Pearson
BTEC Level 2 Technical Diploma in Engineering

Specification

First teaching September 2017
Issue 6
Edexcel, BTEC and LCCI qualifications

Edexcel, BTEC and LCCI qualifications are awarded by Pearson, the UK’s largest awarding body offering academic and vocational qualifications that are globally recognised and benchmarked. For further information, please visit our qualifications website at qualifications.pearson.com. Alternatively, you can get in touch with us using the details on our contact us page at qualifications.pearson.com/contactus

About Pearson

Pearson is the world's leading learning company, with 35,000 employees in more than 70 countries working to help people of all ages to make measurable progress in their lives through learning. We put the learner at the centre of everything we do, because wherever learning flourishes, so do people. Find out more about how we can help you and your learners at qualifications.pearson.com

This specification is Issue 3. Key changes are listed in the summary table on the page after next of the document. We will inform centres of any changes to this issue. The latest issue can be found on the Pearson website: qualifications.pearson.com

References to third-party material made in this specification are made in good faith. We do not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

ISBN 978 1 446 95373 0

All the material in this publication is copyright © Pearson Education Limited 2019
Welcome

With a track record built over 30 years of learner success, BTEC qualifications are widely recognised and respected. They provide progression to the workplace, either directly or via study at higher levels. Proof comes from YouGov research, which shows that 62% of large companies have recruited employees with BTEC qualifications.

Why are BTECs so successful?

BTECs embody a fundamentally learner-centred approach to the curriculum, with a flexible, unit-based structure. In these new BTEC Level 2 Technicals, the focus is on the development of technical, practical and transferable work-related skills, and sector-specific knowledge. The development of these skills is key for learners to progress to work or to an Apprenticeship.

When creating the BTEC Level 2 Technicals, we worked with employers to ensure that the qualifications meet their needs. Employers are looking for recruits with the appropriate technical knowledge, and technical and transferable skills essential for employment.

The BTEC Level 2 Technicals meet these requirements through:

- a range of occupationally-related qualifications, each with a clear purpose, so that there is a qualification to suit each learner’s plan for career progression
- up-to-date content that is closely aligned with employers’ needs for a skilled future workforce
- assessments and projects chosen to help learners progress to the next stage. This means that some assessments and projects are set by the centre to meet local needs, while others are set and marked by Pearson. This ensures that there is a core of skills and understanding common to all learners. For example, an externally-set test can be used to check that learners are confident in using technical knowledge to carry out a certain job.

We provide a wealth of support, both resources and people, to ensure that learners and their tutors have the best possible experience during their course. See Section 11 Resources and support for details of the support we offer.

A word to learners...

BTEC Level 2 Technicals will demand a lot of practical work from you. You will need to:

- complete a range of units
- be organised
- take some assessments that Pearson will set and mark
- take other assessments that will demonstrate your technical and practical skills
- keep a portfolio of your assignments.

But you can feel proud to achieve a BTEC because, whatever your plans in life – whether you decide to go on to work or to an Apprenticeship – success in your BTEC Level 2 Technical qualification will help you to progress to the next stage in your life.

Good luck, and we hope you enjoy your course.
Collaborative development

Learners completing their BTEC Level 2 Technicals will be aiming to go on to employment or to an Apprenticeship. It was essential therefore that we developed these qualifications in close collaboration with experts from professional bodies and businesses, and with the providers who will be delivering the qualifications. We are grateful to all the further education lecturers, tutors, employers, and professional body representatives who have generously shared their time and expertise to help us develop these new qualifications.

In addition, professional bodies and businesses have provided letters of support confirming that these qualifications meet their recruitment requirements. These letters can be viewed on our website.

Summary of Pearson BTEC Level 2 Technical Diploma in Engineering specification Issue 6 changes

<table>
<thead>
<tr>
<th>Summary of changes made between the previous issue and this current issue</th>
<th>Page number</th>
</tr>
</thead>
<tbody>
<tr>
<td>The wording in Section 8 Teacher/centre malpractice has been updated to clarify suspension of certification in certain circumstances.</td>
<td>Pages 141, 142</td>
</tr>
<tr>
<td>The wording under Section 10 Understanding the qualification grade has been updated to clarify current practice in ensuring maintenance and consistency of qualification standards.</td>
<td>Page 146</td>
</tr>
</tbody>
</table>
8 Administrative arrangements
   Introduction
   Learner registration and entry
   Access to assessment
   Administrative arrangements for internal assessment
   Administrative arrangements for external assessment
   Dealing with malpractice in assessment
   Certification and results
   Additional documents to support centre administration

9 Quality assurance
   Centre and qualification approval
   Continuing quality assurance and standards verification

10 Understanding the qualification grade
   Awarding and reporting for the qualification
   Eligibility for an award
   Examples of grade calculations based on table applicable to registrations from September 2017

11 Resources and support
   Support for setting up your course and preparing to teach
   Support for teaching and learning
   Support for assessment
   Training and support from Pearson
Pearson BTEC Level 2 Technicals

Introduction

BTEC Level 2 Technicals are intermediate qualifications for post-16 learners who want to specialise in a specific occupation, occupational area or technical role. They prepare learners for work or an Apprenticeship by giving them the opportunity to develop sector-specific knowledge, technical and practical skills, and to apply these skills in work-related environments. The qualifications also provide progression to Level 3 Tech Level qualifications.

Developed in close conjunction with leading employers, BTEC Level 2 Technicals also develop transferable workplace skills, such as good communication and the ability to work in a team, which employers have identified as essential for gaining employment in the sector and for progression once the learner is working.

At the core of these qualifications is the concept of preparing young people for the working world. Through practical activities and occupationally-fit-for-purpose assessments, learners will gain the skills and behaviours needed for sustainable employment.

BTEC Level 2 Technicals are designed to be used flexibly, depending on their size and scope:

- as part of a full-time 16–19 study programme, alongside mathematics and English GCSEs and/or Functional Skills, work placement and enrichment activities
- as the technical qualification within an Apprenticeship or off-the-job training for those already in work
- as a roll-on, roll-off programme for those entering an Apprenticeship or employment.

Pearson has developed the BTEC Level 2 Technicals suite to meet the Department for Education (DfE) requirements for qualifications to be offered as Technical Certificates for 16–19-year-olds. This specification contains the information you need to deliver the Pearson BTEC Level 2 Technical Diploma in Engineering (QN 603/0421/2). The specification signposts you to additional handbooks and policies. It includes all the units for this qualification.
1 Pearson BTEC Level 2 Technical Diploma in Engineering

Purpose

Who is the qualification for?
This qualification is for learners who want to start a career in engineering. It is designed for post-16 learners and can be taken as part of a wider study programme.

What does the qualification cover?
This qualification has been developed in consultation with employers in the engineering sector in order to ensure learners develop the skills and behaviours that give them the best opportunity to be successful in applying for work.

The content of the qualification consists of five mandatory units and relates directly to the skills, knowledge and behaviours expected by employers in the engineering sector. The areas covered include:

- engineering principles
- processes and materials
- business improvement techniques
- workshop skills
- delivering engineering solutions.

Learners choose two optional units, where the content introduces the more focused knowledge and skills needed to start working in the engineering sector. The areas learners will choose from are:

- machining techniques
- printed circuit board (PCB) components and soldering
- computer numerical control
- electrical components and wiring.

Learners will also enhance their broader skills in literacy and numeracy, which will be invaluable in supporting progression in other areas. In addition, they will develop transferable technical and practical skills in communication (working with colleagues, customers and clients), and research and project work (providing them with an opportunity to demonstrate their reflective practice by suggesting alternative approaches to a problem).

What could this qualification lead to?
Achieving this qualification will give learners an advantage when applying for a job in engineering. The types of role they will be ready for are:

- plant and machine operative
- process operative
- routine inspector and tester
- metal working machine operative.

When studied as part of a full study programme, this qualification also gives learners a sound basis to progress further in the engineering sector to a Level 3 qualification such as a Pearson BTEC Level 3 Extended Diploma in Engineering.
About the engineering sector

Engineering is a dynamic sector that offers huge potential for learners. Engineering turnover grew by 3.4% to £1.21 trillion over the 12 months to March 2014. In the year ending March 2014, the sector accounted for 27.1% of the turnover of all enterprises in the UK. The UK is regarded as a world leader in engineering sectors, including renewable energy, space, low carbon, aerospace, creative industries, utilities, automotive, agri-food and bioscience. The sector employs 5.5 million people across 608,920 enterprises. Between 2012 and 2022, engineering enterprises are projected to need 1.82 million people with engineering skills, including more than 400,000 technician roles (as the predominantly ageing workforce in this area is expected to retire during this period). Filling demand for new engineering jobs will generate an additional £27 billion per year for the UK economy, from 2022.

Careers in engineering offer a fantastic progression pathway to a number of roles throughout an organisation, and the skills developed are transferable to most engineering job functions.
2 Structure

Total Qualification Time (TQT)

For all regulated qualifications, Pearson specifies a total number of hours that it is estimated learners will require to complete and show achievement for the qualification: this is the Total Qualification Time (TQT). Within TQT, Pearson identifies the number of Guided Learning Hours (GLH) that we estimate a centre delivering the qualification might provide. Guided learning means activities, such as lessons, tutorials, online instruction, supervised study and giving feedback on performance, that directly involve tutors and assessors in teaching, supervising and invigilating learners. Guided learning includes the time required for learners to complete external assessment under examination or supervised conditions.

In addition to guided learning, other required learning directed by tutors or assessors will include private study, preparation for assessment and undertaking assessment when not under supervision, such as preparatory reading, revision and independent research.

The Pearson BTEC Level 2 Diploma in Engineering is a qualification having:

- Total Qualification Time: 445 hours
- Guided Learning: 360 hours.

Centres should take note of these hours in planning their programme but should also use their professional judgement to determine the provision of guided learning and study time across the units.

Qualification structure

There are five mandatory units and four optional units in the qualification. Learners are required to complete and achieve all mandatory units and two optional units.

<table>
<thead>
<tr>
<th>Unit number</th>
<th>Unit title</th>
<th>GLH</th>
<th>Type</th>
<th>How assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engineering Principles</td>
<td>45</td>
<td>Mandatory</td>
<td>External</td>
</tr>
<tr>
<td>2</td>
<td>Processes and Materials</td>
<td>45</td>
<td>Mandatory</td>
<td>External</td>
</tr>
<tr>
<td>3</td>
<td>Business Improvement Techniques</td>
<td>30</td>
<td>Mandatory</td>
<td>Internal</td>
</tr>
<tr>
<td>4</td>
<td>Workshop Skills</td>
<td>60</td>
<td>Mandatory</td>
<td>Internal</td>
</tr>
<tr>
<td>5</td>
<td>Machining Techniques</td>
<td>60</td>
<td>Optional</td>
<td>Internal</td>
</tr>
<tr>
<td>6</td>
<td>PCB Components and Soldering</td>
<td>60</td>
<td>Optional</td>
<td>Internal</td>
</tr>
<tr>
<td>7</td>
<td>Computer Numerical Control</td>
<td>60</td>
<td>Optional</td>
<td>Internal</td>
</tr>
<tr>
<td>8</td>
<td>Electrical Components and Wiring</td>
<td>60</td>
<td>Optional</td>
<td>Internal</td>
</tr>
<tr>
<td>9</td>
<td>Delivering Engineering Solutions</td>
<td>60</td>
<td>Mandatory</td>
<td>Internal Synoptic</td>
</tr>
</tbody>
</table>

This qualification has 66% mandatory content and 25% external assessment.
Qualification and unit content

Pearson has developed the content of this qualification in collaboration with employers and representatives from relevant professional bodies and further education providers. In this way, we have ensured that content is up to date and that it includes the knowledge, technical and practical skills and behaviours required to work in the sector and occupational area.

66% of the content in this qualification is mandatory, which provides a balance of breadth and depth, ensuring that all learners develop the technical and practical skills required in the occupational area. Learners are then offered the opportunity to develop a range of transferable skills and attributes expected by employers. It is expected that learners will apply their learning to relevant employment and sector contexts during delivery and that they will have opportunities to engage meaningfully with employers.

BTECs have always required applied learning that brings together knowledge and understanding (the cognitive domain) with practical and technical skills (the psychomotor domain). This is achieved through learners performing practical, work-related tasks that encourage the development of appropriate work-related behaviours (the affective domain) and transferable skills. Transferable skills are those such as communication, teamwork, and planning and completing tasks to high standards, all of which are valued in the workplace.

Our approach provides rigour and balance and promotes the ability to apply learning immediately in new contexts.

Some of the units within the specification may contain references to legislation, policies, regulations and organisations, which may not be applicable in the country you deliver this qualification in (if teaching outside of England), or which may have gone out of date during the lifespan of the specification. In these instances, it is possible to substitute such references with ones that are current and applicable in the country you deliver subject to confirmation by your Standards Verifier.

Assessment

Assessment is designed to fit the purpose and objective of the qualification. It includes a range of assessment types and styles suited to skills and occupationally-based qualifications at this level.

External assessment

In this qualification there are two external assessments, which assess units that contribute to 25% of the total qualification GLH. The external assessments for this qualification take the form of onscreen tests that include a variety of onscreen item types and allow learners to apply their knowledge to several work-related contexts. Each external assessment is linked to a specific unit as indicated in the qualification structure on the previous page.

Onscreen tests have been used to externally assess the identified units because this method is best suited to draw out the evidence required. The units introduce learners to the basic principles of maths and science and provide an introduction to the different processes and materials used in engineering. Learners then use this knowledge and understanding to solve simple engineering problems. The knowledge and skills developed in these external units underpin the practical elements of the internally-assessed units.

Each external assessment is taken under specified conditions, then marked by Pearson and a grade awarded. Learners must achieve both external units at Pass grade or above to achieve the qualification. Learners are permitted to resit the external assessments once during their programme by taking a new assessment.

For further information on external assessment see Section 7 External assessment.
Internal assessment

Units 3, 4, 5, 6, 7, 8 and 9 are assessed through internal assessment. Internal assessment allows learners to apply technical knowledge and demonstrate mastery of practical and technical skills through realistic tasks and activities. This style of assessment promotes deep learning through ensuring the connection between knowledge and practice.

Internal assessment is through assignments that are subject to external standards verification. We provide suggestions in each unit for setting assignments. This means that you can adapt materials to your local contexts and assess assignments that provide the valid and rigorous final assessment for each unit.

You will make grading decisions based on the requirements and supporting guidance given in the units. Learners must achieve all the internal units at Pass grade or above to achieve the qualification. For further information on internal assessment, including resubmissions, see Section 6 Internal assessment.

Synoptic internal assessment

There is one internal unit that provides the main synoptic assessment for this qualification. This synoptic assessment is designed to take place towards the end of the programme and draws on the learning throughout. The design of this assessment ensures that there is sufficient stretch and challenge, enabling the assessment of sector-related knowledge and technical and practical skills at the end of the learning period.

The synoptic assessment for this qualification is based on Unit 9: Delivering Engineering Solutions and takes the form of a practical project that requires learners to consider and select content that will enable them to apply their knowledge and skills from across the other units in an integrated way to a realistic work situation. Learners will draw on the knowledge and skills developed throughout the qualification, selecting and combining skills and applying them to a range of contexts. This unit will enable learners to make connections between the units they have completed, increase their engagement with the subject matter and provide them with a comprehensive overview of the sector. In this unit, learners will apply the basic principles of mathematics and science that underpin all engineering applications, employ appropriate workshop techniques they have gained during the qualification, use different processes and materials and apply appropriate business improvement techniques throughout the planning, making and reviewing process. Learners will gain experience of production planning before moving to manufacturing an engineered product from a realistic design brief, using the skills they have learned in the optional units completed. At the end of the project, they will review the effectiveness of the plan and their own personal performance.

In delivering the unit, you need to encourage learners to draw on their broader learning so that they are prepared for the assessment.

Language of assessment

Assessment of the internal and external units for this qualification will be available in English. All learner work must be in English. A learner taking the qualifications may be assessed in British sign language where it is permitted for the purpose of reasonable adjustment. For information on reasonable adjustments see Section 8 Administrative arrangements.

Grading of the qualification

Achievement in the qualification requires a demonstration of depth of study in each unit, assured acquisition of the practical skills required for employment in the specific sector and successful development of transferable skills.

Units are assessed using a grading scale of Distinction, Merit, Pass and Unclassified. All units in the qualification contribute proportionately to the overall qualification grade.
The qualification is graded using a scale of PP to DD. Please see Section 10 Understanding the qualification grade for more details.

The relationship between qualification grading scales and unit grades will be subject to regular review as part of Pearson's standards monitoring processes on the basis of learner performance and in consultation with key users of the qualification.

**Employer involvement**

Employer involvement in the delivery and/or assessment of technical qualifications provides a clear 'line of sight' to work, enriches learning, raises the credibility of the qualification in the eyes of employers, parents and learners, and furthers collaboration between the learning and skills sector and industry.

Centres need to ensure that all learners have the opportunity to undertake meaningful activity involving employers during their course.

Examples of 'meaningful activity' include:

- working with an industrial partner to develop a range of case studies to aid the delivery and assessment of the unit. Case studies should be varied and detail business processes in realistic scenarios to ensure they reflect industrial practice, e.g. learners could identify possible scales and key stages of production from given case studies to inform their production planning work in Unit 9: Delivering Engineering Solutions, or examples of business processes and visual management methods for Unit 3: Business Improvement Techniques

- structured work experience or work placements that develop skills and knowledge relevant to the industry. Employers could give learners the opportunity to carry out a range of activities in an engineering workplace, e.g. in Unit 5: Machining Techniques, learners could become familiar with industrial machining techniques and the typical industrial environments in which they are used through work experience

- units delivered or co-delivered by industry practitioners; this could take the form of master classes or guest lectures, e.g. centres could arrange for practitioners who work in the fabrication sector, such as technicians, to demonstrate the procedures for setting up work areas for fabrication activities, or those in the machining sector who could talk about the importance of safety in machining, of completing quality checks on completed components and of maintaining accurate quality records

- projects, exercises and/or assessments/examinations set with input from industry practitioners, e.g. local employers could offer assessment support by providing specifications and drawings for engineered products that could be used for assessment purposes to plan production in Unit 9: Delivering Engineering Solutions. The designs for the delivery and assessment of units could be developed in conjunction with an industrial partner, e.g. Unit 5: Machining Techniques will require a range of suitable workpieces and drawings to be made available to learners, or Unit 6: PCB Components and Soldering, which will require a range of suitable circuit designs and associated specification documentation to be available to learners, which could be developed in conjunction with an industrial partner to ensure they represent current industry standard best practice

- industry practitioners operating as 'expert witnesses' that contribute to the assessment of a learner's work of practice, operating within a specified assessment framework. This may be specific projects, exercises or all assessments for a qualification, e.g. as part of the assessment in Unit 9: Delivering Engineering Solutions, employers could provide feedback to learners on the quality of their work, which would also help learners when reflecting on the effectiveness of their engineering skills employed in the assessment task.

