can go wrong and understand the need to identify spares and replacement parts for the work they carry out.

This unit will be assessed by your tutor who will set tasks for you to complete. You are likely to be given one or more tasks which will cover the material you have studied. At least some of these tasks will be set in the workshop and may relate to your work experience. Your tutor will give you opportunities to develop evidence. These opportunities could typically consist of three tasks.

Task 1 could cover the requirements of assessment foci 1.1 and 1.2 with written activities. You would, therefore, be asked to give a written response to these activities and the evidence should be presented in a 'report' and a 'process portfolio' respectively.

A second task could link the assessment foci 2.1 and 3.1 together as a combined practical and written task and again as such the evidence should be presented in a 'process portfolio' and a 'report' respectively.

The third and final task could bring together assessment foci 2.2, 3.2 and 4 and would be mainly of a practical nature with two written activities at the end for you to do. All the evidence for this task should be presented in a 'process portfolio'.

Marking grid A

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|---|--|---|-------------------------|
| LO1.1 Know about types of maintenance | Describes two given different types of maintenance appropriate to engineered products, plant or equipment. (0–4) | Explains the use of two given types of maintenance for engineered products, plant or equipment. (5–7) | Explains the use of two given types of maintenance for engineered products, plant or equipment and justifies the use of one of these. (8–10) | 10 |
| LO1.2 Know about statistical trends | Uses a statistical method to analyse and evaluate a trend, judging its relevance and value in a product, plant or equipment performance. (0–4) | Calculates mean-time-to-failure from given data based on equipment failure rate and weighting factors and draw a conclusion. (5–7) | Describes how statistical data including mean-time-to-failure data can act as an aid to determining equipment reliability. (8–9) | 9 |
| LO2.2 Be able to devise a maintenance procedure | Uses the experience of following a maintenance procedure to devise a different maintenance procedure for a given engineered product, plant or equipment. (0–4) | Uses the experience of following a maintenance procedure to devise a different detailed maintenance procedure for a given engineered product, plant or equipment. (5–6) | Uses the experience of following a maintenance procedure to devise a different detailed maintenance procedure that is easy to follow and use for a given engineered product, plant or equipment. (7–8) | 8 |

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|--|--|---|--|-------------------------|
| LO.3.1 Understand the implications of improperly maintained products, plant or equipment | Describes two implications if products, plant or equipment are not properly maintained. (0–4) | Describes two implications and explains a way of reducing the impact of improper maintenance. (5–6) | Describes two implications of improper maintenance. Explains and justifies a way of reducing the impact of improper maintenance. (7–8) | 8 |
| LO.3.2 Range of spares, replacement parts and stock levels | Identifies spares or replacement parts for a given maintenance task. (0–3) | Identifies spares or replacement parts for a given maintenance task and describes the consequences of not maintaining the appropriate stock levels for those spares and replacement parts. (4–5) | Identifies spares or replacement parts for a given maintenance task, describes the consequences of not maintaining the appropriate stock levels and uses statistical data to justify appropriate stock levels for those spares and replacement parts. (6–7) | 7 |
| LO.4 Be able to carry out a risk assessment in a maintenance environment | Carries out a risk assessment for a given engineering maintenance task using given documentation. (0–4) | Carries out a detailed risk assessment for a given engineering maintenance task using appropriate documentation taking into account correct use and storage of PPE. (5–6) | Carries out a detailed risk assessment for a given engineering maintenance task using appropriate documentation taking into account correct use and storage of PPE, health and safety regulations, warning signs. (7–8) | 8 |

Marking grid B

| Assessment focus | Mark Band 1 | Mark Band 2 | Mark Band 3 | Maximum marks available |
|---|---|---|--|----------------------------------|
| LO2.1 Be able to carry out routine maintenance tasks | Follows a given maintenance procedure to correctly carry out two routine adjustments to an engineered product, plant or equipment. (0–4) | Follows a given maintenance procedure to correctly carry out two routine adjustments and routine servicing including replacement or replenishment of consumable items. (5–7) | Interprets a given maintenance procedure to correctly diagnose and carry out two routine adjustments and routine servicing to an engineered product, plant or equipment, including the replacement or replenishment of consumable items. (8–10) | 10 (10+9+8+8+7+8+10) = 60 |
| Total marks | | | | |

Assessment guidance

Using the marking grid

- Each internally assessed unit has 60 available marks in total.
- In some units the marking grid has been split into two grids – A and B. Marking grid A contains all of the marking criteria for the unit except those which assess a learner's performance in practical activities which are recorded as a witness testimony or observation record. These make up grid B.
- Centres must ensure that learners undertake appropriate assessment tasks to enable them to achieve the requirements of each unit's marking grid(s).
- The basic principle is that this is a 'best fit' grid – ie the assessor must match the overall standard of work for an assessment focus to a band. It is NOT a hurdle approach, whereby the assessor cannot award marks from the next mark band if one item for an assessment focus from a lower mark band has been omitted, regardless of the quality of the rest of the work for that assessment focus.
- If a learner completes all they are asked to do in a band for an assessment focus, they can be awarded the full marks for that mark band.
- If a learner has clearly done more on one aspect of work for an assessment focus required by a mark band, the assessor should consider whether the learner can be awarded marks from the bottom of the next mark band.
- If a learner has completed less than required in any aspect of work for an assessment focus, or indeed omitted an aspect, then the mark moves down within the mark band.
- Marking is completely separate for each assessment focus – ie a learner can get mark band 3 on one assessment focus, mark band 1 on another etc, then all marks are added together for the unit total. It may be possible, depending on weighting of an assessment focus for a learner to pass a unit even if 0 has been given in marks for one assessment focus in the unit.
- A 0 mark should be used only where a learner provides no valid evidence. Any work that starts to address the requirements of the grid should normally be awarded at least one mark.
- Evidence generated for marking grid A will be moderated. This must be in the form of hard evidence which a moderator can reassess, such as learner produced written documents (eg short question answers, multiple choice question answers, materials from presentations, research notes), videos (dated) of practical activities or artefacts.
- Marks gained from marking grid A will be reported separately from those gained from marking grid B.

Guidance for allocating marks

This section provides further guidance for the assessor on how to confirm marks within the objective approach. The guidance can be used to allocate specific marks for that band.

Marking grid A

| Assessment focus LO.1.1 | |
|--------------------------------|---|
| Mark Band 1–3 (0–10 marks) | <p>Each description of a different type of maintenance can be awarded up to 2 marks. A statement or list of types should only attract 1 mark each. The second mark for each is based on the appropriateness of the description.</p> <p>The explanation attracting up to 3 marks should be based on the appropriateness of where maintenance types would be used.</p> <p>The justification attracting up to 3 marks should indicate why the type of maintenance is appropriate. This could be in the form of advantages and limitations.</p> |

| Assessment focus LO.1.2 | |
|--------------------------------|---|
| Mark Band 1–3 (0–9 marks) | <p>To achieve up to 4 marks the learner needs to (i) use a statistical method; and (ii) analyse and evaluate a trend by judging its relevance and value. There are typically up to 2 marks for each of the two aspects of the response but could go to 3 if one aspect is answered well and above that required for mark band 1 but up to a maximum of 4 marks.</p> <p>It is important that both calculations and conclusions are covered for the 3 marks available at mark band 2. The learner (i) calculates mean-time-to-failure; and (ii) draws a conclusion. 2 marks can be awarded for the calculation, based on its accuracy, and should include the use of failure rate information and weighting factors, and 1 mark for the conclusion based on its appropriateness.</p> <p>A simple statement that lacks description should be awarded 1 mark with another mark available for its appropriateness to show how statistical data including mean-time-to-failure data can act as an aid to determining equipment reliability.</p> |

| Assessment focus LO.2.2 | |
|--------------------------------|---|
| Mark Band 1–3 (0–8 marks) | <p>A maintenance procedure is likely to have the following aspects present; sequence to follow, timescales, tooling/resources required, documentation to use, safety practices, relevant diagnostic routines. A maintenance procedure at this level would have at least four of these present which a third party would be able to use but not necessarily be logical or easy to follow, so would be more than just a list. There is typically up to 1 mark for each of the four aspects in the procedure, drawn from the learner previous experience, up to a maximum of 4 marks, if one aspect from the four is missing or only appeared as a list the balance could be 2:1:1:0 (in any order) if one other aspect is more strongly addressed and above that required for this mark band.</p> <p>A detailed maintenance procedure would have all six of the aspects present which a third party would be able to use but not necessarily be logical or easy to follow, so would be more than just a list. There is typically a further 1 mark for each of the additional two aspects in the procedure.</p> <p>For full marks the learner needs to complete a detailed maintenance procedure which would have all six of the aspects present and it would need to be logically laid out and easy to follow. Up to 2 marks can be awarded for how well the procedure is logically laid out and can be followed.</p> |

| Assessment focus LO.3.1 | |
|--------------------------------|---|
| Mark Band 1–3 (0–8 marks) | <p>Typically up to 2 marks can be awarded for each implication described based on how well it relates to the product, plant or equipment not being properly maintained. This could go to 3 if one is carried out well and above that required for mark band 1, up to a maximum of 4 marks. A statement or list of implications should only attract 1 mark each. The second mark for each is based on the appropriateness of the description.</p> <p>Up to 2 marks can be awarded for the explanation based on its appropriateness to demonstrate how the impact would be reduced.</p> <p>Up to 2 marks can be awarded for the justification based on its appropriateness to reduce the impact; this could be in the form of advantages and limitations.</p> |

| Assessment focus LO.3.2 | |
|--------------------------------|--|
| Mark Band 1–3 (0–7 marks) | <p>One mark can be awarded for each spare or replacement part identified up to a maximum of 3 marks.</p> <p>A simple statement about the consequences that lacks detail should be awarded 1 mark and a further mark can be awarded for the description based on its appropriateness to demonstrate the consequences.</p> <p>One mark can be awarded for using the data and 1 mark for justifying the appropriate level of stock.</p> |

| Assessment focus LO.4 | |
|------------------------------|---|
| Mark Band 1–3 (0–8 marks) | <p>For full marks a risk assessment would be basic but should include (i) the hazards present; (ii) who might get harmed; (iii) the risks; and (iv) the precautions to take. There is typically up to 1 mark for each of the four aspects in the risk assessment, up to a maximum of 4 marks.</p> <p>For full marks a detailed risk assessment should include (i) the hazards present; (ii) who might get harmed; (iii) the risks; (iv) the precautions to take; and (v) PPE to use. There is 1 mark for the fifth aspect in the risk assessment above those for mark band 1. One mark can also be awarded for considering the correct storage of PPE.</p> <p>Further to the requirements of the detailed risk assessment and the correct storage of PPE, 1 mark can be awarded for considering health and safety regulations and 1 mark for the inclusion of the use of warning signs.</p> |

Marking grid B

| Assessment focus LO.2.1 | |
|--------------------------------|--|
| Mark Band 1–3 (0–10 marks) | <p>Typically, up to 2 marks can be awarded for each adjustment carried out based on how well the procedure for each was followed, but could go to 3 marks if one is carried out well and above that required by the procedure and expected at mark band 1, up to a maximum of 4 marks.</p> <p>Up to 3 marks can be awarded for the routine servicing which must include the replacement or replenishment of consumable items for mark band 2. If the replacement or replenishment of consumable items is not included this would restrict the marks to 2.</p> <p>Up to 3 marks can be awarded for correctly carrying out and the diagnosis the level of diagnostics applied.</p> |

Approaches to assessment

In order to reflect the applied nature of the qualification a greater proportion of marks in this unit has been allocated to assessment foci 1.2, 2.1 and 2.2. These provide opportunities for the learner to apply their knowledge and understanding to practical, problem solving activities. To a lesser degree this is true for assessment focus 4 about risk assessment.