Meaningful employer involvement, as defined above, must be with employers from the engineering sector and should contribute significantly to at least one mandatory unit.
We have also provided suggestions in some units on how employers could become specifically involved in the delivery and/or assessment of this qualification. The units are:

*Unit 3: Business Improvement Techniques*
*Unit 4: Workshop Skills*
*Unit 5: Machining Techniques*
*Unit 6: PCB Components and Soldering*
*Unit 7: Computer Numerical Control*
*Unit 8: Electrical Components and Soldering*
*Unit 9: Delivering Engineering Solutions.*

These are suggestions only and there will be other possibilities at local level. Centres may choose to use other approaches but must ensure that these meet the requirement for meaningful employer involvement as defined above. Centres must have an employer involvement plan in place at the start of the programme. It must detail their approach to employer involvement and how it will add value to the delivery and assessment of the qualification.

Each centre’s approach to employer involvement will be monitored in two ways. It will be monitored at centre level as part of the annual quality management review process, and captured as part of the standards verification process that addresses centre strategy for delivery, assessment and quality assurance, when we will ask you to show evidence of how employer involvement is provided for all learners. You will need to show evidence in order to gain reporting clearance for certification. It will also be monitored at programme level as part of the standards verification process to confirm that plans for employer involvement meet the requirements of the specification. These approaches are designed to ensure that additional activities can be scheduled where necessary so that learners are not disadvantaged (see Section 9 Quality assurance).
3 Units

Understanding your units

The units in this specification set out our expectations of assessment in a way that helps you to prepare your learners for assessment. The units help you to undertake assessment and quality assurance effectively.

Each unit in the specification is set out in a similar way. There are two types of unit format:

- internal units
- external units.

This section explains how the units work. It is important that all tutors, assessors, internal verifiers and other staff responsible for the programme read and are familiar with the information given in this section.

Internal units

<table>
<thead>
<tr>
<th>Section</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit number</td>
<td>The number is in a sequence for the qualification.</td>
</tr>
<tr>
<td>Unit title</td>
<td>This is the formal title of the qualification and appears on certificates.</td>
</tr>
<tr>
<td>Level</td>
<td>All units are at Level 2 on the national framework.</td>
</tr>
<tr>
<td>Unit type</td>
<td>This says if the unit is mandatory or optional for the qualification.</td>
</tr>
<tr>
<td>Assessment type</td>
<td>This says how the unit is assessed – i.e. whether it is external, internal</td>
</tr>
<tr>
<td></td>
<td>or synoptic internal. See Section 2 Qualification structure for details.</td>
</tr>
<tr>
<td>GLH</td>
<td>Units may have a GLH value of 30 or 60 GLH. This indicates the numbers of</td>
</tr>
<tr>
<td></td>
<td>hours of teaching, directed activity and assessment expected. It also</td>
</tr>
<tr>
<td></td>
<td>shows the weighting of the unit in the final qualification grade.</td>
</tr>
<tr>
<td>Unit in brief</td>
<td>A brief formal statement on the content of the unit that is helpful in</td>
</tr>
<tr>
<td></td>
<td>understanding its role in the qualification. You can use this in summary</td>
</tr>
<tr>
<td></td>
<td>documents, brochures etc.</td>
</tr>
<tr>
<td>Unit introduction</td>
<td>This is designed with learners in mind. It indicates why the unit is</td>
</tr>
<tr>
<td></td>
<td>important, how learning is structured, and how learning might be applied</td>
</tr>
<tr>
<td></td>
<td>when progressing to employment or higher education.</td>
</tr>
<tr>
<td>Learning aims</td>
<td>These help to define the scope, style and depth of learning of the unit.</td>
</tr>
<tr>
<td></td>
<td>You can see where learners should be developing and demonstrating their</td>
</tr>
<tr>
<td></td>
<td>skills or where they should be actively researching or reviewing.</td>
</tr>
<tr>
<td>Unit summary</td>
<td>This section helps tutors to see at a glance the main content areas</td>
</tr>
<tr>
<td></td>
<td>against the learning aims and the structure of the assessment. The</td>
</tr>
<tr>
<td></td>
<td>forms of evidence given are suitable to fulfill the requirements.</td>
</tr>
<tr>
<td>Content</td>
<td>This section sets out the required teaching content of the unit. Content</td>
</tr>
<tr>
<td></td>
<td>is compulsory except when shown as ‘e.g.’. Learners should be asked to</td>
</tr>
<tr>
<td></td>
<td>complete summative assessment only after the teaching content for the</td>
</tr>
<tr>
<td></td>
<td>unit or learning aim(s) has been covered.</td>
</tr>
<tr>
<td>Section</td>
<td>Explanation</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Assessment criteria</td>
<td>Each learning aim has assessment criteria to explain the achievement required to obtain Pass, Merit and Distinction grades.</td>
</tr>
<tr>
<td>Essential information for assessment decisions</td>
<td>This information gives guidance for each learning aim or assignment of the expectations for Pass, Merit and Distinction standard. This section contains examples and essential clarification. It is important that this is used carefully alongside the assessment criteria.</td>
</tr>
<tr>
<td>Assessment activity</td>
<td>This section provides information, suggested scenarios and tasks for summative assessment activities.</td>
</tr>
<tr>
<td>Further information for tutors and assessors</td>
<td>The section gives you information to support the delivery and assessment of the unit.</td>
</tr>
<tr>
<td>Delivery guidance</td>
<td>This section offers suggestions of ways of delivering the unit. It offers ideas on practical activities in a sector context that can be used to help develop relevant skills and to encourage progress.</td>
</tr>
<tr>
<td>Essential resources</td>
<td>Any specific resources that you need to be able to teach and assess are listed in this section. For information on support resources see Section 11 Resources and support.</td>
</tr>
<tr>
<td>Links to other units</td>
<td>This section shows you the main relationships of units to other units. This can help you to structure your programme and make the best use of available materials and resources.</td>
</tr>
<tr>
<td>Employer involvement</td>
<td>This section gives you information on the units that can be used to give learners involvement with employers. It will help you to identify the kind of involvement that is likely to be successful.</td>
</tr>
</tbody>
</table>
## External units

<table>
<thead>
<tr>
<th>Section</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit number</strong></td>
<td>The number is in a sequence for the qualification.</td>
</tr>
<tr>
<td><strong>Unit title</strong></td>
<td>This is the formal title of the qualification and appears on certificates.</td>
</tr>
<tr>
<td><strong>Level</strong></td>
<td>All units are at Level 2 on the national framework.</td>
</tr>
<tr>
<td><strong>Unit type</strong></td>
<td>This says if the unit is mandatory or optional for the qualification. See Section 2 Qualification structure for details.</td>
</tr>
<tr>
<td><strong>Assessment type</strong></td>
<td>This says how the unit is assessed – i.e. whether it is external, internal or synoptic internal. See Section 2 Qualification structure for details.</td>
</tr>
<tr>
<td><strong>GLH</strong></td>
<td>Units have a GLH value of 45 GLH. This indicates the numbers of hours of teaching, directed activity and assessment expected. It also shows the weighting of the unit in the final qualification grade.</td>
</tr>
<tr>
<td><strong>Unit in brief</strong></td>
<td>A brief formal statement on the content of the unit.</td>
</tr>
<tr>
<td><strong>Unit introduction</strong></td>
<td>This is designed with learners in mind. It indicates why the unit is important, how learning is structured, and how learning might be applied when progressing to employment or higher education.</td>
</tr>
<tr>
<td><strong>Summary of assessment</strong></td>
<td>This sets out the type of external assessment used and the way in which it is used to assess achievement.</td>
</tr>
<tr>
<td><strong>Assessment outcomes</strong></td>
<td>These show the hierarchy of knowledge, understanding, skills and behaviours assessed. For tested units, they include information on how this hierarchy relates to command terms in sample assessment materials (SAMs).</td>
</tr>
<tr>
<td><strong>Essential content</strong></td>
<td>For external units all the content is obligatory, the depth of content is indicated in the assessment outcomes and sample assessment materials (SAMs). The content will be sampled through the external assessment over time, using the variety of questions or tasks shown.</td>
</tr>
<tr>
<td><strong>Grade descriptors</strong></td>
<td>We use grade descriptors when making judgements on grade boundaries. You can use them to understand what we expect to see from learners at particular grades.</td>
</tr>
<tr>
<td><strong>Key terms typically used in assessment</strong></td>
<td>These definitions will help you to analyse requirements and to prepare learners for assessment.</td>
</tr>
<tr>
<td><strong>Links to other units</strong></td>
<td>This section shows the main relationships of units to other units. This section can help you to structure your programme and make the best use of available materials and resources.</td>
</tr>
<tr>
<td><strong>Employer involvement</strong></td>
<td>This section gives you information on the units that can be used to give learners involvement with employers. It will help you to identify the kind of involvement that is likely to be successful.</td>
</tr>
</tbody>
</table>
### Units

This section contains all the units developed for this qualification.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Title</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engineering Principles</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Processes and Materials</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Business Improvement Techniques</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>Workshop Skills</td>
<td>47</td>
</tr>
<tr>
<td>5</td>
<td>Machining Techniques</td>
<td>61</td>
</tr>
<tr>
<td>6</td>
<td>PCB Components and Soldering</td>
<td>75</td>
</tr>
<tr>
<td>7</td>
<td>Computer Numerical Control</td>
<td>89</td>
</tr>
<tr>
<td>8</td>
<td>Electrical Components and Wiring</td>
<td>101</td>
</tr>
<tr>
<td>9</td>
<td>Delivering Engineering Solutions</td>
<td>115</td>
</tr>
</tbody>
</table>
Unit 1: Engineering Principles

Level: 2
Unit type: Mandatory
Assessment type: External
Guided learning hours: 45

Unit in brief

Learners are introduced to the basic principles of mathematics and science underpinning all engineering applications, and use them to solve simple engineering problems.

Unit introduction

Engineers use maths and science to solve many of the problems they encounter on a day-to-day basis. They could be processing a set of test figures recorded on a prototype to establish whether the product is performing to specification, calculating the amount of off-cuts and swarf generated by a machine to see if materials are being used efficiently, or putting a new model of washing machine through electrical and mechanical tests to check that it is safe and working as expected. Engineers also use maths and science to calculate the total cost of materials needed or cost per item on a production line, and can apply their knowledge of electrical theory to solve simple electrical problems with circuits or devices.

This unit is the starting point for you to gain the mathematical and scientific skills needed to address many of the interesting challenges faced in engineering. You will look at ways of using arithmetic, algebraic and graphical methods to solve engineering problems, and learn mensuration and trigonometry to measure area, volume, angles and dimensions. You will also learn about the concepts and principles related to electrical and mechanical systems such as magnetic fields, statics and the properties and behaviours of fluids and gases.

Engineering organisations need employees who can apply their knowledge of maths and science to produce items that improve people’s lives. The basis of these underlying theories will support your understanding of why items are made and assembled in a certain order, how energy can be saved, how optimum cutting speeds can be reached and how forces and friction can be reduced. This knowledge will help you to contribute to safe and economical production processes that benefit both customers and the business.

Summary of assessment

This unit is assessed using an onscreen test, set and marked by Pearson. The test contains different types of question and is worth 60 marks. The test duration is 75 minutes. The assessment is available on demand. The first assessment is available in March 2018.

No on-screen calculator is available to learners. Learners/Centres must provide a basic scientific calculator (non-programmable) that includes Trig and Pi functions. Learners should be familiar with the calculators before the assessment.

Sample assessment materials will be available to help centres prepare learners for assessment.
UNIT 1: ENGINEERING PRINCIPLES

Assessment outcomes

**AO1** Demonstrate knowledge of mathematical and scientific key terms, units and formulae used by production operatives in electrical and mechanical engineering
Command words: calculate, convert, give, identify, link, list, match, name, state
Marks: ranges from 1 to 3 marks

**AO2** Demonstrate understanding of the principles and methods related to electrical and mechanical science and mathematics
Command words: calculate, describe, explain, interpret, plot
Marks: ranges from 1 to 4 marks

**AO3** Perform mathematical procedures to solve problems in an engineering context
Command words: calculate, factorise, simplify
Marks: ranges from 1 to 4 marks

**AO4** Analyse and interpret information to make connections and solve problems in an engineering context
Command words: analyse, assess, discuss
Marks: ranges from 1 to 6 marks
Essential content

The essential content is set out under content areas. Learners must cover all specified content before the assessment. Equations that learners must recall can be found at the end.

A Arithmetic, algebraic and graphical methods in engineering contexts

A1 Arithmetic methods

- Arithmetic precedence (BODMAS rule) – brackets, order, division, multiplication, addition, subtraction.
- Addition, subtraction, multiplication and division of whole and decimal numbers.
- Fractions and percentages, percentage error.
- Conversion of length, area and volume between SI units and imperial.
- Engineering calculations involving ratios.
- Positive and negative integers.
- Circles – radius ($r$), diameter ($2r$), circumference ($\pi d$).
- Use of symbols $=, \neq, <, >, \leq, \geq$.
- Powers and roots of numbers, including squares, square roots, cubes and cube roots.
- Answer to a specified number of significant figures.

A2 Algebraic methods

- Change the subject of an equation.
- Substitute numerical values into algebraic equations.
- Solve simple algebraic equations for:
  - a single variable
  - systems of linear equations.

A3 Graphical methods

- Recognise and label axes, grid lines, origin, scales.
- Identify coordinates in all four quadrants.
- Interpret straight-line graphs in the $x, y$ coordinate plane of the form $y = mx + c$
- Identify gradients and intercepts of linear functions graphically.
- Interpret results from distance–time graphs, velocity–time graphs.
- Plot linear data and assess line of best fit.

B Mensuration and trigonometry in engineering contexts

B1 Areas of regular and compound shapes

- Calculate areas of simple shapes – rectangle ($w \times l$), triangle ($\frac{1}{2}bh$), circle ($\pi r^2$), sphere ($4\pi r^2$), curved surface of a cylinder ($\pi dh$).
- Use simple shapes to solve objects with compound shapes.

B2 Volumes of regular and compound three-dimensional objects

- Calculate volume of simple objects (hollow and solid) – rectangular prism ($w \times h \times l$), cylinder ($\pi r^2h$), sphere ($\frac{4}{3}\pi r^3$).
- Use simple objects to solve compound objects (hollow and solid).
B3 Trigonometry
Understand and apply to engineering contexts:
• Pythagoras’ theorem, $a^2 + b^2 = c^2$, side lengths of right-angled triangles
• right-angled triangle functions (use of sine, cosine, tangent).

C Concepts and principles relating to electrical science in engineering contexts

C1 Direct current electrical circuits
• Know the definitions and units:
  o circuit parameters, including voltage (V), current (A), resistance (Ω).
• Recognise:
  o circuit symbols – battery, fixed value resistor, switch, ammeter, voltmeter, lamp, fuse, transistor, diode, light-emitting diode (LED)
  o simple series and parallel circuit diagrams.
• Apply the appropriate formulae to solve electrical circuit problems:
  o calculate values of resistors in a series circuit $R_T = R_1 + R_2 + R_n (\Omega)$
  o calculate values of resistors in parallel $1/R_T = 1/R_1 + 1/R_2 + 1/R_n (\Omega)$
  o use Ohm’s law to carry out circuit calculation $V = IR$
  o circuit power ($P = VI, P =I^2R$)
  o resistance, currents and potential differences in series or parallel circuits using Ohm’s law.

C2 Magnets
Understand how magnets work, including:
• bar magnets:
  o magnetic poles, north and south
  o unlike poles, like poles – attract and repel
  o magnetic field pattern
  o concentration of the fields
• simple electromagnets, definitions and units:
  o magnetic circuit theory – interaction between a current-carrying conductor and magnetic field
  o flux density (wb)
  o number of coils
  o applied voltage (V)
  o materials used to make a simple electromagnet
  o factors that affect field strength.

D Concepts and principles relating to mechanical science in engineering contexts

D1 Parameters of static and dynamic mechanical systems
• Know the definitions and units:
  o mass (kg), weight (N), force (N)
  o moment of a force, $M = Fd$ (Nm)
  o energy and work done (Joules), power (Watts)
  o pressure ($P = \frac{F}{A}$)
  o acceleration due to gravity ($g = 9.81 \text{ ms}^{-2}$)
  o displacement ($s$)
• linear velocity \((\text{ms}^{-1})\)
• density \((\text{mass}/\text{volume})\), mass per unit volume \((\text{kgm}^{-3})\)
• rotational speed \((\text{revolutions per minute, RPM})\)
• acceleration/deceleration \((\text{ms}^{-2})\).

• Apply the appropriate formulae to solve problems:
  o potential energy \((PE = mgh)\)
  o kinetic energy \((KE = 1/2 mv^2)\)
  o relationship between work, force, distance moved and energy:
    - work done = force \times distance moved \((E = F \times d)\)
    - work done is equal to energy transferred
    - power as the rate of transfer of energy or the rate of doing work \((P = \frac{W}{t} \text{ or } P = \frac{\text{energy}}{\text{time}})\).

D2 Statics

• Know the definitions and units:
  o forces and stress – force \((F = ma = mg)\), mass/weight relationship \((W = mg)\).

• Apply the appropriate method to solve problems:
  o vector representation of forces (two forces – horizontal and vertical forces only)
  o use and interpret simple force diagrams
  o determination of magnitude and direction of resultant forces.

• Understand the properties and behaviour of fluids and gases:
  o understand the relationship between atmospheric, gauge and absolute pressure
  o solve problems involving pressure at depth in a fluid: the relationship \(P = \rho gh\)
  o understand that the pressure at a point in a fluid which is at rest acts equally in all directions.

D3 Dynamics

Understand the meaning and be able to describe and calculate the motion of objects:

• the difference between distance and displacement
• the difference between speed and velocity
• the motion of objects: stationary, constant velocity, acceleration, deceleration
• distance, time, speed \((\text{speed} = \frac{\text{distance}}{\text{time}})\), average speed \(= \frac{\text{distance moved}}{\text{time taken}}\)
• calculate velocity using \(v = u + at\)
• calculate displacement using \(s = \frac{1}{2} (u + v)t\)

D4 Mechanical systems

Understand the purpose and operation of basic mechanical systems:

• levers – input, output, fulcrum, load, length
• pulleys – simple pulley, double pulley, diameters
• gear wheels – driver, driven, intermediate/idler, simple gear trains, number of teeth, direction of rotation
• calculations involving basic mechanical systems:
  mechanical advantage = load/effort
  efficiency = work output/work input
Grade descriptors

To achieve a grade learners are expected to demonstrate these attributes across the essential content of the unit. The principle of best fit will apply in awarding grades.

Level 2 Pass

Learners will demonstrate a basic knowledge of arithmetic, algebraic and graphical methods and will show a limited application of them to engineering contexts provided. They will be able to calculate the volume and area of simple shapes and use a limited amount of trigonometry. They will demonstrate basic understanding and application of electrical and mechanical science concepts and principles in relation to engineering, and will be able to solve basic scientific and mathematical problems.

Level 2 Distinction

Learners will demonstrate a comprehensive knowledge of arithmetic, algebraic and graphical methods and will be able to apply them to given engineering contexts in order to solve high-level problems. They will be able to calculate the volume and area of complex shapes and use trigonometry effectively to calculate side lengths and angles. They will understand and apply electrical and mechanical science concepts and principles fully in relation to engineering and can solve complex scientific and mathematical problems, making recommendations based on evidence found.

Key words typically used in assessment

The following table shows the key words that will be used consistently by Pearson in our assessments to ensure learners are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

<table>
<thead>
<tr>
<th>Command or term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyse</td>
<td>Use ideas or concepts to explore something carefully, breaking it down into factors and giving comments on which are most important or relevant.</td>
</tr>
<tr>
<td>Assess</td>
<td>Give careful consideration to all the factors or events that apply and reach a conclusion about which are the most important or relevant.</td>
</tr>
<tr>
<td>Calculate</td>
<td>Determine the answer using mathematical methods.</td>
</tr>
<tr>
<td>Complete</td>
<td>Finish a task by adding to given information.</td>
</tr>
<tr>
<td>Convert</td>
<td>Convert the form of a measurement to different units without a change of size or amount.</td>
</tr>
<tr>
<td>Describe</td>
<td>Give an account of something, such as steps in a process or characteristics of something. The response should be developed but does not require justification or reasoning.</td>
</tr>
</tbody>
</table>
### Links to other units

This is a mandatory unit and underpins knowledge throughout the qualification.

### Employer involvement

Centres may involve employers in the delivery of this unit if there are local opportunities.

There is no specific guidance related to this unit.

---

<table>
<thead>
<tr>
<th>Command or term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discuss</td>
<td>Consider different aspects of a topic, how they interrelate and the extent to which they are important.</td>
</tr>
<tr>
<td>Explain</td>
<td>Provide reasoning to justify or exemplify a point. Answer should respond to the question and provide reasons.</td>
</tr>
<tr>
<td>Factorise</td>
<td>Take out the common factor or factorise into two brackets if a quadratic.</td>
</tr>
<tr>
<td>Give</td>
<td>State an example or name something.</td>
</tr>
<tr>
<td>Identify</td>
<td>Provide or select an answer from a number of alternatives.</td>
</tr>
<tr>
<td>Interpret</td>
<td>Define or explain the meaning of something.</td>
</tr>
<tr>
<td>Label</td>
<td>Name or link something to its correct name.</td>
</tr>
<tr>
<td>Link</td>
<td>Information is matched or a description or explanation is used to give a clearer indication of answer.</td>
</tr>
<tr>
<td>List</td>
<td>List a number of features or points without further elaboration.</td>
</tr>
<tr>
<td>Match</td>
<td>Link information to the correct answer from a list of options.</td>
</tr>
<tr>
<td>Measure</td>
<td>Determine the size, amount, voltage, pressure or other parameters etc., or to specify with appropriate units in extent, amount, etc.</td>
</tr>
<tr>
<td>Name</td>
<td>Give the correct term for something.</td>
</tr>
<tr>
<td>Plot</td>
<td>Represent data on a graph.</td>
</tr>
<tr>
<td>Select</td>
<td>Choose the best or most suitable option.</td>
</tr>
<tr>
<td>Simplify</td>
<td>Collect terms together or cancel down.</td>
</tr>
<tr>
<td>State</td>
<td>Write clearly, listing facts.</td>
</tr>
</tbody>
</table>
### Recall and application of equations

Learners should be able to recall and apply the following equations using standard SI units,

<table>
<thead>
<tr>
<th>Term</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation of a straight-line graph</td>
<td>$y = mx + c$</td>
</tr>
<tr>
<td>Area of a rectangle</td>
<td>$w \times l$</td>
</tr>
<tr>
<td>Area of a triangle</td>
<td>$\frac{1}{2}bh$</td>
</tr>
<tr>
<td>Area of a circle</td>
<td>$\pi r^2$</td>
</tr>
</tbody>
</table>

Learners will not need to recall the following equations to solve calculation based problems, but may be asked to apply them and recall standard SI units.

The relevant equation(s) will be given within each question.

Learners may also need to ‘identify’ the correct equation from a list of alternatives.

<table>
<thead>
<tr>
<th>Term</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The curved surface area of a cylinder</td>
<td>$\pi dh$</td>
</tr>
<tr>
<td>Area of a sphere</td>
<td>$4\pi r^2$</td>
</tr>
<tr>
<td>Volume of a rectangular prism</td>
<td>$whl$</td>
</tr>
<tr>
<td>Volume of a cylinder</td>
<td>$\pi r^2h$</td>
</tr>
<tr>
<td>Volume of a sphere</td>
<td>$\frac{4}{3}\pi r^3$</td>
</tr>
<tr>
<td>Pythagoras’ theorem</td>
<td>$a^2 + b^2 = c^2$</td>
</tr>
<tr>
<td>Ohm’s law</td>
<td>$V = IR$</td>
</tr>
<tr>
<td>Circuit power</td>
<td>$P = VI, P = FR$</td>
</tr>
<tr>
<td>Pressure</td>
<td>$P = \frac{F}{A}$</td>
</tr>
<tr>
<td>Term</td>
<td>Equation</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Potential energy</td>
<td>$PE = mgh$</td>
</tr>
<tr>
<td>Kinetic energy</td>
<td>$KE = \frac{1}{2}mv^2$</td>
</tr>
<tr>
<td>Power</td>
<td>$P = \frac{W}{t}$</td>
</tr>
<tr>
<td>Pressure at depth</td>
<td>$P = \rho gh$</td>
</tr>
<tr>
<td>Speed</td>
<td>$\text{speed} = \frac{\text{distance}}{\text{time}}$</td>
</tr>
<tr>
<td>Velocity</td>
<td>$v = u + at$</td>
</tr>
<tr>
<td>Mechanical advantage</td>
<td>$MA = \text{load/effort}$</td>
</tr>
<tr>
<td>Values of resistors in a series circuit</td>
<td>$R_T = R_1 + R_2 + R_n(\Omega)$</td>
</tr>
<tr>
<td>Values of resistors in parallel</td>
<td>$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_n}(\Omega)$</td>
</tr>
<tr>
<td>Density</td>
<td>$\rho = \frac{m}{V}$</td>
</tr>
<tr>
<td>Work done</td>
<td>$E = F \times d$</td>
</tr>
<tr>
<td>Force</td>
<td>$F = ma = mg$</td>
</tr>
<tr>
<td>Mass/Weight relationship</td>
<td>$W = mg$</td>
</tr>
<tr>
<td>Gravity</td>
<td>$g = 9.81 \text{ ms}^{-2}$</td>
</tr>
<tr>
<td>Moment of a force</td>
<td>$M = Fd \ (\text{Nm})$</td>
</tr>
<tr>
<td>Efficiency</td>
<td>work output/work input</td>
</tr>
<tr>
<td>Displacement</td>
<td>$s = \frac{1}{2}(u + v)t$</td>
</tr>
</tbody>
</table>
Unit 2: Processes and Materials

Level: 2
Unit type: Mandatory
Assessment type: External
Guided learning hours: 45

Unit in brief

Learners are introduced to the different processes and materials used in engineering. They learn the knowledge and skills needed to make the correct choices when selecting materials and processes for particular products or applications.

Unit introduction

Have you ever wondered what the products that we use every day are made of, or how each product is manufactured? Items such as washing machines, motor vehicles and games consoles are made from a range of materials that have been selected by engineers as being best suited to that product, using the most appropriate method of manufacture to ensure the product is successful. Engineers must be aware of the properties and characteristics of common engineering materials if they are to make good decisions about which materials and processes to use. If a product is to be commercially viable, then other factors also need to be considered, for example the materials it is made from and the manufacturing processes it follows need to be cost-effective and sustainable. Also, engineered products need to be made to last so it’s likely that they will need to be treated in some way to make sure they do.

This unit will develop your understanding of material properties and characteristics and how they can be processed, as well as the applications of a range of common materials you may encounter in engineering. You will investigate how materials can be obtained and the methods that can be used to treat them. You will select materials and suitable manufacturing processes for different engineered products and give reasons for your choices.

The knowledge you develop in this unit is essential to a production operative working in any sector of engineering and will contribute to your understanding of how and why products are designed and manufactured in a specific way.

Summary of assessment

This unit is assessed using an onscreen test, set and marked by Pearson. The test contains different types of question and is worth 60 marks. The test duration is 75 minutes. The assessment is available on demand. The first assessment is available in March 2018.

Sample assessment materials will be available to help centres prepare learners for assessment.
Assessment outcomes

**AO1** Demonstrate knowledge of engineering products, processes and materials used by production operatives
Command words: complete, define, give, identify, label, link, match, name, state
Marks: ranges from 1 to 3 marks

**AO2** Demonstrate understanding of relationships between engineering materials, processes and their applications
Command words: calculate, complete, define, describe, explain, identify, label, link, match
Marks: ranges from 1 to 4 marks

**AO3** Analyse information in order to evaluate materials and processes in an engineering context
Command words: analyse, compare, describe, evaluate, explain
Marks: ranges from 1 to 4 marks

**AO4** Make connections, apply and integrate engineering principles and concepts to make supported judgements
Command words: analyse, assess, compare, discuss, evaluate, justify
Marks: ranges from 1 to 6 marks
Essential content

The essential content is set out under content areas. Learners must cover all specified content before the assessment.

A Engineering processes

A1 Mechanical and electrical/electronic engineering processes

- Processes and features, including health and safety issues, characteristics, applications and advantages/disadvantages:
  - material removal – turning, milling, drilling, etching
  - centre lathe:
    - features – chuck, carriage, tool post, tailstock, emergency stop, control lever, gearbox
    - machining operations – drilling/centre drilling, parallel turning, taper turning, facing off, screw cutting, countering, countersinking, chamfering, boring, parting off, knurling
  - milling machine:
    - features – spindle, arbour, table, saddle, knee, machine head, on/off switch
    - machining operations – drilling/centre drilling, end milling, slot milling, countering, countersinking, boring, tapping, profile cutting
  - drilling machine:
    - features – spindle, table, chuck, stand, column, on/off switch, speed belts
    - machining operations – drilling/centre drilling, countering, countersinking, boring, tapping
  - safe operation of machinery – use of guards, personal protective equipment (PPE), securing work in chuck/vice, risk assessments
  - shaping and manipulation – sand casting, die casting, vacuum forming, injection moulding, blow moulding, bending, forging
  - assembly and joining – welding, soldering, adhesion, brazing, threaded fasteners, rivets.

- Recognition and usage:
  - marking-out tools – scriber, centre punch, steel rule, dividers, engineers square, height gauge, surface plate, angle plate, scribbling block, odd leg calipers
  - cutting tools – hacksaw, junior hacksaw, side cutters, wire strippers, tap wrench, taps and dies, die stock, PCB drill, files
  - joining tools – soldering iron, spanners, screwdriver, pliers, hammer
  - work-holding tools – machine vice, mechanics vice, G clamps, three-jaw chuck, four-jaw chuck, clamping kits, rotary table, dividing head, vee blocks
  - testing/inspection tools – multimeter, oscilloscope, micrometer, vernier caliper, tape measure, inside and outside calipers, gauges.

- Understanding of uses of PPE, including:
  - eye protection, ear protection, hand protection, protective clothing, head protection, protective footwear, respiratory protection.

- Recognition and understanding of signs and symbols:
  - mandatory – require actions or activities that contribute towards safety: wear protective footwear, protective clothing, eye protection, hand protection, ear protection, head protection, face mask, respirator
  - warning – warning of potential risks: toxic material, oxidising material, hazardous to the environment, flammable materials, corrosive, irritant, explosive material, slippery surface
  - prohibition – prohibition of actions detrimental to safety: no admittance to unauthorised personnel, not drinking water, do not run, do not enter, no naked flames
safe condition – indication of important areas in the event of a fire or emergency: first aid, fire exit, emergency shower, emergency eye wash, emergency stop, disabled refuge point, assembly point
fire equipment – indication of location of fire equipment: fire alarm, fire hydrant, fire hose reel, fire extinguisher.

A2 Modern production methods
Features, applications and advantages/disadvantages of:
- robots for transportation, pick and place, assembly operations, welding, painting, inspection
- Computer Numerical Control (CNC) machinery for milling, turning, rapid prototyping
- surface mount technology for printed circuit boards (PCBs).

B Engineering materials
B1 Properties of materials
Definitions:
- thermal conductivity – the ability of a material to transmit heat energy
- electrical conductivity – the ability of a material to carry electrical current
- magnetic – the ability of a material to attract and repel another material
- translucence – the ability of a material to allow some light to pass through it
- transparency – the ability of a material to allow light to pass through
- tensile strength – the ability of a material to withstand stretching without breaking
- compressive strength – the ability of a material to be squeezed without breaking
- hardness – the ability of a material to withstand wear, abrasion or indentation
- toughness – the ability of a material to withstand bending without fracture
- brittleness – the ability of a material to break with little or no deformation
- elasticity – the ability of a material to go back to its original length after being stretched or compressed
- plasticity – the ability of a material to be easily shaped or moulded
- malleability – the ability of a material to permit plastic deformation in compression without fracturing
- ductility – the ability of a material to show considerable plastic deformation before breaking
- stiffness – the ability of a material to resist bending without fracture
- corrosion resistance – the ability of a material to resist deterioration by reacting with its immediate environment
- chemical/solvent resistance – the ability of a material to resist chemical attack
- wear resistance – the ability of a material to resist the removal and deformation of material from its surface as a result of mechanical action.

B2 Characteristics of materials
Properties, characteristics, applications and advantages/disadvantages:
- metals – crystal lattice structure, grain structure, crystal growth
- polymeric materials – monomer, polymer, polymer chains
- composite materials – particulate, laminar, fibre reinforcement, fibre alignment.
B3 Materials used in engineering
Types, definitions, properties, applications and advantages/disadvantages:
• ferrous metals and alloys – carbon steels (low, medium, high), cast iron, stainless steel
• non-ferrous metals and alloys – aluminium, copper, zinc, tin, magnesium, duralumin, brass, bronze
• composite materials – glass reinforced fibre (GRP), carbon fibre, Kevlar®
• thermoplastic polymers – polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), polystyrene (PS), acrylic, polycarbonate (PC), nylon, polythene (PE)
• thermosetting polymers – polyester resin, melamine formaldehyde, urea-formaldehyde, epoxy resin
• elastomers – natural rubber, polybutadiene rubber, neoprene
• smart materials – shape-memory alloys (SMAs), shape-memory polymers (SMPs), electrochromic, thermochromic, piezoelectric materials.

B4 Treatments
Applications, characteristics and advantages/disadvantages:
• surface treatments – plating, painting, plastic coating, anodising, galvanising, polishing
• heat treatments for metals – annealing, hardening, tempering, normalising, case hardening.

C Material sustainability and forms of supply
C1 Sustainability of engineering materials
Characteristics, key features, methods, applications and advantages/disadvantages:
• reducing material use by tessellation, lay planning, choosing the correct form of material supply, changing design to minimise materials used
• reusing materials and products by repurposing
• recycling materials by using correct receptacles – separating materials
• safe disposal of material including hazardous and non-hazardous, biodegradation.

C2 Forms of material supply
Features, applications and advantages/disadvantages of:
• bar stock
• sheet
• pipe
• tube
• plate
• castings
• forgings
• wire
• powders
• mouldings
• granules
• resins
• film
• pellets
• channel
• extrusion.
C3 Material investigation

Material investigation, selection and justification considering required properties, features, costs, treatment and life cycle taken from the following sectors.

- Aerospace, including engines, wings, rotor blades, landing gear.
- Automotive, including engines, body panels, wheels, exhaust systems, braking systems, car bumpers.
- Communications, including satellite dishes, smartphones, wireless routers, transmission masts.
- Electrical/electronic, including white goods, televisions, games consoles, laptop computers, small kitchen appliances.
- Mechanical, including bicycles, wheelbarrows, mechanics’ vices, BBQs, fixtures and fittings.
Grade descriptors

To achieve a grade learners are expected to demonstrate these attributes across the essential content of the unit. The principle of best fit will apply in awarding grades.