Opportunities for learners to provide evidence for this unit could typically consist of three tasks, although these do not have to be taken separately. This unit should be assessed by short tasks taken under supervised conditions, in suitable teaching sessions.

Task 1 will require evidence in the form of a ‘report’ for assessment focus 1.1 and a ‘process portfolio’ for the requirements of 1.2. The task should have written activities asking for descriptions of two different types of maintenance, explanations of where different types of maintenance would be used, and justification of the use of a given type of maintenance. It may be appropriate to administer this task over two or three hours.

Centres have freedom of choice with regards to the appropriateness of products, plant and equipment for considering types of maintenance. Their appropriateness would come from the experience that learners have had during the delivery of this unit (see delivery guidance later). The data given, for assessment focus 1.2, to analyse trends and to calculate mean-time-to-failure should not be over complex nor need high level mathematical skills. Learners who are working at GCSE grade C/D should be able to cope with the data given. The evidence for this assessment focus is likely to be in written format or as a word processed document. If learners are unable to respond in this manner a video or audio tape recording would be acceptable for the requirements of 1.1, as long as the Assessor has made a judgement about the evidence and the evidence is accessible and individually ‘owned’ by each learner. If it was necessary for a learner to retake this task, different types of maintenance should be given for assessment focus 1.1. There is also an opportunity to ask the learner to analyse a different trend or a different product, plant or equipment performance for assessment focus 1.2.

Task 2 will require evidence in the form of a ‘process portfolio’ for assessment focus 2.1 and a ‘report’ for the requirements of 3.1 and should be a combined practical and written task and as such may have to be controlled over more than one teaching session. It may be appropriate to administer this task over three or four hours. They will need to be given a maintenance procedure to follow, with opportunities specified by the manufacturer for routine adjustments (at least two adjustments are required), servicing and replacement requirements, and opportunities for diagnosis. Again, the centre has freedom in the choice of plant, equipment, product, or machinery. A typical scenario may be to apply this need to a simple lathe within the engineering workshop. If the manufacturer’s requirements are not known, a simulated set of instructions would suffice. Clearly the requirement for assessment focus 2.1 is practical work and as such may need a learner observation record sheet supplemented by annotated photographs and diagrams as well as annotation on the given maintenance procedure. A set of written activities needs to be given for assessment focus 3.1, to enable learners to describe the implications of improper maintenance and to explain and then justify a way of reducing its impact. This could all be set in the context of the practical work carried out for assessment focus 2.1. The same is true here, for learners who are unable to respond in a conventional way by writing, as already described for assessment focus 1.1. If it was necessary for a learner to retake this task, a different maintenance procedure should be given for assessment focus 2.1. There is also an opportunity to ask the learner to describe different implications about improper maintenance for assessment focus 3.1.

Task 3 should bring together assessment foci 2.2, 3.2 and 4. The evidence for this task should be in the form of a 'process portfolio'. It would be mainly a practical exercise with two written activities at the end. It may be appropriate to administer this task over three or four hours. Firstly, learners could be asked to carry out a risk assessment for a given maintenance task to meet the requirements of assessment focus 4. They could then be set a further activity addressing assessment focus 2.2 whereby they develop a maintenance procedure for that same maintenance task. It is important that the maintenance task will involve opportunities to adopt safety procedures and diagnostic routines. It should be remembered that these diagnostic requirements should not be too complex. The measurement of an out-of-parallel movement on a lathe bed to indicate that adjustment is needed would be sufficient and a suitable example. Also for this assessment focus, learners need only to devise the procedure and not carry it out. The evidence for both assessment foci 2.2, and 4, is likely to be a completed maintenance procedure and a risk assessment, respectively. For assessment focus 3.2, the learner could be asked to identify spares and replacements for the same given maintenance task. Here again the important factor is that these opportunities exist within the maintenance task given and that at least three spare or replacement parts are needed. A learner observation record sheet together with annotated photographs/diagrams and possibly a list of the spares and replacement parts, would be suitable evidence for the mark band 1 of this assessment focus. The two written activities would require the learner to describe what happens when a sufficient stock level of spares and parts is not maintained and show how statistical data is used to justify a particular stock level. For all of the activities set for assessment focus 3.2, it may be better to have a different scenario to that used as the maintenance activity for the assessment foci 2.2 and 4. This will allow a suitable scenario for a large enough spares and parts requirement for the application of statistical methods. Here again, care should be taken to not make the statistical calculations too complex. It may be best to use an electrical or electronics scenario such as lamp replacement. If it was necessary for a learner to retake this task, a different engineered product, plant or requirement for assessment focus 2.2, a different maintenance task for assessment focus 3.2 and a different engineering maintenance task and documentation for assessment focus 4 is required.

The approach outlined so far would allow these tasks to be carried out on a work experience placement provided the right organisation could be found. In this case the centre staff will need to brief the company staff and engineers very carefully about the unit requirements. If the work being carried out relates to an employers business and operations, the employer is likely to want a different form of evidence. This may be in the form of a 'paper' or a 'briefing note' or a formally structured 'report'. In supporting an employer the diverse range of forms of evidence should be taken into consideration. In these cases learner observation record sheets, annotated photographs and video recordings of what the learner did will be vital. In task 1, the data required for trend analysis and mean-time-to-failure calculations could be real.

Guidance for teaching this unit

Delivery guidance

This unit is 30 guided learning hours (GLH) in length. Centres should allocate this amount of time within the timetable for its delivery and assessment. Edexcel has identified that within this time learners will probably require 10 GLH in activities which generate evidence for assessment. This may, for example, include time spent in experiential learning, practising skills, research activities and undertaking summative assessment activities. (See sections relating to *Internal assessment* and *Programme design and delivery* in the generic introductory part of the *Guidance and units* document.)

Although the learning outcomes are in a logical order for assessment purposes, the last outcome is about the practical application of risk assessment procedures. This part of the content will need to be taught in such a way that it compliments the rest of the content delivery. As such, the way to carry out a risk assessment should be taught as soon as sufficient experience of maintenance terminology has been gained. Apart from this consideration the learning outcomes could be taught in the order they appear in the content. As this unit is about the application of maintenance techniques and unit 4 at level 1 of the Engineering Diploma is about the development of routine maintenance skills it may be possible for a centre to deliver these units concurrently but would need to ensure that the evidence produced against the different levels of the diploma is relevant and appropriate to that level and unit specification and requirement.

It is important that learners are introduced to a range of different types of maintenance. This should cover products, plant, instruments and equipment needs. Visits to or placements in engineering industry or other organisations that have a maintenance department or function would be helpful in giving learners first-hand experience of maintenance activities. Alternatively, a visit to the centre by a maintenance engineer to talk about the different types of maintenance and their application would also be beneficial. Learners will also need to be taught about why and how statistical methods are used for analysing trends. The fine details of statistics work are not required at this level as long as the learner understands the basic principles involved, and what a range of data can look like and how trends from the data can be identified.

Learners will need to be shown the correct way to carry out routine maintenance tasks which should include diagnosis, service and adjustments. They will need to be able to do this following manufacturers' guidance on any plant, equipment, engineered product, service or machinery. They will also need to be given opportunities to devise a maintenance procedure including the application of safe working practices and diagnostic routines.

Whilst being taught how to carry out routine maintenance and how to develop a procedure they should be given the knowledge about the effects of poor maintenance on both user and manufacturer for either a product or piece of equipment. The maintaining of stock levels for parts and spares is also an important issue that learners need to know about.

As already stated opportunities should be taken throughout the delivery of this unit to embrace the health and safety requires of the last learning outcome. It is important that learners are made aware of the correct use and storage of Personal Protective Equipment (PPE), relevant health and safety regulations and the use of warning signs. It is important to cover those safety issues that are likely to be required for any maintenance activity that will be carried out during the delivery and assessment of this unit. Care should however be taken to confine delivery to those required for their likely activities so as not to overburden learners with health and safety regulations.

The industrial visits or visiting engineer mentioned above would be appropriate for developing the learner's knowledge of the effects of poor maintenance and health and safety requirements. Whilst some of the learning outcomes require knowledge of maintenance, the approach of utilising industry and their current practices will give a very practical nature to the delivery.

The use of the internet to research the health and safety requirements and risk assessment is something that learners might find rewarding. In a classroom situation, motivational practices such as setting up a competition on who can identify the most health and safety regulations and warning signs that a maintenance engineer is likely to come into contact, might also enliven delivery.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

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

| Skill | When learners are ... |
|--------------------------------|---|
| Independent enquirers | <p>Identifying coursework questions and problems to resolve.</p> <p>Using a statistical method to analyse a trend in product, plant or equipment performance. Assessment focus 1.2.</p> <p>Carrying out a risk assessment for a given engineering maintenance task using given documentation. Assessment focus 4.</p> |
| Creative thinkers | <p>Using the experience of following a maintenance procedure to devise a maintenance procedure for a given engineered product, plant or equipment. Assessment focus 2.2.</p> <p>Carrying out a risk assessment for a given engineering maintenance task. Assessment focus 4.</p> |
| Reflective learners | <p>Setting goals for the development of each of their assignments.</p> <p>Reviewing their progress against the completion of their assignments.</p> <p>Using a statistical method to analyse a trend in product, plant or equipment performance.</p> <p>Using the experience of following a maintenance procedure to devise a maintenance procedure for a given engineered product, plant or equipment. Assessment focus 2.2.</p> |
| Team workers | Not present in this unit. |
| Self-managers | <p>Planning and organising the creation of their assignments for this unit.</p> <p>Dealing with time pressures and deadlines for the production of their assignments.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> <p>Following a given maintenance procedure to correctly carry out routine adjustments to an engineered product, plant or equipment. Assessment focus 2.1.</p> |
| Effective participators | Carrying out a risk assessment for a given engineering maintenance task using given documentation. Assessment focus 4. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---|
| ICT – Use ICT systems | Not present in this unit. |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| ICT – Find and select information | |
| Select and use a variety of sources of information independently for a complex task | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | Using a statistical method to analyse a trend in product, plant or equipment performance. |
| ICT – Develop, present and communicate information | |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | |
| Bring together information to suit content and purpose | Using a statistical method to analyse a trend in product, plant or equipment performance. |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |

| Skill | When learners are ... |
|--|---|
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | Calculating mean-time-to-failure from given data based on equipment failure rate and weighting factors and draw a conclusion. |
| Identify the situation or problem and the mathematical methods needed to tackle it | Using a statistical method to analyse a trend in product, plant or equipment performance. |
| Select and apply a range of skills to find solutions | Using a statistical method to analyse a trend in product, plant or equipment performance. |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | Calculating mean-time-to-failure from given data based on equipment failure rate and weighting factors and draw a conclusion. |
| Draw conclusions and provide mathematical justifications | Calculating mean-time-to-failure from given data based on equipment failure rate and weighting factors and draw a conclusion. |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Describing two different types of maintenance appropriate to engineered products, plant or equipment. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | Describing two different types of maintenance appropriate to engineered products, plant or equipment. Describing two implications if products, plant or equipment are not properly maintained. |

Work experience

This unit could be delivered in the workplace. Learning about maintenance techniques in a real engineering company would enhance opportunities for learners to maximise their potential. Engineering companies will be able to provide maintenance procedures that learners could follow and will have maintenance requirements that will involve identifying spares and carrying out a risk assessment. Some may have a range of data suitable for statistical manipulation.

Specialist resources

Centres will need to identify a range of locally available engineered products, services and systems on which learners will base their maintenance investigations. Most centres will already have suitably equipped workshops and laboratories. In addition, specialised reference material, such as maintenance manuals, exploded views, component lists, adjustment charts, service sheets and other data, should be made available to learners. A well-stocked library complete with internet research facilities should also be provided. Appropriate health and safety materials, including a range of signs and warning notices, should be prominently displayed in workshops and practical resource areas.

When delivering this unit, centres should also consider the use of resources that can be accessed within local industry. These could be used for the generating case study materials and will help bring to life the more theoretical parts of this unit.

Industrial contacts will usually be able to suggest maintenance tasks that learners can observe, including those that involve testing, inspection and the replacement of worn components and consumable materials.

Reference material

Hughes P and Ferrett E – *Introduction to Health and Safety at Work* (Elsevier, 2007) ISBN 0750685034

Mobley K – *Maintenance Fundamentals* (Butterworth-Heinemann, 2004) ISBN 0750671513

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Unit 8: Exploring Engineering Innovation, Enterprise and Technological Advancements

Principal Learning unit

Level 2

Guided Learning Hours: 60

Externally assessed

(58.5 hours learning time and 1.5 hours for assessment)

About this unit

The ability to come up with creative and innovative ideas for new products can lead to global success, but only if the entrepreneurs and inventors behind them know how to turn their ideas into reality.

In this unit, you will discover how to take a good idea and transform it into a feasible product. You will discover how to legally protect an idea and will gain an understanding of the process of research and development. You will learn how to identify appropriate materials, the impact of a product on everyday life, and the environmental considerations of a new product or engineering process.

Learning outcomes

On completion of this unit, a learner should:

- LO.1. Know about the intellectual property within engineering
 - LO.2. Understand the role of research, development and raising finance when designing engineering products
 - LO.3. Know about developments in materials and processes on products
 - LO.4. Know about the effects of engineering technologies in the home, workplace or built environment
 - LO.5. Know about the environmental and social impact of engineering and sustainability of resources.
-

What you need to cover

| | |
|--|--|
| LO.1 Know about the intellectual property within engineering | Learners will need to demonstrate a knowledge of the advantage of creative and innovative thinking within engineering and should be able to apply knowledge of the four main types of intellectual property: patents, designs, trade marks and copyright. |
| LO.2 Understand the role of research, development and raising finance when designing engineering products | <p>Learners will need to examine the role of research and development for engineering products and will be able to identify the appropriate research required for a specific project.</p> <p>Learners will need to understand the necessity of financial support for an engineering product and be able to identify how to meet the financial requirements of a project.</p> |
| LO.3 Know about developments in materials and processes on products | Learners will need to find out about developments in materials technology and should become familiar with the following materials: metals (ferrous and non ferrous), polymers (thermosetting plastic, thermoplastics, rubbers), ceramics and composite materials. |
| LO.4 Know about the effects of engineering technologies in the home, workplace or built environment | Learners will need to be able to investigate the effects of engineering technologies in the home, workplace and built environment and will be able to estimate the impact of a new technology. |
| LO.5 Know about the environmental and social impact of engineering and sustainability of resources | Learners will need to be able to find out about the environmental and social impact of engineering and will be able to apply these factors to an engineering product. They will also need to show an understanding of the following terms: waste disposal, energy efficiency, recycling, reusable, bio-degradable and sustainable. |

Learning outcomes and assessment criteria

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about the intellectual property within engineering | Describe the four main types of intellectual property, and explain the benefits of registering intellectual property. |
| LO.2 | Understand the role of research, development and raising finance when designing engineering products | Describe and explain the role, sources and significance of appropriate research and development when designing a product or process. Describe and review the financing for an engineering project. |
| LO.3 | Know about developments in materials and processes on products | Describe and review the effects of developments in materials and processes and on a product. |
| LO.4 | Know about the effects of engineering technologies in the home, workplace or built environment | Identify and review the effects of engineering technology in the home, workplace or built environment and advances in such technology. |
| LO.5 | Know about the environmental and social impact of engineering and sustainability of resources | Identify and review the environmental and social impact of engineering, and the sustainability of resources. |

How you will be assessed

The assessment for this unit will consist of a short-answer external examination of 90 minutes that will meet all learning outcomes of this unit. The assessment will be externally assessed and will be based on a case study of an engineering product or service. The case study will be issued to learners prior to the examination to enable sufficient research to be undertaken. Detailed guidance will be given with the case study.

Guidance for teaching this unit

Delivery guidance

The learning outcomes for this unit could be delivered in order. The unit is closely linked with *Unit 1: Exploring the Engineering World* and *Unit 2: Investigating Engineering Design* and learners would benefit from an understanding of engineering achievements (Unit 1), the construction and function of engineering products (Unit 2) and appropriate steps in a design solution (Unit 2).

Centres should try to identify and use innovative and creative ideas that will help inspire learners. For example, Trevor Bayliss was inspired to develop his clockwork radio to improve communication of information on the spread of AIDs in the developing world after hearing a news broadcast.

It is essential that learners develop a clear understanding of the four main types of intellectual property. Group work, open discussions, case studies and role play will enable learners to discover appropriate use of registering Intellectual property. Use of the THINK kit® resources developed by the UK Patent Office may be useful.

Learners should be introduced to the role of research and development, and should be encouraged to investigate the research and development stages of existing engineering products. Industrial visits or placements in the engineering industry will enable learners to experience first-hand the stages required in the design and production of engineering products.

In the example of the clockwork radio, financial backing was achieved only after publicity was gained from appearing on the television programme ‘Tomorrow’s World’. To identify ways of raising the finance required for a project, centres could focus on services offered from the financial sector to assist small business. This would include services from local banks, grants or private funding and learners would benefit from guest speakers where appropriate.

Learners will need to identify how developments in engineering materials affect process and products. They should be familiar with metals (ferrous and non ferrous), polymers (thermosetting plastic, thermoplastics, rubbers), ceramics and composite materials. Learners should be introduced to a range of engineering materials and should be given information on properties, characteristics, costs, forms of supply and availability. Access to materials databases and the internet would be an advantage.

Learners should be encouraged to investigate how developments in materials technology and processes impacts the manufacture of products. For example, developments in manufacturing and process methods of titanium for the Mercury and Apollo space programmes has led to titanium alloys being used extensively in military, space and aeronautical applications across the world. Due to titanium’s light weight, high strength to weight ratio, reliability and resistance to corrosion, the developments in this material have now been utilised in the manufacture of a range of products such as bicycle frames, skis and golf clubs.

Learners should be encouraged to identify the impact of technology in the home, workplace and built environment and how new developments have influenced these environments. For example, the impact that James Dyson has had on redesigning household appliances such as the vacuum cleaner.

Learners will need to understand the environmental and social impact of engineering and should review environmental and social factors on an engineering process or product. Learners will need to identify how to reduce waste and energy consumption for both the manufacture and operation of an engineering process or product. In addition, learners will need to demonstrate an understanding of environmental factors when selecting materials for a given application and should identify environmental characteristics of materials including recyclable potential, reusability, bio-degradability and sustainability. Learners would benefit from practical activities and investigations to determine properties of materials.