Level 2 Pass

Learners will have a sound understanding of key terms, processes and technologies and will be able to recall and apply knowledge in familiar situations, including definitions and properties of materials. They will be able to interpret information in order to select and apply knowledge of engineering products, processes, materials and technologies to given situations. They will be able to define and communicate key aspects of engineering processes, selecting appropriate actions in more simple and familiar contexts. They will have a sound understanding of the use of materials in given engineering sectors. They will be able to define stages of the life cycle of materials and be able to relate knowledge of engineering and the way in which engineering relates to sustainability in vocational and realistic situations, making some decisions on valid applications and impact. They will be able to recognise the forms of material supply and will show some understanding of material investigation and selection for familiar engineered products in a number of engineering sectors. They will be able to relate the use of engineering processes and modern products to users and purposes.

Level 2 Distinction

Learners will be able to synthesise knowledge of engineered products, the materials used to make them and engineering processes, bringing together understanding of technologies. They will be able to apply understanding of engineering processes to complex contexts such as modern manufacturing techniques. They will show depth of knowledge and development of understanding of engineering processes and technologies in different situations, being able to make effective judgements based on analysis of given information. They will be able to compare techniques, processes, products and materials to evaluate alternatives against defined criteria. Learners will be able to apply understanding of material properties, characteristics and their uses in given engineering sectors. They will show depth of knowledge and development of understanding of the life cycle of materials, sustainability and environmental impact. They will be able to investigate material use in engineered products, applying knowledge to make informed justifications and conclusions on familiar engineered products. Learners will be able to analyse engineering products, selecting appropriate materials and making recommendations about applications of processes and their environmental impact. They will be able to make judgements about the efficiency of manufacturing systems and potential impacts on product quality and the environment, making recommendations about solutions, controls and future planning.
### Key words typically used in assessment

The following table shows the key words that will be used consistently by Pearson in our assessments to ensure learners are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

<table>
<thead>
<tr>
<th>Command or term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyse</td>
<td>Use ideas or concepts to explore something carefully, breaking it down into factors and giving comments on which are most important or relevant.</td>
</tr>
<tr>
<td>Assess</td>
<td>Give careful consideration to all the factors or events that apply and reach a conclusion about which are the most important or relevant.</td>
</tr>
<tr>
<td>Compare</td>
<td>Identify the main factors that apply in two or more situations and explain the similarities and differences or advantages and disadvantages.</td>
</tr>
<tr>
<td>Complete</td>
<td>Finish a task by adding to given information.</td>
</tr>
<tr>
<td>Define</td>
<td>Give the meaning of a term or phrase.</td>
</tr>
<tr>
<td>Describe</td>
<td>Give an account of something, such as steps in a process or characteristics of something. The response should be developed but does not require justification or reasoning.</td>
</tr>
<tr>
<td>Discuss</td>
<td>Consider different aspects of a topic, how they interrelate and the extent to which they are important.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Bring together all information and review it to form a conclusion. Give evidence for each view or statement.</td>
</tr>
<tr>
<td>Explain</td>
<td>Provide reasoning to justify or exemplify a point. Answer should respond to the question and provide reasons.</td>
</tr>
<tr>
<td>Give</td>
<td>State an example or name something.</td>
</tr>
<tr>
<td>Identify</td>
<td>Provide or select an answer from a number of alternatives.</td>
</tr>
<tr>
<td>Justify</td>
<td>Give reasons or evidence to support an opinion.</td>
</tr>
<tr>
<td>Label</td>
<td>Name or link something to its correct name.</td>
</tr>
<tr>
<td>Link</td>
<td>Information is matched or a description or explanation is used to give a clearer indication of answer.</td>
</tr>
<tr>
<td>List</td>
<td>List a number of features or points without further elaboration.</td>
</tr>
<tr>
<td>Match</td>
<td>Link information to the correct answer from a list of options.</td>
</tr>
<tr>
<td>Command or term</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
</tr>
<tr>
<td>Name</td>
<td>Give the correct term for something.</td>
</tr>
<tr>
<td>Select</td>
<td>Choose the best or most suitable option.</td>
</tr>
<tr>
<td>State</td>
<td>Write clearly, listing facts.</td>
</tr>
<tr>
<td>Summarise</td>
<td>Write down or articulate briefly the main points or essential features.</td>
</tr>
</tbody>
</table>

**Links to other units**

This is a mandatory unit and underpins knowledge throughout the qualification.

**Employer involvement**

Centres may involve employers in the delivery of this unit if there are local opportunities. There is no specific guidance related to this unit.
Unit 3: Business Improvement Techniques

Level: 2
Unit type: Mandatory
Assessment type: Internal
Guided learning hours: 30

Unit in brief

Learners apply business improvement techniques to eliminate waste, reorganise a work area and learn about visual management techniques.

Unit introduction

Everyone who works in an engineering organisation has a responsibility to contribute to improving the business, so if you plan to work in engineering you need to understand how business improvement techniques are identified and applied. Many organisations have a strong culture of continuous improvement and will encourage you to take ownership of improvement activities and develop working practices to increase efficiency, safety and quality, while at the same time reducing cost.

In this unit, you will investigate and carry out a range of business improvement techniques that are common in the workplace. This will include changing business processes in order to reduce waste and reorganising a work area to make it safer and more efficient. You will learn how visual management techniques help communication on the shop floor and how these can be applied in a range of circumstances.

This unit will prepare you for work in the engineering sector by giving you the skills to assess and improve your own work environment to make it more efficient and cost-effective.

Learning aims

In this unit you will:

A Implement waste minimisation techniques in the engineering workplace
B Make improvements to workplace organisation using a 5S workplace scan
C Employ methods of visual management in the engineering workplace.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
</table>
| A Implement waste minimisation techniques in the engineering workplace | A1 Analysing a process  
A2 Types of waste  
A3 Benefits of reducing waste | A portfolio of evidence, including:  
• observation records  
• flow charts  
• 5S workplace scan checklist  
• visual management examples  
• annotated photographs/sketches  
• written notes evaluating the benefits gained. |

| B Make improvements to workplace organisation using a 5S workplace scan | B1 Implementing 5S workplace organisation  
B2 Benefits of 5S workplace organisation | — |

| C Employ methods of visual management in the engineering workplace | C1 Visual management methods  
C2 Characteristics of effective visual management methods  
C3 The benefits of visual management methods | — |

### Key teaching areas in this unit include:

<table>
<thead>
<tr>
<th>Sector skills</th>
<th>Knowledge</th>
<th>Transferable skills/behaviours</th>
</tr>
</thead>
</table>
| • Carrying out process mapping  
• Identifying and reducing waste  
• Implementing 5S  
• Using visual management techniques | • Understanding the different types of waste  
• Understanding the importance of good workplace organisation  
• Understanding the benefits of using visual management techniques | • Communication  
• Problem solving  
• Managing information |
Unit content

Knowledge and sector skills

Learning aim A: Implement waste minimisation techniques in the engineering workplace

A1 Analysing a process
- Creating and analysing process maps (flow charts).
- Identifying value-added activities, e.g. drilling a hole, fitting a component.
- Identifying non-value added activities, e.g. changing tooling, moving materials.
- Processes to reduce/eliminate non-value added activities and minimise waste.

A2 Types of waste
- Common types of waste found in industrial processes, to include transport, inventory, motion, waiting, overproduction, over processing, defects, skills/unrecognised people potential.

A3 Benefits of reducing waste
Benefits of reducing waste, to include:
- reduced cost, e.g. lower production costs, lower transport costs
- improved quality, e.g. fewer defects, less time correcting mistakes
- improved safety, e.g. fewer delays caused by accidents
- improved working practices, e.g. reducing unnecessary operator movement
- improved delivery, e.g. reduced transportation time, reduced lead time
- reduction of waste materials, e.g. reduced scrap rates
- improved resource utilisation, e.g. reduced waiting time, increased efficiency
- improved customer satisfaction, e.g. meeting customer orders on time and to specification.

Learning aim B: Make improvements to workplace organisation using a 5S workplace scan

B1 Implementing 5S workplace organisation
- Use of 5S workplace scan checklists.
- Stages of implementation of 5S:
  - sort – eliminate whatever is not needed or no longer used
  - straighten – organise whatever remains, having a place for everything and everything in its place
  - shine – clean the work area
  - standardise – schedule regular cleaning and maintenance
  - sustain – continuously review and improve workplace organisation.

B2 Benefits of 5S workplace organisation
Benefits of implementing 5S, to include:
- increased safety, reduction of unnecessary operator movement, improved productivity, increased quality, increased employee sense of involvement and ownership of their working environment, increased morale.
Learning aim C: Employ methods of visual management in the engineering workplace

C1 Visual management methods
Different visual management methods, to include:

- shadow boards, colour coding, floor footprints, storyboards, gauges, photographs/pictures, labelling, lights, Kanban (pull systems), graphs.

C2 Characteristics of effective visual management methods

- Effective visual management methods should be accurate and relevant, eye-catching, simple, clear and easy to understand at a glance.

C3 The benefits of visual management methods

Key benefits of visual management, to include:

- increased effectiveness of communication by making information easier to understand, enabling quick decisions to be made based on what we see, key processes easily understood by everyone, customer satisfaction visible in (or near) real time.

Transferable skills

Communication

- Understanding the use and importance of visual communication methods in order to convey complex information simply and quickly.

Problem solving

- Eliminating problematic waste from processes by using mapping techniques to identify areas for improvement.

Managing information

- Understanding how potentially complex information can be distilled into a simple visual format, which is clear and easily understood at a glance.
Assessment criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning aim A: Implement waste minimisation techniques in the engineering workplace</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.P1 Map a business process and identify unnecessary waste.</td>
<td>A.M1 Make changes to a business process in order to minimise waste, based on a comprehensive process map.</td>
<td>A.D1 Evaluate the benefits gained from identifying and minimising waste in a business process.</td>
</tr>
<tr>
<td>A.P2 Make changes to a business process in order to reduce waste.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Learning aim B: Make improvements to workplace organisation using a 5S workplace scan** | | |
| B.P3 Carry out a 5S workplace scan using an appropriate checklist. | B.M2 Implement 5S effectively in a workplace based on a comprehensive 5S workplace scan. | B.D2 Evaluate the benefits gained from the effective implementation of 5S in a workplace. |
| B.P4 Implement basic 5S recommendations in a workplace. | | |

| **Learning aim C: Employ methods of visual management in the engineering workplace** | | |
| C.P5 Identify part of a business process that could be improved by implementing a visual management technique. | C.M3 Implement an effective visual management technique on part of a business process that can be significantly improved. | C.D3 Evaluate the benefits gained by the implementation of an effective visual management technique to significantly improve part of a business process. |
| C.P6 Implement a basic visual management technique to improve a business process. | | |
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:
- produce a comprehensive process map and make feasible suggestions for process changes to minimise waste identified, with an evaluation of the benefits gained from each change, e.g. reordering the steps in the process so that all operations using the same machine are performed together, eliminating unnecessary movement, increasing the flexibility of a production operative through training and upskilling to allow them to move bottlenecks in the process, reducing waiting times between operations. Upskilling a member of staff so that they can take on numerous roles and responsibilities is likely to have the greatest long-term benefit.

For merit standard, learners will:
- produce a comprehensive process map for the manufacture of a product or delivery of an engineering service. The process map will contain no omissions or oversimplifications
- identify at least four non-value added steps
- make changes to the business process flow chart to reduce or eliminate the non-value-added steps identified, minimising waste in the entire process. In each case the process changes should be feasible in practice
- ensure all flow charts accurately reflect the processes being mapped and that they are logically structured, laid out clearly and easy to follow. Annotation will be used where appropriate to provide additional information on process changes.

For pass standard, learners will:
- produce a process map for the manufacture of a product or delivery of an engineering service. The resulting flow chart may contain some omissions or oversimplifications, e.g. transporting components between work areas may be on the chart as a single step. This should be broken down further into loading, moving, unloading etc.
- identify at least two non-value-added steps
- make changes to the business process flow chart to reduce or eliminate the two non-value-added steps identified. In each case, the process changes should be feasible in practice, e.g. reordering the steps in the process so that all operations using the same machine are performed together, which will eliminate unnecessary movement
- ensure all flow charts accurately reflect the process being mapped and should be logically structured and easy to follow.

Learning aim B

For distinction standard, learners will:
- conduct all aspects of 5S implementation in a clearly organised, methodical and systematic manner
- cover all aspects of the designated workplace and the implementation will be comprehensive
- provide an evaluation of the benefits of implementing each phase of 5S and at the end of the process evaluate the benefits gained from the implementation as a whole.

For merit standard, learners will:
- carry out a detailed and comprehensive 5S workplace scan using a given checklist
- show a systematic approach that will result in the production of a comprehensive workplace scan, covering all relevant aspects of the workplace
- implement the sort, straighten, shine and standardise phases of 5S (guided by the work area scan)
- show a clearly organised, methodical and systematic approach to their work, resulting in all the points identified in the workplace scan being addressed.
**For pass standard**, learners will:
- carry out a workplace scan using a given checklist. They may lack a systematic approach to the workplace scan and miss some items in the workshop that should have been recorded
- implement the sort, straighten, shine and standardise phases of 5S (guided by the work area scan). They may lack a clearly organised, methodical and systematic approach to their work, which may lead to some points identified in the workplace scan not being addressed.

**Learning aim C**

**For distinction standard**, learners will:
- clearly identify the benefits gained by the implementation of an effective visual management technique and compare them with any associated costs or limitations
- evaluate whether the benefits outweigh any associated costs or limitations, e.g. if complex written manufacturing instructions are replaced with a series of photographs showing the stages of assembly, the primary benefits might be saving time and reducing the number of errors. Costs will be incurred in generating the required photographs, and a limitation might be that even relatively small changes to the product or stages of assembly might require entirely new photographic guides to be generated. Learners may then come to the reasonable conclusion that for high-volume established products, the use of photographic guides will provide benefits that outweigh any associated costs or limitations.

**For merit standard**, learners will:
- identify a part of a business process where visual management techniques could provide significant improvement. It should be clear which part of the process has been identified, the significance of the expected improvement and the visual management technique to be used
- implement a visual management technique by creating the necessary visual elements and providing notes on their use in practice. The visual elements will have the characteristics necessary for them to be effective, e.g. they will be accurate and relevant, eye-catching, simple, clear and easy to understand at a glance.

**For pass standard**, learners will:
- identify a part of a business process where visual management techniques could improve performance. It should be clear which part of the process has been identified for improvement and which visual management technique is to be used
- implement the visual management technique by creating the necessary visual elements and providing notes of their use in practice, e.g. complex written manufacturing instructions might be replaced with a series of clear photographs showing the stages required in the assembly of a product.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

There is potential in this unit for centres to provide assessments set with employer input, for example employers could provide assessment support by giving learners access to work areas that need review or simulate issues in the work area for learners to improve, using the techniques learned in the unit.

Suggested scenario

You are a production operative working in a local factory. Your team leader has asked you to come to the next team meeting with ideas and suggestions of how to improve business practices by identifying and minimising waste, possible visual management practices, and how a 5S workplace scan might impact positively on the factory.

Your team leader has asked you to walk through the manufacturing process for a product produced in your factory, and to create a process map in the form of a flow chart, which details all the steps required. Once a comprehensive process map is completed, you will need to use this to identify any non-value-added activities and suggest changes to the process that will eliminate waste. You should aim to minimise waste at every stage of the process. You will then redraw the process map to reflect the suggested changes and walk through the new process.

You are also asked to identify an area in your factory where implementing a visual management technique will provide significant benefits. Once identified, you will implement an effective visual management technique in this area.

Your company has also decided to implement 5S throughout your factory. Your team leader has asked you to take photographs of your work area and complete a detailed 5S scan checklist. You should use the completed 5S scan checklist when implementing 5S in your workplace, to ensure this is completed effectively. Once completed, you should photograph the improvements made. You will need to evaluate the impact of all the changes and the benefits that have been gained, before presenting your work to your team leader.

If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

You are a production operative working in a small team of manufacturing operatives, building a second and significantly different product that was previously made in another facility. You are given the basic steps required in the manufacturing process for the product. Your team leader has asked you to walk through the manufacturing process for the product and create a process map in the form of a flow chart, which details all the steps required.

Once a comprehensive process map is completed, you will need to use this to identify any non-value-added activities and suggest changes to the process that will eliminate waste. You should aim to minimise waste at every stage of the process. You will then redraw the process map to reflect the suggested changes and walk through the new process.
Your team leader is pleased with your work on investigating the use of visual management techniques that can be applied in your factory. Your team leader has asked you to visit another factory and look at some different visual management techniques that are being used, study them, and evaluate their benefits.

On your return, you are asked to recommend two visual management techniques that you think will have the most impact on manufacturing processes in your factory. You will need to fully explain the techniques and evaluate their potential impact in comparison to the alternatives seen during your visit.

Your team leader asks you to take photographs of your work area and fill in a detailed 5S scan checklist. You should use the completed 5S scan checklist when implementing 5S in your workplace to ensure this is completed effectively. Once completed, you should photograph the improvements made.

Finally, you need to evaluate the impact of all the changes and the benefits that have been gained, before presenting your work to your team leader.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

**Introduction to unit**

A tutor-led discussion introducing learners to the importance of business improvement techniques when applied to engineering processes and an overview of the techniques covered in this unit. Learners walk through an industrial process modelled in the classroom or workshop, and are asked to identify ways that the process might be improved. This will lead into the introduction, discussion and classification of the various common forms of waste.

An industrial visit to a local engineering company would be beneficial at an early stage in the delivery of this unit. Learners will see real examples of work area organisation, visual communication and management techniques, and examples of waste and how this is minimised. Learners will ask questions and see the importance of the techniques they will be studying in a real-world context.