Guidance for the delivery of personal, learning and thinking skills (PLTS)

Although PLTS are not identified within this unit as an inherent part of the assessment criteria, there are opportunities to develop a range of PLTS through various approaches to teaching and learning. (*Annexe B* of this document lists the personal, learning and thinking skills and their elements.)

| Skill | When learners are ... |
|--------------------------------|---|
| Independent enquirers | <p>Researching and developing ideas.</p> <p>Describing the need to raise finances for an engineering project. Assessment focus 2.</p> <p>Identifying the environmental and social impact of engineering and sustainability of resources. Assessment focus 5.</p> |
| Creative thinkers | <p>Innovative design solutions.</p> <p>Identifying the effect of engineering technology in the home, workplace or built environment. Assessment focus 4.</p> |
| Reflective learners | <p>Setting goals for the development of their research.</p> <p>Reviewing their progress.</p> |
| Team workers | Not present in this unit. |
| Self-managers | <p>Planning and organising appropriate research for their case study. (External assessment)</p> <p>Dealing with time pressures and deadlines for the production of their research.</p> <p>Seeking advice and support from their peers and tutors when needed.</p> |
| Effective participators | Not present in this unit. |

Functional skills – Level 2

| Skill | When learners are ... |
|---|---------------------------|
| ICT – Use ICT systems | Not present in this unit. |
| Select, interact with and use ICT systems independently for a complex task to meet a variety of needs | |
| Use ICT to effectively plan work and evaluate the effectiveness of the ICT system they have used | |
| Manage information storage to enable efficient retrieval | |
| Follow and understand the need for safety and security practices | |
| Troubleshoot | |
| ICT – Find and select information | Not present in this unit. |
| Select and use a variety of sources of information independently for a complex task | |
| Access, search for, select and use ICT-based information and evaluate its fitness for purpose | |
| ICT – Develop, present and communicate information | Not present in this unit. |
| Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records. | |
| Bring together information to suit content and purpose | |
| Present information in ways that are fit for purpose and audience | |
| Evaluate the selection and use of ICT tools and facilities used to present information | |

| Skill | When learners are ... |
|--|--|
| Select and use ICT to communicate and exchange information safely, responsibly and effectively including storage of messages and contact lists | |
| Mathematics | Not present in this unit. |
| Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations | |
| Identify the situation or problem and the mathematical methods needed to tackle it | |
| Select and apply a range of skills to find solutions | |
| Use appropriate checking procedures and evaluate their effectiveness at each stage | |
| Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations | |
| Draw conclusions and provide mathematical justifications | |
| English | |
| Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts | Speaking when taking part in formal and informal discussions/exchanges, when they are appraising the effects of materials and engineering technology. |
| Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions | Conducting research into materials and the effects of engineering technologies. |
| Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively | They also have opportunities in writing when they are writing documents to communicate information, ideas and opinions when they are describing different materials and aspects of engineering technologies. |

Work experience

Learners will be able to apply knowledge and experience obtained from relevant work experience to many aspects of this unit and should be encouraged to recall their experiences when applicable.

Reference material

Cushing S – *GCSE Engineering* (Hodder and Arnold, 2004) ISBN 0340814086

Tooley M, O'Dwyer N, Deacon M and Tooley R – *Level 2 Diploma in Engineering – Student Book* (Heinemann, 2008) ISBN 9780435756208

Tooley M, O'Dwyer N and Tooley R – *Level 2 Diploma in Engineering Assessment and Delivery Resource* (Heinemann, 2008) ISBN 9780435756215

Tooley M – *Engineering GCSE* (Newnes, 2002) ISBN 0750656441

The UK Patent Office – www.patent.gov.uk

List of annexes

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Annexe A: Qualification codes

The National Qualifications Framework (NQF) code is known as a Qualification Accreditation Number (QAN). This is the code that features in the DfES Funding Schedules – Sections 96 and 97 and is to be used for all qualification funding purposes. Each unit within a qualification will also have an NQF unit code.

The qualification and unit codes will appear on the learner's final certification documentation.

The QANs for the qualifications in this publication are:

500/2364/0 Edexcel Level 1 Principal Learning in Engineering

500/2363/9 Edexcel Level 2 Principal Learning in Engineering

These Principal Learning qualifications contribute to the following Diploma qualifications at the same level:

500/2810/8 Edexcel Level 1 Foundation Diploma in Engineering

500/2819/4 Edexcel Level 2 Higher Diploma in Engineering

These qualification titles will appear on learners' certificates.

Learners need to be made aware of this when they are recruited by the centre and registered with Edexcel. Providing this happens, centres are able to describe the programme of study leading to the award of the qualification in different ways to suit the medium and the target audience.

Other codes

The codes below will be required when making entries for individual units and the overall Principal Learning qualification:

| | | |
|---------------|---|---|
| Unit codes | Each unit is assigned a unit code. This unit code is used as an entry code to indicate that a learner wishes to take the assessment for that unit. Centres will need to use the entry codes only when entering learners for their examination or coursework moderation. | Please refer to the Edexcel <i>Information Manual</i> , available on the Edexcel website. |
| Cash-in codes | The cash-in code is used as an entry code to aggregate the learner's unit scores to obtain the overall grade for the qualification. Centres will need to use the cash-in codes only when entering learners for their qualification award. | Please refer to the Edexcel <i>Information Manual</i> , available on the Edexcel website. |

Annexe B: Personal, learning and thinking skills

QCA – a framework of PLTS

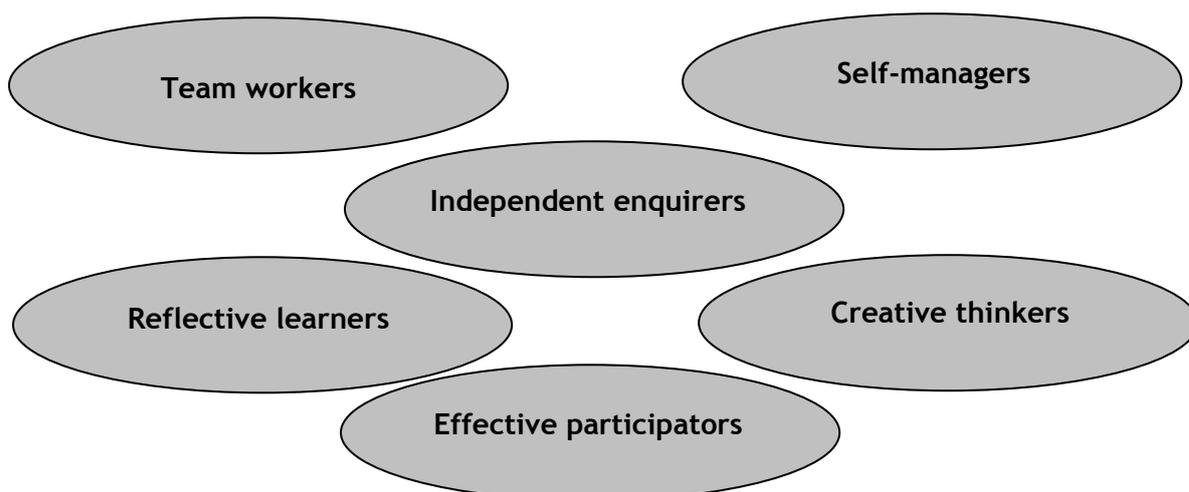


Qualifications and
Curriculum Authority

A FRAMEWORK OF PERSONAL, LEARNING AND THINKING SKILLS 11-19 IN ENGLAND

The framework comprises six groups of skills that, together with the functional skills of English, mathematics and ICT, are essential to success in learning, life and work. In essence the framework captures the essential skills of: managing self; managing relationships with others; and managing own learning, performance and work. It is these skills that will enable young people to enter work and adult life confident and capable.

The titles of the six groups of skills are set out below.



For each group there is a focus statement that sums up the range of skills. This is followed by a set of outcome statements that are indicative of the skills, behaviours and personal qualities associated with each group.

Each group is distinctive and coherent. The groups are also inter-connected. Young people are likely to encounter skills from several groups in any one learning experience. For example an Independent enquirer would set goals for their research with clear success criteria (Reflective learner) and organise and manage their time and resources effectively to achieve these (Self-manager). In order to acquire and develop fundamental concepts such as organising oneself, managing change, taking responsibility and perseverance, learners will need to apply skills from all six groups in a wide range of learning contexts 11–19.

The Skills

Independent enquirers

Focus:

Young people process and evaluate information in their investigations, planning what to do and how to go about it. They take informed and well-reasoned decisions, recognising that others have different beliefs and attitudes.

Young people:

- identify questions to answer and problems to resolve
- plan and carry out research, appreciating the consequences of decisions
- explore issues, events or problems from different perspectives
- analyse and evaluate information, judging its relevance and value
- consider the influence of circumstances, beliefs and feelings on decisions and events
- support conclusions, using reasoned arguments and evidence

Creative thinkers

Focus:

Young people think creatively by generating and exploring ideas, making original connections. They try different ways to tackle a problem, working with others to find imaginative solutions and outcomes that are of value.

Young people:

- generate ideas and explore possibilities
- ask questions to extend their thinking
- connect their own and others' ideas and experiences in inventive ways
- question their own and others' assumptions
- try out alternatives or new solutions and follow ideas through
- adapt ideas as circumstances change

Reflective learners

Focus:

Young people evaluate their strengths and limitations, setting themselves realistic goals with criteria for success. They monitor their own performance and progress, inviting feedback from others and making changes to further their learning.

Young people:

- assess themselves and others, identifying opportunities and achievements
- set goals with success criteria for their development and work
- review progress, acting on the outcomes
- invite feedback and deal positively with praise, setbacks and criticism
- evaluate experiences and learning to inform future progress
- communicate their learning in relevant ways for different audiences

Team workers

Focus:

Young people work confidently with others, adapting to different contexts and taking responsibility for their own part. They listen to and take account of different views. They form collaborative relationships, resolving issues to reach agreed outcomes.

Young people:

- collaborate with others to work towards common goals
- reach agreements, managing discussions to achieve results
- adapt behaviour to suit different roles and situations
- show fairness and consideration to others
- take responsibility, showing confidence in themselves and their contribution
- provide constructive support and feedback to others

Self-managers

Focus:

Young people organise themselves, showing personal responsibility, initiative, creativity and enterprise with a commitment to learning and self-improvement. They actively embrace change, responding positively to new priorities, coping with challenges and looking for opportunities.

Young people:

- seek out challenges or new responsibilities and show flexibility when priorities change
- work towards goals, showing initiative, commitment and perseverance
- organise time and resources, prioritising actions
- anticipate, take and manage risks
- deal with competing pressures, including personal and work-related demands
- respond positively to change, seeking advice and support when needed

Effective participators

Focus:

Young people actively engage with issues that affect them and those around them. They play a full part in the life of their school, college, workplace or wider community by taking responsible action to bring improvements for others as well as themselves.

Young people:

- discuss issues of concern, seeking resolution where needed
- present a persuasive case for action
- propose practical ways forward, breaking these down into manageable steps
- identify improvements that would benefit others as well as themselves
- try to influence others, negotiating and balancing diverse views to reach workable solutions
- act as an advocate for views and beliefs that may differ from their own

(See www.qca.org.uk/qca_16953.aspx)

PLTS Performance Indicator (suggested recording sheet)

| Name: | Date: | | | | |
|--|---------------------------------------|---|---|---|---|
| | Level of success 1 = low, 5 = high | | | | |
| Independent enquirers | | | | | |
| Identify questions to answer and problems to resolve | 1 | 2 | 3 | 4 | 5 |
| Plan and carry out research, appreciating the consequences of decisions | 1 | 2 | 3 | 4 | 5 |
| Explore issues, events or problems from different perspectives | 1 | 2 | 3 | 4 | 5 |
| Analyse and evaluate information, judging its relevance and value | 1 | 2 | 3 | 4 | 5 |
| Consider the influence of circumstances, beliefs and feelings on decisions and events | 1 | 2 | 3 | 4 | 5 |
| Support conclusions, using reasoned arguments and evidence | 1 | 2 | 3 | 4 | 5 |
| Creative thinkers | | | | | |
| Generate ideas and explore possibilities | 1 | 2 | 3 | 4 | 5 |
| Ask questions to extend their thinking | 1 | 2 | 3 | 4 | 5 |
| Connect their own and others' ideas and experiences in inventive ways | 1 | 2 | 3 | 4 | 5 |
| Question their own and others' assumptions | 1 | 2 | 3 | 4 | 5 |
| Try out alternatives or new solutions and follow ideas through | 1 | 2 | 3 | 4 | 5 |
| Adapt ideas as circumstances change | 1 | 2 | 3 | 4 | 5 |
| Reflective learners | | | | | |
| Assess themselves and others, identifying opportunities and achievements | 1 | 2 | 3 | 4 | 5 |
| Set goals with success criteria for their development and work | 1 | 2 | 3 | 4 | 5 |
| Review progress, acting on the outcomes | 1 | 2 | 3 | 4 | 5 |
| Invite feedback and deal positively with praise, setbacks and criticism | 1 | 2 | 3 | 4 | 5 |
| Evaluate experiences and learning to inform future progress | 1 | 2 | 3 | 4 | 5 |
| Communicate their learning in relevant ways for different audiences | 1 | 2 | 3 | 4 | 5 |
| Team workers | | | | | |
| Collaborate with others to work towards common goals | 1 | 2 | 3 | 4 | 5 |
| Reach agreements, managing discussions to achieve results | 1 | 2 | 3 | 4 | 5 |
| Adapt behaviour to suit different roles and situations | 1 | 2 | 3 | 4 | 5 |
| Show fairness and consideration to others | 1 | 2 | 3 | 4 | 5 |
| Take responsibility, showing confidence in themselves and their contribution | 1 | 2 | 3 | 4 | 5 |
| Provide constructive support and feedback to others | 1 | 2 | 3 | 4 | 5 |
| Self-managers | | | | | |
| Seek out challenges or new responsibilities and show flexibility when priorities change | 1 | 2 | 3 | 4 | 5 |
| Work towards goals, showing initiative, commitment and perseverance | 1 | 2 | 3 | 4 | 5 |
| Organise time and resources, prioritising actions | 1 | 2 | 3 | 4 | 5 |
| Anticipate, take and manage risks | 1 | 2 | 3 | 4 | 5 |
| Deal with competing pressures, including personal and work-related demands | 1 | 2 | 3 | 4 | 5 |
| Respond positively to change, seeking advice and support when needed | 1 | 2 | 3 | 4 | 5 |
| Effective participators | | | | | |
| Discuss issues of concern, seeking resolution where needed | 1 | 2 | 3 | 4 | 5 |
| Present a persuasive case for action | 1 | 2 | 3 | 4 | 5 |
| Propose practical ways forward, breaking these down into manageable steps | 1 | 2 | 3 | 4 | 5 |
| Identify improvements that would benefit others as well as themselves | 1 | 2 | 3 | 4 | 5 |
| Try to influence others, negotiating and balancing diverse views to reach workable solutions | 1 | 2 | 3 | 4 | 5 |
| Act as an advocate for views and beliefs that may differ from their own | 1 | 2 | 3 | 4 | 5 |

Note to learner: The circled number represents an indication of your PLTS performance so far.

Note to tutor: Indicate the level of success by circling the appropriate number during your feedback with the learner.

Summary of the PLTS coverage throughout the programme

Level 1

| Personal, learning and thinking skill | Unit | | | | | | |
|--|------|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Independent enquirers | X | ✓ | ✓ | X | ✓ | X | ✓ |
| Creative thinkers | | | X | X | | X | ✓ |
| Reflective learners | X | ✓ | ✓ | ✓ | X | X | X |
| Team workers | X | | | X | | ✓ | |
| Self-managers | X | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| Effective participators | X | | | ✓ | X | X | |
| ✓ – required component X – opportunities for development | | | | | | | |

Level 2

| Personal, learning and thinking skill | Unit | | | | | | | |
|--|------|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Independent enquirers | X | X | ✓ | ✓ | X | ✓ | ✓ | X |
| Creative thinkers | X | ✓ | X | X | ✓ | X | X | X |
| Reflective learners | X | X | X | ✓ | | ✓ | ✓ | X |
| Team workers | | | | | | ✓ | | |
| Self-managers | X | X | ✓ | ✓ | ✓ | ✓ | X | X |
| Effective participators | | ✓ | | ✓ | | | X | |
| ✓ – required component X – opportunities for development | | | | | | | | |

Annexe C: Wider curriculum mapping

Study of the Edexcel Diplomas in Engineering provides opportunities for the learner to develop an understanding of spiritual, moral, ethical, social and cultural issues as well as an awareness of citizenship, environmental issues, European developments, health and safety considerations and equal opportunities issues.

The Edexcel Diplomas in Engineering make a positive contribution to wider curricular areas as appropriate.

Spiritual, moral, ethical, social and cultural issues

The specification contributes to an understanding of moral, ethical, social and cultural issues, especially when learners are dealing with colleagues and customers.

Citizenship issues

Learners undertaking the Principal Learning in Engineering will have the opportunity to develop their understanding of citizenship issues throughout the Edexcel Diplomas in Engineering.

Environmental issues

Learners are led to appreciate the importance of environmental issues throughout the engineering sector. Many of the units allow learners to consider the influence that engineering processes have on the environment and the ways that this impact can be reduced.

European developments

Much of the content of the Edexcel Diplomas in Engineering applies throughout Europe even though the delivery is in a UK context.

Health and safety considerations

The Edexcel Diplomas in Engineering are practically based and so health and safety issues are encountered throughout the units. Learners will develop awareness of the safety of others as well as themselves in all practical activities.

Equal opportunities issues

Equal opportunities issues are implicit throughout the Edexcel Diplomas in Engineering.

Wider curriculum mapping

Level 1

| | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|
| Spiritual | | | | | | | |
| Moral and ethical | ✓ | ✓ | | | | | |
| Social and cultural | ✓ | ✓ | | | | | ✓ |
| Citizenship issues | ✓ | ✓ | | | ✓ | | ✓ |
| Environmental issues | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| European developments | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Health and safety considerations | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Equal opportunities issues | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Level 2

| | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Spiritual | | | | | | | | |
| Moral and ethical | ✓ | ✓ | | | | | | ✓ |
| Social and cultural | ✓ | ✓ | | ✓ | | | | ✓ |
| Citizenship issues | ✓ | ✓ | | ✓ | | | | ✓ |
| Environmental issues | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| European developments | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| Health and safety considerations | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Equal opportunities issues | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Annexe D: Glossary of terms

There are some terms that you may come across in the specification, which have a particular meaning within the context of the Diploma. **You are therefore advised to familiarise yourself with the definitions of the terms in this glossary.**

| Term | Definition |
|-----------------------|---|
| Additional learning | Units or qualifications that learners choose to include in their Diploma. Additional learning is complementary in character. It consists of further learning and can include national curriculum entitlement areas and/or learning options such as languages, music or science that relate to individual needs, interests and aspirations, provided these do not duplicate learning in Principal Learning and Generic Learning. |
| Applied learning | Acquiring and applying, knowledge, skills and understanding through <i>tasks</i> set in sector <i>contexts</i> that have many of the characteristics of real work or are set within the workplace. Most importantly, the <i>purpose</i> of the task in which learners apply their knowledge, skills and understanding must be relevant to real work in the sector. |
| Assessment criteria | Specify the standard a learner is expected to meet to demonstrate that a learning outcome, or set of learning outcomes, has been achieved. Assessment criteria should be sufficiently detailed to support a consistent judgement that a learning outcome has been achieved – there are no minimum or maximum number of assessment criteria that relate to each learning outcome. The criteria should not dictate the method of assessment to be used. |
| Diploma | A defined set of qualifications that have been combined according to a set of rules. The Diplomas are designed to support progression to further study, training and employment. |
| Experiential learning | A process that stresses the central role of experience in learning related to the world of work. Learners reflect on their experience, draw out and articulate lessons learnt (generalise), and then apply their learning to new situations or activities. |
| External assessment | Assessment tasks are set and candidates' work is assessed by Edexcel. |
| Formative assessment | This is concerned with the short-term collection and use of evidence as guidance of learning, mainly in day-to-day classroom practice. |
| Functional skills | Functional skills are core elements of English, mathematics and ICT, providing the essential knowledge, skills and understanding needed to operate confidently, effectively and independently in life and at work. |

| Term | Definition |
|---|--|
| Generic Learning | <p>Generic Learning enables learners to develop and apply the skills and knowledge necessary for learning, employment and personal development.</p> <p>The Generic Learning component of the Diploma is made up of the following constituent parts:</p> <ul style="list-style-type: none"> • functional skills • personal, learning and thinking skills • a project • work experience. |
| Generic skills | <p>Generic skills are relevant to learning, training and working in all lines of learning and all sectors. They include functional skills and personal, learning and thinking skills.</p> |
| Internal assessment | <p>Tasks are set and marked against criteria provided by Edexcel and subjected to external moderation. Internal assessment is normally supervised and conducted under controlled conditions.</p> |
| Level | <p>The level at which a qualification or unit is positioned for accreditation. Levels are defined in terms of complexity, autonomy and range of achievement.</p> |
| Line of learning | <p>The broad subject areas that each Diploma will cover. There are 17 lines of learning, including: Creative and Media; Information Technology; Society, Health and Development; Engineering; Construction and the Built Environment.</p> |
| Personal, learning and thinking skills (PLTS) | <p>The framework of skills, which will equip all young people for successful employment and lifelong learning. PLTS require learners to be:</p> <ul style="list-style-type: none"> • independent enquirers • creative thinkers • reflective learners • team workers • self-managers • effective participators. |
| Principal Learning | <p>Learning modules and units of assessment that the learner must include in their Diploma. Principal Learning includes a minimum of 50 per cent of applied learning and consists of knowledge, understanding, skills and attitudes that support progress through the line of learning into the sectors concerned. Opportunities to develop and apply generic skills are also integrated into Principal Learning.</p> |
| Project | <p>A freestanding qualification within the Diploma.</p> |

| Term | Definition |
|----------------------|---|
| Specialist learning | Units or qualifications that learners choose to include in their Diploma. Specialist learning allows the learner to take up further, more specialist learning, within their line of learning. It consists of qualifications and units that will support progression across the range of progression pathways within a chosen sector, as identified and recommended by the employers and higher education advisers on the Diploma Development Partnership. |
| Summative assessment | This serves to inform an overall judgement of achievement. |
| Transcript | A report of the units and qualifications that make up a learner's programme and achievement. It lists the learner's units and grades for each of the components of their Diploma qualification and also records work experience and personal, learning and thinking skills. |
| Work experience | A component of the Diploma, which enables learners to utilise and develop their knowledge and skills in the actual workplace. |

Annexe E: Internal Assessment of Principal Learning Units: Controls for Task Setting, Task Taking and Task Marking – for Principal Learning in Construction and the Built Environment, Creative and Media, Engineering, Information Technology and Society, Health and Development

This annexe should be read in association with the latest edition of the Joint Council for Qualifications document ‘GCSE, GCE, ELC, Functional Skills, Principal Learning in the Diploma and Project Qualifications – Instructions for conducting coursework’, available from the JCQ website, www.jcq.org.uk

Section 1: Introduction

It is a requirement of the *Criteria for accreditation of Diploma qualifications at Levels 1, 2 and 3* that:

‘Internal assessment [of Principal Learning] must normally be supervised and conducted under controlled conditions to ensure reliability and fairness.’