**Suggested time:** about 3 hours.

**Activity: Identifying and eliminating waste from business processes**

A tutor-led analysis of a case study example of a business process. This could be manufacturing a product (e.g. the manufacture of a sheet metal fabricated toolbox) or carrying out an engineering service (e.g. changing the coolant on a lathe). If possible, the process should be walked through with learners in an engineering workshop environment. In groups, learners will break down the process into a series of discrete steps. The details of each step will be recorded on sticky notes, which will then be arranged into a process flow chart. Each step will be categorised as value added or non-value added. Learners will work together to identify and categorise the types of waste present in the process. They will then discuss what changes could be made to reduce or eliminate the non-value-added steps in the process.

Each group of learners will present their findings to their tutor and the rest of the class. In a tutor-led class discussion, a comparison will be made between each presentation to determine the group who has been most effective in eliminating waste and how this was achieved.

**Suggested time:** about 5 hours.

**Activity: Applying 5S**

A tutor-led discussion in a workshop deliberately left untidy and disorganised. Learners discuss the potential consequences on efficiency when processes are carried out in a similar environment. Learners are then asked to clean up and put tools away. During this process, they are asked to consider a number of questions, which might include: whether there are sufficient brushes, bins and other facilities required to keep the workshop tidy and how easy these are to find; whether it is obvious where each tool or piece of equipment is kept; whether the correct number of each item is still present; whether obsolete or rarely used tools and equipment are cluttering up the workshop; the general state of cleanliness and repair of the workshop facilities; whether there are rules in place to ensure the workshop is kept tidy and if these are clearly on display etc.

Back in the classroom, the tutor introduces the 5S methodology of workplace organisation, and learners are asked to work in groups to consider the benefits of using the 5S approach when applied to the questions they were asked to consider in the workshop. These are then shared in a tutor-led discussion, which goes on to discuss the benefits that can be gained from the effective implementation of 5S.
Learners will be asked to revisit the workshop and carry out a 5S workplace scan using a given checklist. The results will be shared with the group in a tutor-led discussion.

**Suggested time:** about 5 hours.

**Activity: Applying visual process management techniques**

A tutor-led analysis of case study examples showing the use of visual process management techniques in a manufacturing context. Examples may include: the use of shadow boards to organise the tools and equipment required at a workstation; how Kanban cards are used to replenish the stock of screws used on a production line; how floor markings are used to guide operatives, act as hazard warnings and aid the organisation of the workplace; how photographs or storyboards can be used on a production line to guide the assembly of a finished product; how go/no go gauges are used during inspection processes.

Learners are asked to consider what common characteristics are present in the examples given to develop an understanding of the qualities that define effective visual management.

Learners are then given case study material in which visual management is not used and they are asked to identify areas where it might be applied to improve the processes involved. Where practical, learners should design and test these visual solutions. This may involve making a model, sketches, simulations or full-size working solutions that are then compared with the original case study scenario to determine their potential impact.

**Suggested time:** about 6 hours.
Essential resources

For this unit, learners will need access to:

- a range of case studies giving examples of business processes and visual management methods
- workshops/work areas where workplace organisation techniques can be implemented.

Links to other units

This unit has strong links to:

- Unit 4: Workshop Skills
- Unit 5: Machining Techniques
- Unit 6: PCB Components and Soldering
- Unit 7: Computer Numerical Control
- Unit 8: Electrical Components and Wiring
- Unit 9: Delivering Engineering Solutions.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from a manufacturing environment or another engineering sector to share an insight into business improvement techniques used in their organisations, how the techniques used have changed working practices for the better, and whether they have improved business
- working with an industrial partner to develop a range of case studies to aid the delivery and assessment of the unit. Case studies should be varied and detail business processes in realistic scenarios to ensure they reflect industrial practice
- work experience, which will expose learners to a wide range of business processes that might be used as the basis for some of the teaching and learning or assessment activities
- local businesses that have staff who are experienced in a range of business improvement techniques. They can be a valuable resource in teaching and learning and when conducting practical activities
- employers who provide assessment support by giving learners access to work areas that need review or simulate issues in the work area for learners to improve using the techniques gained in this unit, enabling them to see a ‘real world’ impact of their new skills.
Unit 4: Workshop Skills

Level: 2
Unit type: Mandatory
Assessment type: Internal
Guided learning hours: 60

Unit in brief

Learners develop the skills needed to safely carry out an engineering activity in a workshop environment using sheet metal, including preparation, marking out, cutting and assembling components to make a fabricated structure.

Unit introduction

We are surrounded by engineered products that have been fabricated from sheet metal. These thin sheets of metal have been formed and shaped with accuracy and precision to make sure they do the job for which they are designed.

In this unit, you will gain the workshop skills required in many fields of engineering, particularly industries where fabrication techniques are used to prepare, form and assemble materials and components. You will learn how to manage your work area by preparing for practical work and closing down on completion, and how to select the correct tools and documentation for a given fabrication task. You will use a range of tools and materials, along with fixtures and fittings, to join and assemble products.

This unit will prepare you for working in an industrial environment where fabrication and sheet metal work are an integral part of a manufacturing process, or for work as an engineering technician. You will develop a range of transferable skills that you will use when working in different engineering environments, and you will gain experience of using a range of tools and techniques with precision.

Learning aims

In this unit you will:

A. Manage a work area safely for a fabrication activity
B. Manufacture components in a sheet metal fabrication environment safely
C. Assemble fabricated structures safely.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
</table>
| A Manage a work area safely for a fabrication activity | A1 Preparing for a work activity  
A2 Carrying out a work activity  
A3 Closing down a work area | A portfolio of evidence, including:  
• annotated photographs of work-in-progress and completed items  
• workshop logbook, including written notes and sketches  
• risk assessment records  
• tutor observation records and written evaluations. |
| B Manufacture components in a sheet metal fabrication environment safely | B1 Measuring and marking out  
B2 Material types  
B3 Materials  
B4 Cutting  
B5 Forming | |
| C Assemble fabricated structures safely | C1 Joining processes  
C2 Assemblies  
C3 Quality and accuracy standards | |

### Key teaching areas in this unit include:

<table>
<thead>
<tr>
<th>Sector skills</th>
<th>Knowledge</th>
<th>Transferable skills/behaviours</th>
</tr>
</thead>
</table>
| • Interpreting engineering drawings and diagrams  
• Carrying out risk assessments  
• Interpreting specifications and work instructions  
• Preparing to carry out fabrication activities  
• Carrying out work activities safely | • Identification and understanding of drawing conventions  
• Types and forms of materials  
• Cutting, shaping and forming techniques  
• Identification and use of fixings related to fabrication techniques | • Problem solving  
• Managing information  
• Self-management and development |
Unit content

Knowledge and sector skills

Learning aim A: Manage a work area safely for a fabrication activity

A1 Preparing for a work activity
- Identifying hazards and carrying out a risk assessment.
- Selecting correct and appropriate personal protective equipment (PPE).
- Obtaining and understanding drawings/work instructions, e.g. third angle orthographic, isometric, assembly drawings, parts drawings, parts lists, job cards.
- Obtaining suitable tools and materials and carrying out checks to ensure that they are safe and in a usable condition.

A2 Carrying out a work activity
- Following correct procedures to carry out a given task.
- Working safely at all times.
- Recording actions, including processes, problems and results.

A3 Closing down a work area
- Completing all tasks and relevant documentation.
- Leaving the work area clean, tidy and safe.
- Returning drawings/work instructions and tools on completion.
- Disposing of unusable tools, equipment and waste materials.

Learning aim B: Manufacture components in a sheet metal fabrication environment safely

B1 Measuring and marking out
Safe use of tools and equipment for measuring and marking out:
- measuring tools, e.g. rule, tape rule, protractor, height gauge
- marking out tools, e.g. scriber, centre punch, chalk line, square, trammel, dividers, templates, surface plate, chalk, engineers' blue, laser measuring and marking equipment
- features, e.g. datum lines and centre lines, square and rectangular profiles, circles, curved profiles, cutting detail, hole centring, circular outlining, linear outlining.

B2 Material types
Standard fixtures and forms of supply of common engineering materials:
- sheet, plate and material sections, e.g. hot-rolled black, cold-rolled
- up to and including 3 mm thickness of standard sections
- material forms used in fabrication and assembly, e.g. standard bar and section lengths, standard profiles, cutting detail for flat covers and plates, frames, pipe and tube sections, columns, beams, struts
- fixtures and fittings used in fabrication, e.g. seals, gaskets, trims, panels, screens, fish plates, gussets, spars and brackets, structural support pads, bed plates.
B3 Materials
Types of material used in fabrication:
- metallic – ferrous and non-ferrous, e.g. mild steel, tinned steel, galvanised steel, aluminium, stainless steel, brass, copper
- non-metallic – plastics, rubbers, e.g. mouldings, sheets and extrusions.

B4 Cutting
Safe use of cutting tools and techniques:
- hand tools, e.g. tin snips, hacksaw, files
- hand power tools – drill, nibbler
- machine tools, e.g. bench shears, band saw, guillotine, pillar drill, punch, cropping
- machine cutting operations – straight cuts, external contoured cuts, round holes
- filing
- drilling.

B5 Forming
Safe use of forming tools and techniques:
- tools and equipment, e.g. hammers, mallets, stakes, formers, hand bending, powered bending machines, hand rolling, powered rolling machines
- safety checks on tools and equipment, e.g. hammer shafts are secure, striking faces on stakes and formers are free from burrs and defects, machine guards and devices are operational
- operations – bends, folds, curved panels, cylindrical section, ducting/trunking.

Learning aim C: Assemble fabricated structures safely

C1 Joining processes
Types of permanent and non-permanent joining:
- thermal, e.g. tack welding, brazing, soldering, resistance spot welding, electric welding techniques, gas welding techniques
- mechanical fasteners, e.g. hollow rivets, solid rivets, self-piercing rivets, threaded inserts, structural fasteners, bolts, screws
- adhesives, e.g. structural adhesives, epoxides, acrylics, cyanoacrylates.

C2 Assemblies
Types of assembly:
- straightforward assemblies (characterised by linear edges, perpendicular changes of section and regular joins), e.g. regular-shaped frames/hoods/guards/panels, regular-sectioned ducting/trunking, square, rectangular and box sections, cylindrical sections
- more complex assemblies (characterised by non-linear edges, changes of section that are not necessarily perpendicular and irregular joins), e.g. reduction pieces, irregular-shaped frames/hoods/guards/panels, sectioned ducting/trunking incorporating changes in section/cross-sectional area, irregular-shaped box sections, oval and tapered cylindrical sections.

Types of components in the assemblies:
- straightforward components, e.g. regular sheet metal covers, pre-fabricated square and rectangular components, pre-fabricated cylindrical and conical components, brackets. Light rolled angle or tee section
- more complex types of component, e.g. irregular sheet metal covers, pre-fabricated non-square/rectangular components, pre-fabricated non-circular cylindrical and conical profiles, flanges, pipes. Light rolled channel or I form section.
C3 Quality and accuracy standards
Joining and assembling within tolerance:
• aligning parts in accordance with given specifications
• ensuring overall linear dimensions meet specification
• ensuring overall dimensions are within geometrical tolerances, e.g. square, straight, free from twists, pitches of erection holes meet specification requirements
• assemblies have secure and firm joints
• assemblies are clean and free from burrs and sharp edges.

Transferable skills

Problem solving and communication
• Developing skills to solve 3D problems through assembling a fabricated structure, gaining skills in communication through working in teams, cooperating with others and following instructions in order to produce a fabrication to a required quality standard.

Managing information
• Gaining skills in the interpretation of documents and drawings, including the use and application of referencing as a result of interpreting documentation to assemble a fabricated structure accurately.

Self-management and development
• Prioritising activities and gaining an understanding of the relationship between tasks in order to organise time and resources when working in a fabrication workshop.
## Assessment criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning aim A: Manage a work area safely for a fabrication activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A.P1</strong> Manage a work area for a fabrication activity, carrying out basic tests on equipment.</td>
<td><strong>A.M1</strong> Manage a work area for a fabrication activity safely, carrying out tests on equipment, identifying issues and solving simple problems.</td>
<td><strong>A.D1</strong> Manage a work area for a fabrication activity safely, carrying out thorough testing of equipment and showing initiative when confronted with issues.</td>
</tr>
<tr>
<td><strong>A.P2</strong> Demonstrate safe working practices and identification of hazards and risks when setting up and closing down a work area for a fabrication activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim B: Manufacture components in a sheet metal fabrication environment safely</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B.P3</strong> Measure and mark out different types of material for the component parts of a functional, fabricated structure.</td>
<td><strong>B.M2</strong> Manufacture components safely and accurately, showing good skill with only minor aesthetic issues identified by inspection.</td>
<td><strong>B.D2</strong> Manufacture components safely and accurately, showing a high level of skill with no aesthetic issues identified by inspection.</td>
</tr>
<tr>
<td><strong>B.P4</strong> Demonstrate safe and accurate use of cutting and forming tools and techniques in the production of functional component parts of a fabricated structure.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim C: Assemble fabricated structures safely</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C.P5</strong> Select and use suitable tools, fixtures and fittings to safely assemble a functional fabricated structure.</td>
<td><strong>C.M3</strong> Assemble a fabricated structure safely and accurately, showing good skill with only minor aesthetic issues identified by inspection.</td>
<td><strong>C.D3</strong> Assemble a fabricated structure safely and accurately, showing a high level of skill with no aesthetic issues identified by inspection.</td>
</tr>
</tbody>
</table>
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:
- demonstrate that they can manage a work area by correctly setting up and preparing it for a fabrication activity, selecting the correct equipment and materials required. They will check and test all the necessary equipment to ensure it is fit for use, and demonstrate they can lay out and put together the equipment while following the correct health and safety protocols.
- demonstrate control over the set-up procedures, showing initiative if faced with a problem such as a piece of equipment not functioning correctly or not being available. They might do this through finding a replacement piece of equipment, selecting a suitable alternative or checking why something is not functioning.
- show full consideration and application of the required health and safety procedures they have to adhere to, carrying out a risk assessment.
- demonstrate that they can safely close down a work area on completion of the work activity, with all relevant documentation completed fully and clearly.

For merit standard, learners will:
- demonstrate that they can manage a work area by correctly setting up and preparing it so that it is fit for use for a fabrication activity. They will select most of the correct equipment and materials but may need some guidance. They will carry out tests on the equipment to ensure it is ready for use.
- demonstrate a clear understanding of procedures, applying them correctly while setting up the work area, although they may need some assistance if faced with a problem with equipment or materials.
- demonstrate a clear understanding of health and safety protocols associated with handling the equipment and materials they have selected, carrying out a risk assessment.
- demonstrate that they can safely close down a work area on completion of the work activity, with all relevant documentation completed fully.

For pass standard, learners will:
- demonstrate that they can prepare and set up a work area for a fabrication activity by assembling the appropriate equipment and materials required, although they may not have selected all of these themselves. They will attempt to set up the workspace, although further adjustments may be required to make it fit for use.
- carry out basic tests, such as visual checks on equipment, to ensure the equipment is fit for purpose.
- follow health and safety procedures when handling or putting together equipment and materials.
- demonstrate that they can safely close down a work area on completion of the work activity, with relevant documentation completed, although some information may be missing.
Learning aim B

For distinction standard, learners will:

- demonstrate a consistently high level of accuracy and initiative when marking out and cutting components that form part of a fabricated structure
- make any correctional adjustments that may be necessary to ensure that individual component parts meet specifications
- assess their own levels of safe working; this could be achieved through the use of annotated photographs or short written reports relating to both marking out and cutting operations
- carry out a comprehensive final quality inspection of the finished component and maintain detailed records of this process. All inspection results must be accurate and verified by the tutor. Inspection results will confirm that there are no quality issues relating to component accuracy and form, and that the components are both functional and have no aesthetic issues.

For merit standard, learners will:

- demonstrate confidence in their working when marking out, cutting and forming components; the work will be mostly accurate, although there may be some errors and inaccuracies. The component parts will function as intended, although they may not fully meet the specification
- use tools and equipment safely and with confidence, and perform both cutting and forming operations appropriately and with limited guidance
- observe safe working practices and use a range of techniques confidently to produce component parts. This will include the use of hand tools, power tools and machinery in line with the requirements of the components being made
- check components for accuracy but may not necessarily record their results fully or make changes to ensure compliance with specifications
- carry out a final quality inspection of the finished component and maintain records of this process, although these may lack detail. Inspection results will confirm that there are no issues relating to component functionality but there may be minor quality issues, such as cosmetic appearance. This must not directly impact basic component function.

For pass standard, learners will:

- competently carry out a range of operations to measure and mark out when producing components for a fabrication
- cut and form materials safely
- carry out a final quality inspection of the finished component and maintain a basic record of this process, but this might lack detail or contain omissions. All inspection results must be accurate and verified by the tutor. Inspection results will reveal significant aesthetic or quality issues that might compromise the long-term reliability of the component, but the component should be functional.
Learning aim C

For distinction standard, learners will:

- select and use appropriate permanent and non-permanent joining methods when assembling a complex fabricated structure
- select and consistently use tools and equipment safely and skilfully to make sure that the completed structure complies with given specifications, including both dimensional and geometrical tolerances
- carry out a comprehensive final quality inspection of the finished fabricated structure and maintain detailed records of this process. All inspection results must be accurate and verified by the tutor. Inspection results will confirm that there are no quality issues relating to the fabrication.

For merit standard, learners will:

- demonstrate that they are able to work safely with a range of tools, and that they are able to select and use appropriate fixtures and fittings to complete a fabrication activity with confidence
- select and use both permanent and non-permanent joining methods as appropriate for components within the structure, and must demonstrate accuracy in their final fabricated structure
- carry out a final quality inspection of the finished fabrication and maintain records of this process, although these may lack detail. Inspection results will confirm that there are no issues relating to fabrication functionality but there may be minor quality issues, such as cosmetic appearance. This must not directly impact basic function.