Further guidance from the Qualifications and Curriculum Development Agency has identified three stages of assessment for which control must be specified:

- **Task setting**
- **Task taking** (controls on time, resources, supervision, and collaboration)
- **Task marking.**

Further to the areas specified above, this annexe in collaboration with the individual specifications also sets the parameters for:

- guidance and support;
- submission, revision, re-working;
- the involvement of parents/carers;
- malpractice; and the authentication of learners’ work.

This annexe details the controls that normally apply to all Edexcel Principal Learning internally assessed units. However tutors and assessors must also apply any specific controls or additional requirements that may be identified within the *Assessment information for assessors* section in individual units.

There are three levels of control that can apply to each stage.

| | |
|------------------------|---|
| High control | Where the assessment requirements are tightly prescribed. |
| Medium control | Where the assessment requirements are specified in terms of parameters that allow consortia some flexibility to suit local circumstances. |
| Limited control | Where the assessment requirements are specified in terms of broad parameters that allow consortia to determine the details of the assessment. |

It is the responsibility of the consortium to ensure that internal controlled assessment for Principal Learning is conducted and marked in accordance with the requirements specified by Edexcel and conducted in line with the *JCQ Instructions for conducting coursework*.

Section 2: Edexcel Controlled Assessment Profile

In Edexcel's internally-assessed Principal Learning units, some aspects are subject to medium control and others have limited control. The table below shows the standard profile for all Edexcel Principal Learning internally-assessed unit specifications. Individual unit specifications will indicate where a divergence has occurred from this profile.

| Aspect | Level 1 | Level 2 | Level 3 |
|---------------|---------|---------|---------|
| Task setting | Limited | Limited | Limited |
| Time | Limited | Limited | Limited |
| Resources | Limited | Limited | Limited |
| Supervision | Medium | Medium | Medium |
| Collaboration | Limited | Limited | Limited |
| Marking | Medium | Medium | Medium |

Section 3: Assessment controls

3.1 Task setting

Limited control

Edexcel will publish, as part of its tutor support materials, at least one model assignment for each internally assessed unit. It is recommended that these model assignments are used in the assessment of each unit. However in order that these assignments can best meet learner interests and local needs they will include guidance for tutors and assessors to show the ways in which they may be adapted and contextualised. If the tutor decides to either adapt or write their own assignments then each assignment must meet the following conditions:

- each internally assessed unit must be assessed through a single coherent assignment which addresses the overall theme of the unit to emphasise how the different learning outcomes all relate to each other. Each assignment may be broken down into a series of related tasks
- assignments must have an applied work-related context
- across all tasks, assignments must address all learning outcomes and assessment criteria, and must give access to the full range of marks
- the evidence produced must conform to the requirements published in the *How you will be Assessed* section of the relevant unit specification
- in some units the marking grid is divided into parts A and B. All tasks which will be marked against the A grid must generate learner evidence that can be re-assessed at a later stage during internal standardisation activity or external moderation

- where tutors decide to set their own assignments, another person, who understands the requirements of the specification, **must** check that each new assignment is appropriate for the line of learning and the level, and also that a new assignment will allow candidates full access to the marking criteria. This is especially important when a new tutor/assessor is required to produce assignments. Suitable people may include a Domain or Lead Assessor. This review process must be documented and the evidence of the review must be made available for the external moderator if requested
- if the assignment is to be produced outside the teaching institution, for example by a supervisor at the learner's work experience placement, then the tutor or assessor at the teaching institution responsible for that unit, must sign off the assignment for validity before the learner attempts the assignment.

In addition to these requirements, further guidance on writing assignments is provided in this specification, in the section 'Assessment and grading of the principal learning specifications'.

Complexity

If the level of complexity of the evidence required is not already identified within the specification, then an indication can be assumed from the amount of time set within the specification for the production of the assessment evidence, considering the level at which the specification is being taken. The expectations of what a Level 1 learner can accomplish in 10 hours are far different from that which can be expected from a Level 3 learner in the same time period.

Unless it is otherwise specified, learners should be set a task of equivalent complexity, whether they are expected to achieve marks at mark band 1 of the marking grid or mark band 3.

3.2 Task taking (controls on time, resources, supervision, and collaboration)

If not specified within the unit, it is to be assumed that tasks or the whole assignment will normally be attempted at the end of the learning process.

Time – Limited control

Each unit has a time for assessment allocated. While it is not a requirement that this time should be observed to the minute for internal assessments, it should be taken as strong guidance and variance should not normally be by more than plus or minus 10%. Learners given significantly less time may well be disadvantaged in relation to the quality and breadth of work they can produce, while those given significantly more may well be disadvantaged by an excess of time spent on assessment rather than learning.

Resources – Limited control

Unless otherwise stated in the individual unit specification, learners are entitled to have full access to all resources seen fit for purpose by the centre tutor/assessor. Any specific resources (eg equipment, published material) required or prohibited for assessment will be detailed in the individual unit.

Supervision – Medium control

Learners must normally be supervised by the centre tutor/assessor whilst producing evidence for the summative assessment activity, unless otherwise stated in the individual unit specification. Supervision is defined as normal classroom/workshop/studio working conditions, with the tutor/assessor being present in the same room whilst the summative assessment evidence is produced by the learner, but not requiring examination conditions.

Where supervision is relaxed:

- because it is not possible to directly supervise the activity that is required to produce summative assessment evidence, eg researching data, then the tutor/assessor must authenticate the learner work following the process identified in the section headed ‘Authentication’; or
- because the most suitable environment for producing the evidence means the tutor/assessor cannot be present, eg work experience, the tutor/assessor must ensure an appropriate person supervises the evidence production. All such evidence must be authenticated (see *Authentication* below) and, where this covers performance evidence, a signed learner observation record must be completed with enough reliable information to allow the tutor to accurately assess the evidence (see *3.4 Task marking* below).

It is not permissible for summative assessment evidence to be produced in the learner’s home environment, without the direct supervision of their assessor.

Due to the nature of producing an artefact, its production as part of the summative assessment will often be dictated by the availability of materials, equipment etc, therefore it may well be produced outside of the centre. However, the assessor must be confident that the work is that of the learner. In order to be confident, Edexcel requires one of the following situations to apply:

- the work is carried out under the direct supervision of the teaching centre assessor. This is the most desirable option
- the learner demonstrates to the teaching centre assessor equivalent levels of skill in each of the processes included in the production of the final artefact. Ideally this would be in the course of the regular teaching/learning programme, but exceptionally, if the assessor feels a skill has been assessed at a level beyond expectations, the assessor may require the learner to repeat that skill before authenticating the work.

If the artefact can only be produced remotely, for example during work experience, the assessor must have enough reliable information to allow them to both accurately assess the outcome and have a signed learner observation record from an appropriate person who directly observed the learner producing the artefact. An ‘appropriate person’ is defined as someone with a supervisory role within the workplace (or equivalent), and who has the required skills. This person must not be a family member, and must record and supply the required information for the assessor.

Collaboration (Group work) – Limited control

Some units may require learners to work as part of a group. In other units, unless it is specifically forbidden, tutors may choose to have learners working collaboratively. When producing assignments which require or allow learners to work in groups, tasks must be written to allow each group member to fully meet the requirements of the assessment criteria.

Learners must not have their assessment opportunities reduced by the poor performance of other group members. Where this becomes apparent the tutor or assessor should intervene, or provide suitable alternative activities which do not greatly add to the learners’ workloads.

Group tasks should not rely on the performance of individual members of the group to allow other group members to meet all of the assessment criteria.

It is important that each learner is assessed on their individual contribution to the achievements of the group. Where several individuals contribute to a single piece of work, individual contributions must be clearly shown on the work to enable external moderation to take place. This can be indicated by learners or through the tutor’s annotations.

Guidance and support

At the start of the assignment learners will often be required to plan out their programme of work. The tutor/assessors should agree these plans and where appropriate agree milestones where they can monitor learners' responses. Appropriate intervention is to be encouraged to ensure learners have every opportunity of success. However, if the planning process forms part of the assessment criteria, care must be taken to ensure that the plan remains the learner's own work.

Within some unit specifications, the level of assistance given to a learner is a discriminating factor used to decide a learner's positioning within the marking bands. To aid the assessor in selecting the appropriate level of assistance given to the learner a glossary of descriptors is included in the units and should be used for guidance when marking the learners work. In some cases, where a glossary doesn't exist, the following definitions should be used:

- *Assistance* – The learner has to be guided and advised to make progress, and responds to ideas suggested. The tutor/assessor needs to direct significant aspects of the work.
- *Limited assistance* – The learner suggests ideas for themselves, but makes use of guidance and advice from the tutor/assessor to make progress. The tutor/assessor assists in some aspects of the work, but generally does not direct it.
- *Independently* – The learner develops ideas themselves, using the tutor/assessor as an advisor rather than as a director. The tutor/assessor facilitates the work but does not need to direct its progress.

It is expected that all learners should develop as independent learners, but this does not mean that they should not be given any support in order to be able to research, write up and complete their reports. The hallmark of the independent learner, whatever the level, is knowing when and whom to ask for support in helping to carry the work forward.

All learners must be fully and equally briefed at the start of any task or assignment about the requirements of that task, including how they will be marked. They should be given the opportunity to ask any questions in order to clarify the requirements.

Once the assignment is under way, the tutor should respond to questions and requests for advice, but should normally refrain from intervening unasked. Responses can advise the learner on such matters as further sources of information, and can point out where further work is needed, but must always stop short of actually stating what to write.

In some units the amount of support and guidance a learner may receive in the course of carrying out the task or assignment is specified. This occurs, for example, when differentiation between mark bands is achieved in part by the support the learner needs to complete a practical task safely.

Tutors or assessors must always intervene where matters of health and safety are concerned. When this happens, the assessor should make a judgement about the appropriate marks that can be applied to the learner's work in the light of the intervention, and attach to the work a record of the intervention and justification for the marks awarded.

3.3 Feedback, re-working and submission

All Principal Learning awarding bodies are required to follow the instructions for feedback, re-working and submission specified by the JCQ

Candidates are free to **revise and redraft** a piece of coursework without teacher involvement before submitting the final piece. Candidates should be advised to spend an appropriate amount of time on the work commensurate with the marks available.

Teachers may review coursework before it is handed in for final assessment. Provided that advice remains at the general level, enabling the candidate to take the initiative in making amendments, there is no need to record this advice as assistance or to deduct marks. Generally one review should be sufficient to enable candidates to understand the demands of the assessment criteria. Advice may be given in either oral or written form.

Having reviewed the candidate's coursework **it is not acceptable** for teachers to give, either to individual candidates or to groups, detailed advice and suggestions as to how the work may be improved in order to meet the assessment criteria. Examples of unacceptable assistance include:

- detailed indication of errors or omissions
- advice on specific improvements needed to meet the criteria
- the provision of outlines, paragraph or section headings, or writing frames specific to the coursework task(s)
- personal intervention to improve the presentation or content of the coursework.

As indicated above, a clear distinction must be drawn between any interim review of coursework and final assessment for the intended examination series. Once work is submitted for final assessment it may not be revised: in no circumstances are 'fair copies' of marked work allowed. **Adding or removing any material to or from coursework after it has been presented by a candidate for final assessment will constitute malpractice.**

Where coursework is submitted in digital format there may be instances where the construction of the e-coursework does not attract any marks, in which case this construction may be done by the teacher instead of the candidate.

If a candidate requires additional assistance in order to demonstrate aspects of the assessment, the teacher should award a mark which represents the candidate's unaided achievement. The authentication statement should be signed and information given on the Candidate Record Sheet.

Teachers must keep live coursework secure and confidential at all times whilst in their possession. It is not acceptable for teaching staff to share coursework with other candidates.

There may be occasions when a learner needs to retake a task or assignment. This is acceptable at the discretion of the tutor, but the assignment should normally be set in a different context so that the learner is not repeating exactly the same tasks which they have had the chance to practise beforehand. Individual units will have further guidance where appropriate.

Authentication

All candidates must confirm that any work they submit for assessment is their own.

Where learners are required to gather information and resources, tutors or assessors should take the opportunity to discuss authentication and plagiarism at the outset.

Where learner observation records and practical activity logs are required Edexcel will provide exemplar pro formas. Centres may choose to develop their own documentation, but they must record at least the information contained within the exemplar pro formas.

Once the assignment has been completed the assessor may need to interview or test the learner on their understanding of the information and/or the resources that they have identified and used. This may be necessary if, for example:

- the assessor needs to confirm the authenticity of the work
- the unit marking grid carries marks for information and/or resource gathering.

It will be up to the centre assessor to decide on the appropriate format, although the activity should be of a 'closed book' nature.

If the assessor decides to interview the learner, the assessor is required to question the learner regarding their information or resources until the assessor is sufficiently satisfied with the authentication. Whilst the interview is in progress the learner should not have access to the information or resources unless the individual unit specifies otherwise. It can be either a group or individual interview.

If the assessor decides to test the learner, the assessor is required to follow the usual testing format, with learners working in silence, and placed in a manner so that they do not see other learners' responses. The questions are at the discretion of the assessor, as is the length and timing of the test. Learners are not permitted to view the questions prior to the test and should not have access to their work during the test unless the individual unit specifies otherwise.

The documented outcome could be either notes following an interview with one or a group of learners and signed by the assessor, or marked test papers.

Each candidate is required to sign a declaration before submitting their coursework to their subject tutors/assessors for final assessment, to confirm that the work is their own and that any assistance given and/or sources used have been acknowledged. Ensuring that they do so is the responsibility of the candidate's centre.

It is also a requirement that tutors/assessors confirm to the awarding body that all of the work submitted for assessment was completed under the required conditions and that they are satisfied that the work is solely that of the individual candidate concerned. Where assessment is supervised by someone other than the tutor, additional confirmation is required from the person who has supervised the assessment.

All tutors/assessors who have assessed the work of any candidate entered for each component must sign the declaration of authentication.

3.4 Task marking (standardisation and marking) - Medium control

Marking

Edexcel requires all consortium assessors to use only Edexcel authorized documentation in the assessment of its Principal Learning internal assessed units. All Edexcel Principal Learning internal assessed unit specifications have mark descriptors, and these must be used when assessing learner work. Consortium assessors must not try to re-interpret the mark descriptors, or use any other unauthorised publication which aims to do so.

If written evidence and artefacts are completed under the supervision of someone else (see *Supervision* above), this person may comment upon what is produced, but only the tutor can allocate marks.

Where performance evidence is observed by someone other than the tutor, this person must record their comments on the learner observation record. It is then the responsibility of the tutor to judge this evidence and allocate marks.

Standardisation

All Principal Learning awarding bodies are required to follow the instructions for standardisation specified by the JCQ.

Centres should use reference and archive materials (such as exemplar material provided by the awarding body or, where available, work in the centre from the previous year) to help set the standard of marking within the centre.

Prior to marking, a trial marking exercise should be undertaken. Teachers mark the same relatively small sample of work to allow for the comparison of marking standards. The exercise can take place at appropriate stages during the course and has three beneficial effects: it helps to bring about greater comparability in the marking standards; it may identify at an early stage any teachers whose standards are out of line with that of their colleagues; and it alleviates a heavy marking load at the end of the course.

Where the work for a unit has been marked by more than one teacher in a consortium, standardisation of marking should normally be carried out according to one of the following procedures:

Either a sample of work which has been marked by each teacher is re-marked by the teacher who is in charge of internal standardisation – normally the Domain Assessor;

Or all the teachers responsible for marking a component exchange some marked work (preferably at a meeting led by the Domain Assessor) and compare their marking standards.

Where standards are found to be inconsistent, the discrepant teacher(s) should make adjustments to their marks or re-consider the marks of all candidates for whom they were responsible. The new marks should be checked by the teacher in charge of internal standardisation.

Following completion of the marking and of internal standardisation, the coursework must be retained within the consortium and not returned to the candidates.

Consortia should retain evidence that internal standardisation has been carried out.

Annexe F: Learning outcomes and assessment criteria for each unit

The following sections state the learning outcomes and assessment criteria for each unit that are presented on the National Database of Accredited Qualifications, NDAQ. Each section outlines the intermediary stage in generating the marking grid from the learning outcomes via assessment criteria.

Unit title: Level 1 Unit 1 Introducing the Engineering World

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|--|
| | The learner should: | The learner can: |
| LO.1 | Know about different engineering sectors and employment opportunities | Identify different sectors that form the engineering industry, the work undertaken and potential job roles and responsibilities. |
| LO.2 | Know about presentation methods, the benefits of working in a team, and the contribution engineering makes to the world we live in | <p>Identify the benefits of teamwork.</p> <p>Identify commonly used methods of presentation.</p> <p>Identify examples of the contribution engineering has made on the way we live.</p> <p>Identify the social and economic impact engineering has had on the world we live in.</p> |
| LO.3 | Know how environmental factors influence the engineering world | Identify the environmental factors and green issues engineers should consider and how environmental legislation has influenced the engineering industry. |

Unit title: Level 1 Unit 2 Practical Engineering and Communication Skills

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|---|---|
| | The learner should: | The learner can: |
| LO.1 | Understand own responsibilities and those of their colleagues under health and safety legislation | Identify and review the requirements of working safely with colleagues in different situations and comply with and apply relevant health and safety legislation. [IE4] |
| LO.2 | Know about the cutting, forming and joining processes used when producing engineered products | Review two cutting and two forming processes used in industry, describe a joining process and relate each process to industrial applications. |
| LO.3 | Be able to disassemble and assemble engineered products | Use documentation and equipment to dismantle a product, clean and lay out component parts. Identify replacement parts, reassemble and compile a report including reasons for replacements. [SM2] |
| LO.4 | Be able to produce sketches of an engineered product or assembly | Produce sketches of an engineered product or assembly in orthographic 1st and 3rd angle projection and isometric and oblique views, hatch sections and dimension the sketches correctly. Show drawing conventions and layout. |
| LO.5 | Be able to plan and produce an engineering product | Compile a plan of operation to produce an engineered product [SM3]; manufacture the product, review the success of the plan and explain possible improvements [RL3, RL5, SM2]. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 1 Unit 3 Introduction to Computer Aided Engineering

| Learning outcome number | Learning outcome The learner should: | Assessment criteria The learner can: |
|-------------------------|---|--|
| LO.1 | Be able to use a CAD system to produce a working drawing of a 2D component and an electrical circuit | Produce a dimensioned drawing of an engineered component in line with BS:8888 and a circuit diagram in line with BS 3939 complete with annotation, and prepare a template. |
| LO.2 | Be able to use a CAM system to convert the drawing data into a computer numerically controlled (CNC) operating program | Use and review CAM software and cutting information to convert a CAD drawing geometry into a machine tool cutter path, process the cutter path data into a coded CNC operating program [IE4, SM2]. |
| LO.3 | Be able to set and safely operate a CNC machine tool to produce an accurately machined component and check their own production | Load a CNC program into the controller, set work datums and tool offset values. Safely execute the program to produce a first-off component, uses override controls to gain optimum performance, check the component for dimensional accuracy and compliance, record and review performance [RL3]. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 1 Unit 4 Developing Routine Maintenance Skills

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about different types of maintenance procedures and supporting documentation used in industry | Identify and describe three different types of maintenance procedure including how, where and why each is used. Describe and explain how to use different sorts of documentation when planning and/or carrying out maintenance tasks and give an example of a maintenance task where each would be used. |
| LO.2 | Be able to use tools safely and effectively to carry out a routine maintenance task | Carry out a routine maintenance task [SM2], follow a given schedule and effectively use documentation, tools and equipment in a safe manner. |
| LO.3 | Be able to assess a product, piece of equipment or system against causes of failure | Devise and review a plan [EP2] and use appropriate tools and equipment to see if a product, piece of equipment or system might fail in service [RL3]. Record key measurements. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 1 Unit 5 Introduction to Engineering Materials