For pass standard, learners will:

- need support in the selection of the appropriate tools or processes, and their final outcomes may be lacking in precision and not comply in full with specifications. The components will have been manufactured safely, and learners will have complied with safe working requirements. They are unlikely to perform any tests for compliance on the components they have made, with little or no evidence of testing taking place
- use their knowledge and understanding to competently produce a fabricated assembly from a range of components, using both permanent and non-permanent joining methods. They may need guidance in the selection of appropriate processes, however they will be expected to select the majority of the tools and consumables they use independently
- produce a fabricated structure that is fit for purpose but may not fully meet all of the specification criteria for geometric tolerances
- carry out a final quality inspection of the finished fabrication and maintain a basic record of this process, but this may lack detail or contain omissions. All inspection results must be accurate and verified by the tutor. Inspection results will reveal significant aesthetic or quality issues that might compromise the long-term reliability of the fabrication, but the structure will still be functional.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

Suggested scenario

You are working in a fabrication workshop. Your supervisor is impressed by the work you have carried out so far and has suggested that you could develop your skills further by producing a fabrication independently, so that you become more aware of the requirements for accuracy at each stage of the fabrication process. Your supervisor needs you to demonstrate that you can work with precision and use a range of fabrication tools and equipment safely in order to assemble a fabricated structure on your own. When carrying out these tasks, your supervisor will be monitoring the accuracy of your work and your ability to make sure that work conforms to the operational requirements of a specification.

If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

You have been asked by your supervisor to provide a demonstration to potential trainees of the types of work that an engineer working in a fabrication environment would carry out. You are asked to prepare for an activity and then carry out a range of tasks that will involve marking out, cutting, forming and assembly. You must demonstrate how activities are carried out safely at all times and ways to make sure that components and the structure are produced with accuracy.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

### Introduction to unit

A tutor-led practical activity to introduce learners to the fabrication workshop and the types of tools and equipment they will use when carrying out fabrications, through the assembly of small products or structures from a given kit of parts and fixings. This will be followed by an induction into workshops and an introduction to the general safety and emergency procedures that must be followed. This could then be followed by a brief introduction to identify specific processes used in the fabrication and sheet metal work industries.

A further tutor-led session could examine safe working practices in more detail, including consideration of the health and safety legislation related to fabrication and sheet metal working environments. This should include the procedures for setting up the working environment before starting a fabrication task, and also the method for closing down the work area. Where possible, this could be supported by external guest speakers or visits to industrial fabrication workshops.

Learners complete worksheets to identify potential hazards in the workshop/workplace and how the risk from these hazards has been minimised using good practice.

**Suggested time:** about 3 hours.

### Activity: Introduction to fabrication

A tutor-led workshop demonstration of different stock material types that learners will use when carrying out fabrication activities, including sheet, tube, sections and plate. Tutors should introduce learners to both metallic and non-metallic materials. Tutors could then demonstrate the safe use of the tools and equipment that are used for marking out materials for a fabrication activity. Learners will also experience appropriate induction programmes while on work experience placements.

Learners could carry out a practical session in the workshop to gain familiarisation with a range of measurement techniques and tools. They could develop these skills through the marking of sheet, tube and sectional materials as used in industry, and where possible they could apply these skills practically while on work experience placements.

A further tutor demonstration could look at how different marking out techniques are used according to material type and surface form.

Learners could complete worksheets to identify the appropriate tools and equipment for marking a range of materials and forms for a fabrication activity.

**Suggested time:** about 8 hours.

### Activity: Cutting materials

A tutor-led workshop demonstration of safe working practices when using cutting tools and machinery. This should include a variety of cutting tools types, including hand operated, power tools and machines. The demonstration should include how to set tools up for use, any consumables that would be needed and how to maintain tools safely.

Tutors should demonstrate the cutting operations listed in the unit specification, and for each one explain the purpose and how to carry out each operation safely.
This could then be followed by individual practice of a range of cutting operations. Learners should demonstrate that they have a good awareness of safety in the workshop when using cutting equipment and that they are able to set tools up correctly. The practical activities should give learners an opportunity to practise and develop their skills in carrying out a range of cutting operations, including cutting straight cuts, profiles and shapes, and cutting of sheets and sections.

**Suggested time:** about 12 hours.

### Activity: Forming materials

A tutor-led workshop demonstration of safe working practices when using forming tools and machinery. The demonstration should also cover bending and folding theory, types of machine, the safe use of rolling machinery and forming with hammers and mallets. This could be supported through the use of an industrial visit, or the use of guest speakers to explain the processes that are used in an industrial context.

There should be further emphasis on safety in the workshop when using forming equipment, with learners completing appropriate worksheets to identify hazards, risks and control measures. This could be followed by a number of practical activities where learners will gain experience of bending and folding, including how to safely set up and use the equipment. This will include checks that should be carried out before, during and after forming. Similarly, learners should practise and develop their skills in rolling materials, as well as working with hand power tools that are used for forming operations.

Learners could then carry out a further practical workshop activity to develop their skills in using hammers, mallets, stakes and formers for manual forming activities.

**Suggested time:** about 12 hours.

### Activity: Assembling fabrications

A tutor-led practical demonstration of safe working practices when completing the assembly of fabricated structures both in the workshop and in industry, making reference to drawings and other documentation. Documentation could be produced in conjunction with local engineering organisations, with learners gaining experience of using the formal drawings and documents used in industry.

Tutors should demonstrate a range of joining techniques, including thermal joining processes, mechanical fastenings and adhesives. The demonstration should also include types of assembly and effective use of materials to complete the assembly. Finally, tutors should explain to learners the different quality standards that relate to assembly of fabrications, including dimensional accuracy, tolerances and geometrical tolerances. Learners should be shown how to record compliance with tolerances and how these relate to accuracy.

Learners should practise assembling fabricated structures, including preparation of joints for assembly and then the safe joining and assembly of components. Learners should practise joining a number of materials with a range of joining techniques, including permanent methods such as thermal, mechanical and bonding with adhesives. This could be carried out while on work experience placements or in a fabrication workshop.

Learners should develop their skills in working to a specification and complete fabrications to given tolerances and then check the accuracy of the assembled components.

**Suggested time:** about 20 hours.
Essential resources

For this unit, learners will need access to the relevant tools, machinery and safety equipment listed in the unit content.
Centres will need to ensure that they have sufficient hand tools, power tools and machines to enable all learners to perform the tasks individually.

Links to other units

This unit has strong links to:
• Unit 1: Engineering Principles
• Unit 2: Processes and Materials
• Unit 5: Machining Techniques
• Unit 9: Delivering Engineering Solutions.

Employer involvement

This unit would benefit from employer involvement in the form of:
• guest speakers who work in the fabrication sector, such as technicians, to talk about the working day, procedures for setting up work areas for fabrication activities and safe working practices
• working drawings provided by industrial partners for simple and complex fabrications that could be manufactured using the workshop facilities available
• work experience in the fabrication sector, offering the opportunity to carry out a range of activities as described in the unit content
• industrial visits to fabrication workshops to gain further understanding of how processes are carried out in an industrial context.
Unit 5: Machining Techniques

Level: 2  
Unit type: Optional  
Assessment type: Internal  
Guided learning hours: 60

Unit in brief

Learners safely set up machine tools and use drilling, turning and milling techniques to produce and inspect several workpieces.

Unit introduction

The machines that you will use during this unit are some of the most important pieces of engineering equipment. Most modern Computer Numerically Controlled (CNC) machine tools have been developed from conventional drills, lathes and milling machines. You can use these three types of machine to produce a huge variety of different components, parts and products.

This unit will help you to understand how to generate and form workpieces through standard engineering machining techniques that involve removal of material. You will learn how to select and use a range of tools and work-holding devices so that you can carry out a variety of machining processes. You will learn how to set the machines before you use them, how to monitor the machining processes and how to inspect the workpieces you produce for compliance and accuracy. You will also learn how to operate the machinery safely.

This unit will prepare you for a mechanical or manufacturing engineering apprenticeship, and for technician-level roles, for example as a machine setter and setter operator.

Learning aims

In this unit you will:

A Prepare for machining operations
B Make workpieces using drilling, turning and milling techniques safely
C Undertake a quality control check for compliance and accuracy of a workpiece.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
</table>
| **A** Prepare for machining operations | **A1** Tools  
**A2** Work-holding devices  
**A3** Selecting appropriate tooling and work-holding devices | A portfolio of evidence, including:  
• tutor observation records  
• annotated photographs  
• videos with learners’ narration, notes  
• completed quality inspection records  
• written justifications and evaluations  
• workshop logbook. |
| **B** Make workpieces using drilling, turning and milling techniques safely | **B1** Techniques for machining features of the workpiece  
**B2** Machining parameters  
**B3** Safe working practices |  
| **C** Undertake a quality control check for compliance and accuracy of a workpiece | **C1** Quality control checks for compliance and accuracy |  

### Key teaching areas in this unit include:

<table>
<thead>
<tr>
<th>Sector skills</th>
<th>Knowledge</th>
<th>Transferable skills/behaviours</th>
</tr>
</thead>
</table>
| • Applying safe working practices  
• Setting and adjusting machining parameters  
• Selecting tooling and work-holding devices  
• Carrying out milling, drilling and turning  
• Working accurately | • Applications of milling, drilling and turning  
• Identification and applications of tooling and work-holding devices | • Problem solving  
• Managing information  
• Self-management and development |
Unit content

Knowledge and sector skills

Learning aim A: Prepare for machining operations

A1 Tools

Tools for specific drilling, turning and milling techniques:
- for drilling – simple tools, e.g. centre drill, drill bit; more complex tools, e.g. flat-bottomed drill, counterboring tool, countersinking tool, reamer, tap
- for turning – simple tools, e.g. turning tools, facing tools; more complex tools, e.g. form tools, parting off tools, single-point threading, boring bar, recessing tool, centre drill, twist drill, reamer, tap, die, knurling tool
- for milling – simple tools, e.g. face mills, end mills; more complex tools, e.g. slot drills, slotting cutters, slitting saws, profile cutters, twist drills, reamer, boring tools
- tooling materials – high-speed steel, cobalt steel, tungsten carbide, diamond.

A2 Work-holding devices

Work-holding devices for drilling, turning and milling:
- for drilling – simple work-holding device, e.g. machine vice; more complex work-holding devices, e.g. clamping direct to machine table, angle plate, vee block and clamps
- for turning – simple work-holding device, e.g. 3-jaw chuck with hard jaws; more complex work-holding devices, e.g. 4-jaw chuck with hard jaws, centres (live or dead), faceplate, fixed steady or travelling steady
- for milling – simple work-holding device, e.g. machine vice; more complex work-holding devices, e.g. clamping direct to machine table, angle plate, vee block and clamps, indexing head/device, rotary table.

A3 Selecting appropriate tooling and work-holding devices

Selection of drilling, turning and milling tooling and work-holding devices suitable for producing features in a workpiece:
- for drilling – selecting appropriate tooling and work-holding devices for simple features, e.g. for through holes in square bar, use machine vice and drill bit; more complex features, e.g. for counterbored holes in round bar, use vee block and clamps, drill bit and counterboring tool
- for turning – selecting appropriate tooling and work-holding devices for simple features, e.g. flat face on round bar use 3-jaw chuck and facing tool; more complex features, e.g. knurled diameters on long round bar use 3-jaw chuck with live (rotating) centre and knurling tool
- for milling – selecting appropriate tooling and work-holding devices for simple features, e.g. flat faces on a square bar use machine vice and end mill; more complex features, e.g. enclosed slot in a round bar use vee block and clamps and slotting cutter.
Learning aim B: Make workpieces using drilling, turning and milling techniques safely

B1 Techniques for machining features of the workpiece
Use of drilling, turning and milling techniques for producing features in a workpiece:

- for drilling – simple features, e.g. through holes, blind holes; more complex features, e.g. flat-bottomed holes, counterbored holes, countersinking, reaming, tapping
- for turning – simple features, e.g. flat faces, parallel diameters; more complex features, e.g. stepped diameters, tapered diameters, drilled holes, bored holes, reamed holes, profile forms, internal threads, external threads, parting off, chamfers, knurls, grooves, undercuts
- for milling – simple features, e.g. flat faces, square faces; more complex features, e.g. parallel faces, angular faces, steps, shoulders, open-ended slots, enclosed slots, recesses, tee shots, drilled holes, bored holes, profile forms, serrations, indexed or rotated forms.

B2 Machining parameters
Parameters for drilling, turning and milling techniques:

- for drilling – positional, e.g. position of workpiece, position of tool in relation to workpiece; dynamic, e.g. tooling revolutions per minute (speed), linear feed rate (feed), swarf clearance
- for turning – positional, e.g. position of workpiece, position of tool in relation to workpiece; dynamic, e.g. workpiece revolutions per minute (speed), linear feed rate (feed), depth of cut for roughing and finishing, swarf clearance
- for milling – positional, e.g. position of workpiece, position of tool in relation to workpiece; dynamic, e.g. miller cutting revolutions per minute (speed), linear/table feed rate (feed), depth of cut for roughing and finishing, swarf clearance.

B3 Safe working practices
Safe working practices relevant to drilling, turning and milling techniques:

- for drilling – handling drilling tools, tool breakage procedure, swarf handling and disposal, cutting fluids
- for turning – handling turning tools, tool breakage procedure, swarf handling and disposal, backlash in machine slides, cutting fluids
- for milling – handling milling tools, tool breakage procedure, swarf handling and disposal, backlash in machine slides, cutting fluids
- general safety awareness, e.g. wearing appropriate personal protective equipment (PPE) alertness to moving parts, ensuring machine guards are in place, use of emergency stop, machine isolation, keeping a clean and tidy work area, removing burrs and edges, identification of risks, associated hazards and their control.
Learning aim C: Undertake a quality control check for compliance and accuracy of a workpiece

C1 Quality control checks for compliance and accuracy
Checks for accuracy and compliance relevant to drilling, turning and milling techniques:

- for drilling – visual checks, e.g. workpiece to be free from false tool cuts, burrs and sharp edges removed; specific checks, e.g. dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface texture 1.6 \( \mu \text{m} \) (63 \( \mu \text{in} \)), reamed holes within H8, screw threads BS medium fit

- for turning – visual checks, e.g. workpiece to be free from false tool cuts, burrs and sharp edges removed; specific checks, e.g. dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6 \( \mu \text{m} \) (63 \( \mu \text{in} \)), reamed or bored holes within H8, screw threads BS medium fit, angles within +/-1.0°

- for milling – visual checks, e.g. workpiece to be free from false tool cuts, burrs and sharp edges removed; specific checks, e.g. dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6 \( \mu \text{m} \) (63 \( \mu \text{in} \)), flatness and squareness within 0.125 mm per 25 mm, angles within +/-1.0°.

Transferable skills

Problem solving
- Selecting the most appropriate techniques, tooling and work-holding devices to manufacture a range of simple and complex features.

Managing information
- Collecting, recording and interpreting quality inspection data.

Self-management and development
- Development of practical skills relating to drilling, milling and turning processes will be self-managed by learners.
## Assessment criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning aim A: Prepare for machining operations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.P1 Select tools to safely drill, turn and mill simple and complex features, to a given brief.</td>
<td>A.M1 Select the most appropriate tools and work-holding devices to safely drill, turn and mill simple and complex features, to a given brief.</td>
<td>A.D1 Justify the selection of the most appropriate tools and work-holding devices to safely drill, turn and mill simple and complex features, to a given brief.</td>
</tr>
<tr>
<td>A.P2 Select appropriate work-holding devices to safely drill, turn and mill simple features, to a given brief.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim B: Make workpieces using drilling, turning and milling techniques safely</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.P3 Set up work-holding devices, tooling and initial positional and dynamic parameters for a given brief.</td>
<td>B.M2 Monitor and adjust positional and dynamic parameters when safely drilling, turning and milling workpieces, showing good skill.</td>
<td>B.D2 Monitor and adjust positional and dynamic parameters effectively when safely drilling, turning and milling workpieces, showing a high level of skill.</td>
</tr>
<tr>
<td>B.P4 Manufacture functional workpieces using drilling, turning and milling, showing some skill.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.P5 Demonstrate compliance with safe working practices when setting up and using drilling, turning and milling machining techniques.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim C: Undertake a quality control check for compliance and accuracy of a workpiece</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.P6 Carry out quality control checks for compliance and accuracy on machined workpieces, maintaining a record of the inspection.</td>
<td>C.M3 Carry out quality control checks for compliance and accuracy on machined workpieces, maintaining accurate records of the inspection.</td>
<td>C.D3 Carry out a comprehensive assessment of workpieces, maintaining detailed records of the inspection and making recommendations for improvement.</td>
</tr>
</tbody>
</table>
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:
• provide a written justification to explain why they have chosen the tooling and work-holding devices used in the machining operations carried out during the manufacture of two workpieces. This will include a discussion of potential alternatives and why these were considered less suitable than the tooling and work-holding devices actually used.

For merit standard, learners will:
• consistently select effective and efficient tools and work-holding devices for drilling, turning and milling machining operations during practical tasks to create simple and complex features on a workpiece(s), e.g. they will drill a counterbored hole using a counterboring tool and use a self-centring 3-jaw chuck when parallel turning round bar.

For pass standard, learners will:
• select appropriate tools for drilling, turning and milling machining operations during practical tasks to create simple features on a workpiece(s). These may not be the most effective or efficient tools available to them, e.g. they might drill a counterbored hole using two operations with a drill bit and flat bottomed drill instead of a single operation using a counterboring tool
• select appropriate work-holding devices for drilling, turning and milling machining operations during practical tasks to create simple features on a workpiece(s). These might not be the most effective or efficient work-holding devices available to them, e.g. they might choose to use a 4-jaw chuck when parallel turning round bar instead of 3-jaw chuck that will be self-centring.

Learning aim B

For distinction standard, learners will:
• monitor and adjust positional and dynamic parameters effectively and in a systematic way, showing a clear understanding of their effects on accuracy and surface finish
• carry out machining processes with a high level of skill. They will manipulate tools, equipment and machine parameter settings with practised dexterity and produce accurate features, using near optimal parameter settings to machine features quickly and efficiently
• demonstrate compliance with safe working practices throughout all the practical activities carried out in the unit.

For merit standard, learners will:
• monitor and adjust positional and dynamic parameters during machining processes as necessary for the desired level of accuracy and surface finish, e.g. in turning, reducing the depth of cut after roughing in order to carry out finishing cuts with improved surface finish. There may be some instances where these are not effectively monitored and adjusted, leading to minor quality issues
• carry out machining processes with a good level of skill. They will manipulate tools, equipment and machine parameter settings confidently and produce accurate features, although some unnecessary stops and/or sub-optimal dynamic parameter settings will slow their progress
• demonstrate compliance with safe working practices throughout all the practical activities carried out in the unit.
UNIT 5: MACHINING TECHNIQUES

For pass standard, learners will:
- manufacture two significantly different workpieces. Each workpiece will have at least six features, including both simple and complex features. Between them, the two workpieces will require learners to machine both simple and complex features using milling, drilling and turning processes
- set up work-holding devices and tooling in preparation for use. This will include setting positional parameters, e.g. securing workpieces safely in the correct position for machining. It will also include setting initial dynamic parameters such as feeds and speeds
- carry out machining processes with some skill. They will handle tools, equipment and machinery safely and produce some accurate features, although they may appear hesitant and lack confidence when applying the processes required. Significant quality issues may be present on only one of the two components. Significant issues are those serious enough to affect the safety, fit or function of the components and might include burrs, sharp edges, false cuts or dimensions outside required tolerances. The second of the two components must have no quality issues present
- demonstrate compliance with safe working practices throughout all the practical activities carried out in the unit
- sometimes require support from tutors, e.g. ensuring that they are using the correct tools and holding pieces, if they had not already selected them as a result of the previous task (learning aim A).

Learning aim C

For distinction standard, learners will:
- carry out a comprehensive quality inspection of the finished workpieces and maintain detailed records of this process. All inspection results must be accurate
- make recommendations for improvement of two workpieces made by their peers.

For merit standard, learners will:
- carry out a quality inspection of the finished workpieces and maintain records of this process, although these may lack detail. All inspection results must be accurate.

For pass standard, learners will:
- carry out a quality control inspection of the finished workpieces and maintain a basic record of this process, but this might lack detail or contain omissions. All inspection results must be accurate.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

There is potential in this unit for centres to provide assessments set with employer input, for example employers could provide assessment support by giving learners access to work areas that need review or simulate issues in the work area for learners to improve, using the techniques learned in the unit.

Suggested scenario

As an apprentice in a manufacturing company, you have been asked to make two components that will be used in the repair of a conveyor system from drawings and a sample broken component provided by your supervisor. These will need to be manufactured safely and accurately within given tolerances if they are to fit the machine being repaired and allow it to function properly.

You will be expected to carry out the following.

- Select, set up and use appropriate machining techniques, tooling and work-holding devices safely in the manufacture of the components.
- Set, monitor and adjust machining parameters as necessary during the manufacture of each component to ensure the required accuracy, compliance and surface finish.
- Demonstrate a good understanding of safe working practices and general safety awareness at all times.

In your training logbook, you will be expected to reflect on the completion of these components by completing the following.

- Justify, in comparison to alternatives, your selection of machine, tool and work-holding device that was used to make each feature. You should back this up with photographic evidence of the components.
- Evaluate the effectiveness of the safe working practices employed during the manufacture of the components and suggest any possible improvements.

There has also been an arrival of some components made by another plant. Your supervisor has asked to complete a quality control inspection of the components to ensure their fitness for purpose. You will need to complete a quality control record of your findings and report back to your supervisor.
If a retake assessment is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

As an apprentice in a manufacturing company, you have been asked to make two components that will be used to repair worn components on a drilling jig used on the shop floor. You have been given drawings and a sample component to work from. These will need to be manufactured safely and accurately within given tolerances if they are to function as required.

You will be expected to carry out the following.

- Select, set up and use appropriate machining techniques, tooling and work-holding devices safely in the manufacture of the components.
- Set, monitor and adjust machining parameters as necessary during the manufacture of each component to ensure the required accuracy, compliance and surface finish.
- Demonstrate a good understanding of safe working practices and general safety awareness at all times.

In your training logbook, you will be expected to reflect on the completion of these components by completing the following.

- Justify, in comparison to alternatives, your selection of machine, tool and work-holding device that was used to make each feature. You should back this up with photographic evidence of the components.
- Evaluate the effectiveness of the safe working practices employed during the manufacture of the components and suggest any possible improvements.

There has also been an arrival of some components made by another plant. Your supervisor has asked to complete a quality control inspection of the components. You will need to make a record of your findings and report back to your supervisor.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

### Introduction to unit

A tutor-led discussion of the importance of material removal processes in the manufacture of engineering products and components. A brief discussion of the limitations of primary forming techniques, such as casting and forging should be discussed. An engine block might be a good example where a large casting is used to form the basic component but material removal techniques are required to cut internal threads, machine mating surfaces and other features requiring accuracy and surface finishes that can't be achieved by casting.

A number of machined components containing a range of simple and complex features, along with their associated drawings should be available for discussion with the group. Features on the components should be named and linked back to how they are represented on the drawings. Reading dimensions and tolerances from the drawings should be explained.

Photographs of the components and copies of drawings can be annotated by learners to identify the full range of features covered in the unit content. Learners must become familiar with recognising them.

Component photographs should also be annotated with key dimensions and tolerances taken from the engineering drawings. This could be done in small groups and then checked and verified as a class.

A visit to the workshops in which the practical work required in this unit is to be carried out should be done early in its delivery. Learners should be introduced to each of the machine types they will be required to use. At this initial stage, the requirements for good safety awareness should be emphasised during the discussion, and a brief demonstration of each machine should be given.

**Suggested time:** about 5 hours.

### Activity: Researching tools and work-holding devices used in drilling, milling and turning

The full range of tools and work-holding devices required to make the workpieces used in learning and skills development, and those planned for use in assessment activities, should be made available. As learners will be handling them, the safety requirements should be discussed. Learners should photograph and then research each of them, learning their names, the machines on which they are used, and the types of workpieces and features they are used to make.

A series of short practical demonstrations and/or videos should be used to support these research activities.

**Suggested time:** about 5 hours.

### Activity: Carrying out drilling operations

Learners will need to develop the practical skills necessary to carry out drilling safely and accurately. Safe working practices essential to workshop safety of individual learners and their colleagues should be emphasised and discussed, including the use of guards, PPE and the position of emergency stop buttons. Learners should make notes and record their activities in a workshop logbook.

The safe use of the pillar drill should be demonstrated to learners, including setting up appropriate tooling, work-holding devices and positional and dynamic parameters appropriate for the features and material being drilled. A range of simple and complex tools should be demonstrated.
Individual learners can perform some of these demonstrations once suitably familiar with the processes involved and under close supervision. Learners should be asked to use appropriate measuring equipment to determine the accuracy and compliance of the features drilled in the demonstrations. Depending on the resources available, and once considered suitably competent and safe, learners can practise their skills in using a pillar drill safely and accurately, making workpieces of their own. They will be familiar with them from activities carried out in the unit introduction. Learners will assess the accuracy of their work and should see an improvement as their skills develop.

**Suggested time:** about 8 hours.

**Activity: Turning**

Learners will need to develop the practical skills necessary to carry out turning safely and accurately. Safe working practices and the correct use of guards, PPE and the position of emergency stop buttons should be emphasised. Learners should make notes and record their activities in a workshop logbook.

The safe use of the centre lathe should be demonstrated to learners, including setting up appropriate tooling, work-holding devices and positional and dynamic parameters appropriate for the features and material being turned. A range of simple and complex tools should be demonstrated. Individual learners can perform some of these demonstrations once suitably familiar with the processes involved, and under close supervision. Learners should be asked to use appropriate measuring equipment to determine the accuracy and compliance of the features turned in the demonstrations. Depending on the resources available, and once considered suitably competent and safe, learners can then practise their skills in using a centre lathe safely and accurately, making workpieces of their own. They will be familiar with these from the activities carried out in the unit introduction. Learners will assess the accuracy of their work and should see an improvement as their skills develop.

**Suggested time:** about 10 hours.

**Activity: Milling**

Learners will need to develop the practical skills necessary to carry out milling safely and accurately. Safe working practices and the correct use of guards, PPE and the position of emergency stop buttons should be emphasised. Learners should make notes and record their activities in a workshop logbook.

The safe use of the vertical milling machine should be demonstrated to learners, including setting up appropriate tooling, work-holding devices and positional and dynamic parameters appropriate for the features and material being turned. A range of simple and complex tools should be demonstrated. Learners can perform some of these demonstrations once suitably familiar with the processes involved, and under close supervision. Learners should be asked to use appropriate measuring equipment to determine the accuracy and compliance of the features turned in the demonstrations. Depending on the resources available, and once considered suitably competent and safe, learners can then practise their skills in using a centre lathe safely and accurately, making workpieces of their own. They will be familiar with these from the activities carried out in the unit introduction. Learners will assess the accuracy of their work and should see an improvement as their skills develop.

**Suggested time:** about 10 hours.
Essential resources

For this unit, learners will need access to:

- centre lathes, vertical milling machines and pillar drills as required by the learning aims and unit content
- auxiliary equipment, including appropriate work-holding devices and tools as required by the learning aims and unit content
- a range of measuring equipment suitable for determining the dimensions of workpieces and their features
- a range of engineering drawings and example workpieces containing simple and complex features for drilling, milling and turning. The two workpieces required in the assessment activities must contain between them at least two simple and two complex features from each of the drilling, milling and turning categories defined in the unit content.

Links to other units

This unit has strong links to Unit 7: Computer Numerical Control.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from the manufacturing industry, to share insights into industrial machining techniques and continuing importance of machining to a range of sectors. Speakers could talk about the importance of safety in machining, the importance of quality checks on completed components and maintaining accurate quality records
- a range of suitable workpieces and drawings. The designs for these could be developed in conjunction with an industrial partner
- work experience, which will allow learners to become familiar with industrial machining techniques and the typical industrial environments in which they are used. The nature of the skills and experience being developed in this unit mean that it is particularly suited to incorporating a period of work experience. Learners could shadow an inspector when carrying out a quality check
- a machine operator or supervisor, to support practical lessons and provide feedback and developmental advice to learners as their skills develop. This would help to ensure that the machining techniques taught effectively mirror those in current use in industry.
Unit 6: PCB Components and Soldering

Level: 2
Unit type: Optional
Assessment type: Internal
Guided learning hours: 60

Unit in brief

Learners set up and carry out the assembly of electronic circuits using printed circuit boards (PCBs) and investigate industrial electronic circuit manufacturing processes.

Unit introduction

If you look inside any piece of modern technology, for example a television or a games console, a washing machine or a microwave oven, you will find that they rely on electronics to make them work. Inside them all, you will find a printed circuit board (PCB). A PCB allows large numbers of electronic components to be connected to each other easily and reliably. Understanding how to prepare the necessary equipment and components, and then assemble a PCB, are important skills for anyone wanting to become involved in manufacturing an enormous range of products.

In this unit, you will prepare the necessary information, components and equipment required to assemble PCBs. You will carry out the soldering and assembly processes required to make a PCB, and check the quality of your work. You will investigate the techniques and equipment used in industry to manufacture PCBs in large numbers.

As well as hands-on practical skills, this unit will also develop your ability to work independently using written instructions, drawing and diagrams to carry out practical tasks. These skills are highly valued by employers and this unit will help prepare you for progression to employment as a manufacturing operative in industry.

Learning aims

In this unit you will:

A Prepare safely for the assembly of through-hole PCBs
B Assemble a functional through-hole PCB safely
C Explore ways in which PCBs are manufactured on an industrial scale.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
</table>
| **A** Prepare safely for the assembly of through-hole PCBs | A1 Understanding PCB manufacturing specifications | A portfolio of evidence, including:  
• observation records  
• annotated photographs  
• written notes  
• completed risk assessment(s) |
| | A2 Identifying electronic components |  |
| | A3 Equipment preparation |  |
| | A4 Risk assessment |  |
| **B** Assemble a functional through-hole PCB safely | B1 Soldering techniques | • quality inspection records  
• testing results. |
| | B2 Quality control and testing |  |
| **C** Explore ways in which PCBs are manufactured on an industrial scale | C1 Through-hole technology (THT) | A presentation evaluating the advantages of industrial PCB manufacturing techniques and equipment. |
| | C2 Surface-mount technology (SMT) |  |

### Key teaching areas in this unit include:

<table>
<thead>
<tr>
<th>Sector skills</th>
<th>Knowledge</th>
<th>Transferable skills/behaviours</th>
</tr>
</thead>
</table>
| • Interpreting electronic circuit diagrams and component layouts  
• Preparing to carry out manufacturing activities  
• Carrying out soldering safely | • Identification of electronic components and their symbols  
• PCB manufacturing techniques and equipment widely used in industry | • Managing information  
• Self-management and development  
• Organisational skills |
Unit content

Knowledge and sector skills

Learning aim A: Prepare safely for the assembly of through-hole PCBs

A1 Understanding PCB manufacturing specifications
Understanding and use of:
- schematic circuit diagrams, PCB component layout diagrams, standard component symbols to British Standard BS EN 60617, PCB silk screen print component identification, component lists, manufacturing aids such as photographs of populated PCBs.

A2 Identifying electronic components
- Identification of common component types, polarity, pin identification and component value markings, to include:
  - resistors, capacitors, transistors, diodes, integrated circuits, resistor colour codes.
- Mechanical components, to include:
  - connectors, DIL IC sockets.

A3 Equipment preparation
- Work area organisation.
- Identification and gathering of tools and equipment, to include:
  - soldering iron, stand, lead-free solder, wire strippers, side cutters, end cutters, de-soldering pump or braid, needle-nose pliers.
- Setting up fume extraction equipment.
- Checking soldering equipment, to include checking:
  - plug and flex for damage
  - soldering tip is clean and free of corrosion/damage.
- Correct use of soldering iron stand and cleaning tools.
- Handling and preparation of components.

A4 Risk assessment
- Safe working practices when soldering PCBs.
- Risk assessment appropriate to carrying out soldering, to include:
  - Health and Safety Executive (HSE) five steps to risk assessment
  - identifying the hazards
  - deciding who might be harmed and how
  - evaluating risks and deciding on control measures
  - recording findings and implementing control measures
  - reviewing risk assessment regularly and updating it as necessary.
Learning aim B: Assemble a functional through-hole PCB safely

B1 Soldering techniques
Techniques for hand soldering through-hole components into a PCB, to include:
• soldering using multi-core lead-free soldering technique to avoid dry joints
• tinning component legs and multi-strand wire
• using heat sinks and shunts
• using IC sockets
• using heat shrink sleeving or insulation tape
• using de-soldering braid or pump
• wire preparation, e.g. stripping, tinning, trimming
• connection of off-board components
• component polarity and placement.

B2 Quality control and testing
• Quality control checks, to include:
  o component placement and polarity, quality of soldering, functional testing.
  o Testing electronic circuits to check voltage levels, continuity and current, and to identify
    and diagnose faults, including the use of:
    o a voltmeter (or multimeter) to measure voltage levels across components and power supplies
      in a circuit
    o an ohmmeter (or multimeter) to check for continuity in circuit tracks and wires,
      and to detect breaks and bridges in connections
    o an ammeter (or multimeter) to measure total circuit current.

C Explore ways in which PCBs are manufactured on an industrial scale

C1 Through-hole technology (THT)
THT manual component placement techniques and equipment, to include:
• axial component preforming and cropping of taped components
• radial component cropping of taped components
• workstation organisation, to include type and position of component storage
• production aids, to include work-holding devices, images/photographs to guide
  component placement
• auto conveyor wave soldering
• visual inspection of component placement to ensure correct type, position and orientation
• automated testing using multi-pin PCB test fixtures
• typical circuit complexity – low/medium
• typical batch size – 10 to 1000
• production flexibility – good with short set-up times, allowing quick changeovers
  between products
• typical costs – high unit cost, low set-up cost, medium equipment costs.
C2 Surface-mount technology (SMT)
SMT techniques and equipment, to include:
• application of solder paste to required template
• high-speed automated pick and place machines using multiple component reels/magazines
• solder paste reflow ovens to mechanically fix and electrically connect components
• automatic optical inspection of component placement
• automated testing using multi-pin PCB test fixtures
• typical circuit complexity – high
• typical batch size – 1000 to 10,000
• production flexibility – poor with long and complex set-up requirements
• typical costs – low unit cost, high set-up cost, high equipment cost.

Transferable skills

Managing information
• PCB specifications may contain complex information in a range of formats, including schematic diagrams, images, component lists and written instructions. These must be managed and accurately interpreted in order to manufacture a PCB.

Self-management and development
• Managing the development of own skills through purposeful practice, becoming competent and then increasingly skilful in the application of PCB manufacturing techniques.