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|--|
| | The learner should: | The learner can: |
| LO.1 | Know about the properties that are used to describe the performance of engineering materials | Identify and define different material properties that describe the performance of engineering materials and how these affect the application of materials. |
| LO.2 | Know about the materials that engineers use and their forming processes | <p>Identify and review appropriate properties, forming processes and engineering applications for three different ferrous metals.</p> <p>Identify and review appropriate properties, forming processes and engineering applications for three different non-ferrous metals.</p> <p>Identify and review appropriate properties, forming processes and engineering applications for two different thermoplastic and one elastomer material.</p> <p>Identify and review appropriate properties, forming processes and engineering applications for three different thermosetting plastic materials.</p> |
| LO.3 | Be able to identify engineering materials and carry out tests to evaluate their properties | <p>Identify materials and their form and dimension specified on an engineering document.</p> <p>Identify engineering materials by visual and tactile inspection and review their selection and use in components.</p> <p>Carry out and review tests on the mechanical properties of engineering materials [IE3, SM2].</p> |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 1 Unit 6 Electronic Circuit Construction and Testing

| Learning outcome number | Learning outcome The learner should: | Assessment criteria The learner can: |
|-------------------------|--|--|
| LO.1 | Know how electronic components are identified | Identify at least six components on a given circuit diagram from standard symbols and use a catalogue to extract details of further physical and electronic components. |
| LO.2 | Be able to use symbols to produce an electronic circuit diagram | Sketch an electronic circuit diagram, which includes at least six components, using standard symbols, reproduce the circuit diagram using a computer-based electronic circuit simulation package and be able to retrieve, modify and resave the circuit diagram. |
| LO.3 | Be able to work in a team to plan the construction of an electronic circuit from a circuit diagram and then individually build the circuit | Work in a team to plan the construction of a given electronic circuit [TW1, TW2] and then individually, prototype the circuit using a breadboard, build the circuit using stripboard and construct the circuit on a given printed circuit board [SM2]. |
| LO.4 | Be able to test an electronic circuit | Use an electronic circuit simulation package and setup and use physical test equipment [SM2, SM3] to test the operation of the given electronic circuit by measuring six different circuit input and output signals for each, reviewing the results. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 1 Unit 7 Engineering the Future

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about the new developments in materials and engineering technology that impact on everyday life | Describe and explain three different new or smart engineering materials and three different new technologies and their properties and applications. Use own and others' ideas and experiences to describe three new engineering technologies, their application in everyday life [CT3] and potential impact. |
| LO.2 | Know how products are recycled or safely disposed of at the end of their useful life | Outline the recycling process for different products which can be recycled, and detail how and why those that cannot [IE3] can be safely disposed of and the benefits of recycling. |
| LO.3 | Be able to identify renewable energy sources and the environmental issues of each one | Identify and review how energy is generated from two different renewable source, the environmental impact of using renewable sources and the benefits and disadvantages of storage. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 2 Unit 1 Exploring the Engineering World

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about engineering sectors and their products or services | Describe two different sectors in engineering and explain the function and operation of different engineering products or services provided by engineering companies. |
| LO.2 | Know about job opportunities available within the engineering industry and the role of professional engineering institutions | Review career opportunities within engineering at a local and/or national level and the roles and function of the engineering council and licensed professional engineering institutions. |
| LO.3 | Know about the achievements in engineering that relate to social and economic development | Describe the key achievements in engineering in the 19th, 20th and 21st centuries and their impact on social and economic life. |
| LO.4 | Understand the rights and responsibilities of employers and employees in engineering | Comment on and explain the rights and responsibilities of employers and employees in relation to relevant legislation. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 2 Unit 2 Investigating Engineering Design

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|---|--|
| | The learner should: | The learner can: |
| LO.1 | Know about the construction and function of an engineered product or system | Dismantle and reassemble an engineered product or system, describing its construction, function and operation and review its performance. |
| LO.2 | Be able to prepare a product design specification | Identify the physical constraints, performance requirements and reliability indicators in a given design brief for an engineered product or system. Produce a product design specification that contains the dimensional constraints, functional requirements, operating performance and the economic and manufacturing considerations for an engineered product or system. |
| LO.3 | Be able to prepare initial design proposals | Use own and others' ideas and experiences to produce and review three initial design proposals for consideration [CT3, EP2]. |
| LO.4 | Be able to prepare and submit a final design solution | Prepare and submit final design solution documents including a written report and a presentation. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 2 Unit 3 Engineering applications of computers

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about computer applications in process control and manufacturing | Describe and review how two different industries use computers in process control and manufacturing. |
| LO.2 | Be able to use computer-based systems to solve an engineering problem | Set up and review the use of appropriate computer-based equipment to solve a given engineering problem [IE3, SM2]. |
| LO.3 | Understand microprocessor control applications in everyday consumer products | Describe and review how microprocessor systems and their component parts control the features or actions of at least two consumer products. |
| LO.4 | Know about computer aided technology in maintenance operations | Describe how two different computer applications can be used in a given maintenance operation and show how they can be used in the diagnosis of faults. |

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills. *Annexe B* of this document lists the personal, learning and thinking skills and their elements.

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

Unit title: Level 2 Unit 4 Producing Engineering Solutions

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|--|
| | The learner should: | The learner can: |
| LO.1 | Understand health and safety procedures, standards and risk assessment in engineering activities | Identify and review health and safety responsibilities and the need for a risk assessment for a given engineering activity and carry out and review a risk assessment [IE6]. |
| LO.2 | Be able to plan for an engineering product or service | Produce, apply and review a plan to include materials or components, tools and equipment and sequence of events for the manufacture of an engineered product or to carry out a service [EP3]. |
| LO.3 | Be able to select suitable materials, parts or components for an engineered product or service | Use information given on own plan to identify, select and prepare materials, parts or components for the production of an engineered product or the carrying out of a service. Review the selection and preparations made. |
| LO.4 | Be able to use processes, tools and equipment to make an engineered product or carry out a service | Produce an engineered product or carry out a service following own plan and use additional drawings or documentation, processes, tools and equipment in a correct and safe manner [SM2]. |
| LO.5 | Be able to apply inspection techniques to the engineered product or service | Perform and review inspection techniques on an engineered product or service and the results obtained to check compliance with plan [RL3]. |

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Unit title: Level 2 Unit 5 Electrical and Electronic Circuits and Systems

| Learning outcome number | Learning outcome The learner should: | Assessment criteria The learner can: |
|-------------------------|--|---|
| LO.1 | Understand safe working practices in the workshop/ laboratory and understand relevant electrical and electronic principles | Explain the need for and use safe working practices when constructing, testing and fault-finding on electronic circuits. Use electrical and electronic principles to determine values in AC and DC circuits. |
| LO.2 | Be able to recognise and select components used in electrical and electronic circuits | Identify up to 12 different components used in electrical and electronic circuits and select appropriate components for different electrical/electronic circuit applications. |
| LO.3 | Be able to construct an electronic circuit and understand its basic operating principles | Use appropriate techniques to construct an electronic circuit from a given circuit diagram and explain the overall operation of the circuit and the function of its components [SM2]. |
| LO.4 | Be able to test and find faults on electronic circuits | Use appropriate techniques and test instruments to carry out basic voltage, current and signal tests on a working circuit in order to verify that it is functioning correctly [SM2, CT5] and to locate and identify different faults. |

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| | EP – effective participators |

Unit title: Level 2 Unit 6 Application of Manufacturing Techniques in Engineering

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|---|--|
| | The learner should: | The learner can: |
| LO.1 | Be able to work effectively in a production team and reflect on their performance | Participate effectively in a production team [TW2] and review own role in the team [TW4], including strengths and weaknesses [RL1]. |
| LO.2 | Know about production information and how this is used to plan and schedule for manufacturing | Describe and interpret the essential production information found in product drawings and a specification for a given engineered product. Produce and review a production plan and schedule for the manufacture of a quantity of the same engineered product [SM3]. |
| LO.3 | Be able to set up and use tools and CNC equipment safely to process materials | Select and prepare material, set up and use CNC tools and equipment to manufacture a quantity of the same simple engineered product safely, maintaining a clean and tidy working environment [SM2]. Review the success of this activity [RL5]. |
| LO.4 | Be able to apply appropriate quality control techniques and interpret quality data | Use quality control techniques, including statistical methods, and accurately record data. Establish whether a sample of engineered products conforms to the standards specified [IE4] and review reasons for success/failure. |

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|------------|---|

Unit title: Level 2 Unit 7 Applications of Maintenance Techniques in Engineering

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|---|--|
| | The learner should: | The learner can: |
| LO.1 | Understand different types of maintenance for engineered products, plant or equipment including the use of statistical trends | <p>Explain and review the use of different types of maintenance appropriate to engineered products, plant or equipment.</p> <p>Use and review a range of statistical methods and calculations [IE4] to support engineering maintenance.</p> |
| LO.2 | Be able to carry out routine maintenance tasks and devise a maintenance procedure | <p>Follow a given maintenance procedure to diagnose and correctly carry out routine maintenance activities on an engineered product, plant or equipment, replenishing or replacing consumable items.</p> <p>Use the experience of following a maintenance procedure to devise a different detailed maintenance procedure [RL5] for a given engineered product, plant or equipment.</p> |
| LO.3 | Understand the effects of poor maintenance and the range of spares and replacement parts | <p>Describe the implications of improper maintenance and review a way to reduce its impact.</p> <p>Identify spares or replacement parts for a given maintenance task and explain the requirements to maintain optimum stock levels of spares and replacement parts and the role of statistical data.</p> |
| | Be able to carry out a risk assessment in a maintenance environment | Carry out a risk assessment for a given engineering maintenance task using appropriate documentation [IE4], taking into account relevant health and safety considerations. |

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|------------|--|

Unit title: Level 2 Unit 8 Exploring Engineering Innovation, Enterprise and Technological Advancements

| Learning outcome number | Learning outcome | Assessment criteria |
|-------------------------|--|---|
| | The learner should: | The learner can: |
| LO.1 | Know about the intellectual property within engineering | Describe the four main types of intellectual property, and explain the benefits of registering intellectual property. |
| LO.2 | Understand the role of research, development and raising finance when designing engineering products | Describe and explain the role, sources and significance of appropriate research and development when designing a product or process. Describe and review the financing for an engineering project. |
| LO.3 | Know about developments in materials and processes on products | Describe and review the effects of developments in materials and processes and on a product. |
| LO.4 | Know about the effects of engineering technologies in the home, workplace or built environment | Identify and review the effects of engineering technology in the home, workplace or built environment and advances in such technology. |
| LO.5 | Know about the environmental and social impact of engineering and sustainability of resources | Identify and review the environmental and social impact of engineering, and the sustainability of resources. |

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