Organisational skills
• PCB manufacturing must be carried out methodically to ensure all components are inserted correctly before being soldered in place. A systematic and organised approach to the preparation of tools, equipment and components is required to ensure that manufacturing can be carried out effectively.
### Assessment criteria

<table>
<thead>
<tr>
<th>Learning aim A: Prepare safely for the assembly of through-hole PCBs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pass</strong></td>
</tr>
<tr>
<td><strong>A.P1</strong> Select components and identify and select tools and equipment for the safe assembly of PCBs.</td>
</tr>
<tr>
<td><strong>A.P2</strong> Carry out a risk assessment on hand soldering a through-hole PCB.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning aim B: Assemble a functional through-hole PCB safely</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pass</strong></td>
</tr>
<tr>
<td><strong>B.P3</strong> Assemble a functional PCB from a given specification, showing some skill.</td>
</tr>
<tr>
<td><strong>B.P4</strong> Carry out quality control inspection and testing of a manufactured PCB.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning aim C: Explore ways in which PCBs are manufactured on an industrial scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pass</strong></td>
</tr>
<tr>
<td><strong>C.P5</strong> Explain industrial THT PCB manufacturing methods.</td>
</tr>
<tr>
<td><strong>C.P6</strong> Explain industrial SMT manufacturing methods.</td>
</tr>
</tbody>
</table>
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:

- demonstrate the ability to select at least ten different through-hole components from a range of alternatives. For instance, given its standard symbol and value in the PCB specification, learners will select a 47 µF 50 V electrolytic capacitor from a range of alternative similar components (and repeat this process for at least nine other components)

- demonstrate the required knowledge to correctly identify component types and values for at least ten through-hole components quickly and with practised confidence. For instance, learners will identify a given component as a 0.25 W resistor from its shape and physical size, and read its value and tolerance by interpreting a four-band (brown, black, red, gold) colour code as 1 kΩ with 5% using a resistor colour-coded reference chart (and repeat this process for at least nine other components)

- organise collected components in preparation for manufacturing, e.g. components might be transferred into separate zip-lock bags, correctly labelled with component name, value and circuit reference

- select and organise appropriate tools and equipment in their work area to a professional standard in preparation for assembly, e.g. the soldering iron will be positioned so that its lead does not restrict movement, an appropriate stand and tip cleaning tools will be used, fume-extraction equipment will be positioned and adjusted to ensure maximum effectiveness, and the work area will be clear of all non-essential items and clutter

- select the most appropriate tools and equipment for each of the processes involved in the assembly of the PCB, e.g. selecting heat shrink sleeving instead of tape to insulate wired connections to off-board components, using side cutters instead of needle-nose pliers to trim component leads

- provide a risk assessment identifying all significant hazards involved in the assembly of a PCB, and suggest appropriate and feasible control measures. Learners will follow the standard five-step model for generating risk assessments (as available from the HSE website www.hse.gov.uk).

For merit standard, learners will:

- demonstrate the ability to select at least ten different through-hole components from a range of alternatives

- demonstrate the required knowledge to correctly identify component types and values for at least ten through-hole components. This will be done accurately but learners may need to refer back to their notes or other reference information, in addition to a resistor colour-code chart

- organise collected components in preparation for manufacturing, e.g. components might be transferred in separate zip-lock bags, although labelling may not contain all important information and may be missing the component name, value or circuit reference

- select and organise appropriate tools and equipment in their work area in preparation for assembly. The requirements of the manufacturing process might not have been completely thought through and all the required equipment may not have been collected at this stage

- provide a risk assessment identifying a range of significant hazards involved in the assembly of a PCB, but this may not be comprehensive. Learners will follow the standard five-step model for generating risk assessments (as available from the HSE website).
UNIT 6: PCB COMPONENTS AND SOLDERING

For pass standard, learners will:

- demonstrate the ability to select at least ten different through-hole components from a range of alternatives. This will be done accurately but learners may need to refer to notes or other reference information in order to do so. They may not be able to name all the components or accurately state their values when asked to do so.
- demonstrate an attempt to organise components in preparation for manufacturing, e.g. components might be transferred into a single zip-lock bag to prevent them from being lost.
- select and organise tools and equipment in their work area in preparation for assembly. The requirements of the manufacturing process might not have been completely thought through and some items of equipment may not have been collected at this stage. Others may not be the most appropriate tools available, e.g. learners may have selected a large pair of pliers instead of side snips for wire cutting, or chosen a soldering iron with a tip too large to be used effectively on the PCB being assembled. Learners may not be able to correctly name or fully explain the correct use of some tools and equipment when asked to do so.
- provide a risk assessment identifying a range of significant hazards involved in the assembly of a PCB.
- demonstrate a clear understanding of the importance of health and safety in the workplace by conducting all practical tasks safely and applying safe working practices as instructed by centre staff.

Learning aim B

For distinction standard, learners will:

- carry out manufacturing processes with a high level of skill. They will manipulate tools and equipment with dexterity and produce good-quality soldered joints quickly and efficiently, with minimum repositioning or reworking.
- identify and correct mistakes, if made, during assembly using appropriate techniques to maintain overall quality, e.g. where de-soldering is required, an appropriate heat shunt should be used to protect components from overheating, and either a de-soldering pump or braid used to remove solder before component removal.
- carry out a comprehensive, final quality inspection of the finished electronic circuit and maintain detailed records of this process. They will examine the type, position and polarity of all the circuit components. All soldered joints will be visually examined and their quality assessed. Any off-board components such as lead-mounted LEDs, switches or battery connectors will be examined and measured where appropriate. All inspection results must be accurate and verified by the tutor. Inspection results will confirm that there are no quality issues relating to component placement or soldering.

Testing will confirm that the PCB is fully functional. All the requirements of the given PCB specification must be met.

For merit standard, learners will:

- carry out manufacturing processes, demonstrating a good level of skill. They will manipulate tools and equipment competently and produce good-quality soldered joints, although some repositioning or reworking might be required as they work.
- identify and correct mistakes, if made, during assembly, e.g. where de-soldering is required, a de-soldering pump or braid is used to remove solder before component removal, however learners might not use an appropriate heat shunt to prevent overheating.
• carry out a final quality inspection of the finished electronic circuit and maintain records of this process, although these may lack detail. Learners will examine the type, position and polarity of components, the quality of soldered joints and the length of any off-board wiring. All inspection results must be accurate and verified by the tutor. Inspection results will confirm that there are no issues relating to component placement but there may be minor quality issues relating to soldering. These will be cosmetic in nature, such as the use of too much solder on some joints. One element of the given PCB specification may not be fully met. This must not directly impact basic circuit function, e.g. battery connection leads may not be of the specified colour or length, and LEDs may not have been mounted at the specified height above the surface of the board.

Testing will confirm that the PCB is fully functional.

For pass standard, learners will:

• carry out manufacturing processes, demonstrating some skill. They will manipulate tools and equipment safely and produce at least some good-quality soldered joints, although significant repositioning or reworking might be required as they work. Mistakes might include components connected backwards, dry joints or shorts caused by the use of too much solder on adjacent pads. These will be identified and corrected during assembly.

• carry out a final quality inspection of the finished electronic circuit and maintain a basic record of this process, but this might lack detail or contain omissions. All inspection results must be accurate and verified by the tutor. Inspection results will reveal significant quality issues that might compromise the long-term reliability of the circuit, such as lifting pads or tracks caused by overheating or too much or too little solder on a significant number of joints.

Testing will confirm that the PCB is fully functional.

Two or more requirements of the given PCB specification that do not directly impact basic circuit function may not be met. For example, battery connection leads may not be of the specified colour or length, and LEDs may not have been mounted at the specified height above the surface of the board.

Learning aim C

For distinction standard, learners will:

• show a detailed understanding of electronic circuit manufacturing methods by explaining the use of manual component placement and soldering, industrial THT manufacturing techniques and the use of SMT.

• evaluate the use of each technique given different manufacturing volume requirements, and justify their selection of an appropriate manufacturing method in a given scenario.

For merit standard, learners will:

• show an understanding of electronic circuit manufacturing methods by explaining the use of manual component placement and soldering, industrial THT manufacturing techniques and the use of SMT, making comparisons between them and analysing their advantages and disadvantages. This will include a discussion of individual unit cost, manufacturing flexibility and equipment costs.

For pass standard, learners will:

• show an understanding of industrial electronic circuit manufacturing methods using THT and SMT.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

Learning aims A and B

Suggested scenario

You are a manufacturing operative working in a production cell specialising in the manufacture of low-volume or one-off electronic circuits for use in a range of industries. Your supervisor has given you a manufacturing specification for a PCB and asked that you construct a single circuit by hand. You will need to carry out the following.

- Prepare all the necessary tools and equipment required to complete the task.
- Identify and prepare all the components required as specified in the manufacturing information pack.
- Carry out a risk assessment on the construction of an electronic circuit using hand-soldering techniques. This will form part of the annual review of health and safety risk assessments maintained by your manufacturing cell.
- Safely carry out the construction of the electronic circuit using appropriate hand-soldering techniques.
- Perform and suitably record a quality inspection of component placement, soldered joints and compliance with the PCB specification and test the function of the circuit.
- Make any necessary corrections or modifications.

If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

You are a manufacturing operative working in a production cell specialising in the manufacture of low-volume or one-off electronic circuits for use in a range of industries. Your supervisor has given you a manufacturing specification for a PCB and asked that you construct a single circuit by hand. This circuit will be significantly different to that used in the original assignment. You will need to carry out the following.

- Prepare all the necessary tools and equipment required to complete the task.
- Identify and prepare all the components required as specified in the manufacturing information pack.
- Carry out a risk assessment on the construction of an electronic circuit using hand-soldering techniques. This will form part of the annual review of health and safety risk assessments maintained by your manufacturing cell.
- Safely carry out the construction of the electronic circuit using appropriate hand-soldering techniques.
- Perform and suitably record a quality inspection of component placement, soldered joints and compliance with the PCB specification and test the function of the circuit.
- Make any necessary corrections or modifications.
Learning aim C

Suggested scenario

The demand for one of the PCBs you make is growing, and has now reached a level where your current team of operatives using manual through-hole component placement and soldering methods are finding it hard to keep up. Your manager has asked you to research and evaluate high-volume manufacturing techniques and equipment that could be brought in to help cope with demand. You should consider how these compare to manual production methods.

You have been asked to recommend equipment and techniques suitable for manufacturing in batches of 300 circuits. You should indicate why a range of alternatives are less suited to the job, and how it would be an improvement on the continued use of entirely manual production methods.

You have been asked to feed back to your employer at the next team meeting about whether the component can be mass produced.

If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

A customer has shown significant interest in one of the circuits produced by the company where you work as a manufacturing operative, and has made an enquiry with your sales team. The request would require a dramatic increase in the volume of production, to around 40,000 circuits per year. Your manager has asked you to research and evaluate high-volume manufacturing techniques and equipment that could be brought in to help cope with demand. You should consider how these compare to manual production methods.

You have been asked to recommend equipment and techniques suitable for manufacturing in large batches of 8000 circuits. You should indicate why a range of alternatives are less suited to the job, and how it would be an improvement on the continued use of entirely manual production methods.

You have been asked to present your findings to the management team at their next meeting.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

**Introduction to unit**

An industrial visit to a local PCB manufacturing company would be beneficial at an early stage in the delivery of the unit. Learners will have the opportunity to see industrial PCB manufacturing equipment and techniques. They will talk to industry specialists and ask questions, and see the real industrial importance of the topics they will be studying in this unit.

A tutor-led discussion covering the emergence of consumer electronics and the development of PCBs as a way of simplifying the manufacture of electronic circuits. Learners are asked to work in groups and determine the advantages of using PCBs over the bulky and unreliable point-to-point wiring techniques used before their widespread adoption.

Examples of PCBs should be available for learners to look at and inspect. These should include examples of single and double sided, through hole (THT) and surface mount (SMT), hand soldered and commercially manufactured boards.

**Suggested time:** about 4 hours.

**Activity: Electronic components, circuit diagrams and PCB components layouts**

Tutors will introduce a range of electronic components to learners, using physical examples of the components as they are supplied by manufacturers and examples of components fitted to finished PCBs. These should be related to their standard symbols, which can be found on schematic circuit diagrams. Card-matching games, flash cards or other techniques can be used to help learners link the names, physical examples and symbols for the full range of components.

The function of components should be briefly discussed, and the circuits to be used in later practice and assessed practical tasks can be demonstrated and/or constructed in circuit simulation computer-aided design (CAD) software as part of teaching and learning.

Identification of component values should be discussed with the group, including reference to preferred values, units and prefixes.

Resistor colour codes should be introduced and their use practised. This can be linked to the use of an ohmmeter to measure resistance values of a range of resistors to confirm that the colour codes have been correctly interpreted. This will lead to a discussion of resistor tolerances.

Identification of component polarity (e.g. diodes, LEDs, electrolytic capacitors), leg identification (e.g. transistors) and pinouts (e.g. integrated circuits) should all be demonstrated by the tutor and practised by learners.

Examples of unpopulated PCBs complete with silk screen component layout, fully populated and complete PCBs, related schematic circuit diagrams, PCB component layout diagrams and component lists should all be introduced to learners. Methods of identifying individual components on the PCB layout by cross-referencing component labels (e.g. R1, C3, IC1 etc.) should be practised.

**Suggested time:** about 8 hours.
### Activity: Demonstrating tools, equipment and techniques used to construct and test electronic circuits by hand

Before starting any practical work, learners need to be aware of the health and safety risks involved. A tutor-led discussion will introduce the notions of hazards, risk and control measures before covering the five steps to risk assessment in more detail. Existing institutional risk assessments for a range of activities should be discussed with learners.

Throughout the practical demonstrations, learners should be asked to keep notes on any hazards, associated risks and control measures already in place to ensure the safe completion of the electronic circuit construction.

Tutors should introduce a full range of hand tools required to prepare components, populate and solder PCBs. This might be done initially through a practical tutor demonstration using a desktop portable camera to display the process on a projector screen in the classroom. This will ensure that all learners have a close-up view of the safe and correct use of the tools and techniques required. The demonstration should include the information and diagrams typically used to specify the PCB and guide its assembly. These allow the identification of the required components and specify their correct position on the PCB.

Effective soldering (and de-soldering) techniques should be carefully demonstrated so that learners have a clear idea of how they should proceed when starting subsequent practical tasks and soldering for what may be the first time.

Once the circuit is complete, checks for correct component placement, dry joints, shorts or other faults should be demonstrated.

The circuit function can now also be demonstrated. Learners should already be familiar with circuit function and output from previous lessons where the circuit was tested using simulation software.

**Suggested time:** about 4 hours.

### Activity: PCB assembly

When tutors are confident that learners have a good understanding of what is involved, they should be issued with the same information used in the tutor demonstration and asked to assemble the PCB. This will be their opportunity to practise the skills required before building a different electronic circuit during assessment activities for the unit.

**Suggested time:** about 16 hours.

### Activity: Industrial methods of constructing electronic circuits

To learn about industrial methods, an industrial partner might be able to provide site visits or visiting experts to support teaching and learning. If this is not possible, there are many appropriate videos and interactive resources available on the subject.

Learners should be asked to consider the problems that might be encountered in large-volume production runs of electronic circuits that are made by hand, using the techniques they have practised. In small groups, they should list all the stages of the manual manufacturing processes and determine which are the most time-consuming. They should then consider possible ways in which these could be sped up and present their ideas to the group.

Learners should research the methods that large industrial manufacturers use to populate and solder their circuit boards, to illustrate how the issues with manual processes have been overcome in industry.

Research should include both THT and SMT manufacturing techniques and their advantages over the manual construction of electronic circuits.

**Suggested time:** about 6 hours.
Essential resources

For this unit, learners will need access to:

- a range of general and specialist tools and equipment for constructing and testing electronic circuits (as defined in the unit content)
- a range of non-populated PCBs, electronic components and associated circuit and PCB layout diagrams and other information sufficient to allow their construction and testing.

Links to other units

This unit has strong links to:

- Unit 3: Business Improvement Techniques
- Unit 8: Electrical Components and Wiring.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from the electronics industry who can give an insight into the industrial PCB manufacturing techniques studied in the unit. Speakers could share their expertise on the various ways in which PCBs are manufactured on an industrial scale, and the advantages of industrial PCB manufacturing techniques and equipment in comparison to low-volume techniques
- industrial partners to help develop the range of suitable circuit designs and associated specification documentation that must be available to learners, to ensure they represent current industry-standard best practice
- work experience, to provide a valuable insight for learners into industrial manufacturing techniques and best practice, which would directly inform and develop their skills, knowledge and experience across the unit from performing manual soldering operations to evaluating automated PCB manufacturing systems
- a range of examples of populated and unpopulated PCBs, illustrating a range of manufacturing techniques that will be required in the teaching and learning for this unit. Local businesses can be an excellent source for these example materials that can otherwise be difficult to obtain
- support from local business staff as mentors. For instance, a PCB production operative or supervisor might be asked to support practical lessons and provide feedback and developmental advice directly to learners as their practical skills develop. This would also help to ensure that the manufacturing techniques being taught effectively mirror those in current use in industry.
Unit 7: Computer Numerical Control

Level: 2
Unit type: Optional
Assessment type: Internal
Guided learning hours: 60

Unit in brief

Learners apply the principles of Computer Numerical Control (CNC) machining, develop a computer part program and manufacture a component using a CNC machine.

Unit introduction

Have you ever wondered how machined parts, from bicycle gear mechanisms to parts used in jet engines, are manufactured in large numbers and to a high degree of accuracy? The answer is with the help of Computer Numerical Control (CNC) machines. These machines need you to tell them what to do. Manufacturers use CNC machining for components that are difficult to manufacture by traditional methods, for example dyes for injection moulding machines, valves, and automotive components, as well as gears for bicycles and aerospace engine parts. CNC machines can be used for complicated one-off components or batch-production components, where it is more economical than using traditional methods. Think about the difficulty of setting up and machining complex products with traditional machines; CNC machines do this easily. Many of the products and components we use daily rely on CNC machining processes, so these machines will always have a role to play in manufacturing industries in the UK and the rest of the world.

In this unit, you will produce a part program to machine a component. You will carry out practical activities to plan and program a CNC machine tool to manufacture a component. As part of the process, you will write a part program and use some simple measures to see how effective it is and whether improvements can be made. You will use simulation software to safely determine if the program is fit for purpose. Finally, you will prepare the CNC machine and safely manufacture a component and check its conformity to specification and size.

As a future engineer, it is important to understand the manufacturing systems and mechanisms of planning and creating components through programming CNC machine tools. This unit will help to prepare you for employment, for example as a CNC machine operator and setter, for an apprenticeship, or for entry to further education to study engineering.

Learning aims

In this unit you will:
A Develop a CNC part program
B Simulate a CNC part program and safely prepare a CNC machine for manufacture
C Manufacture a component safely using a CNC machine.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> Develop a CNC part program</td>
<td><strong>A1</strong> Part programs</td>
<td>A development log that includes:</td>
</tr>
<tr>
<td></td>
<td><strong>A2</strong> Measuring effectiveness and improving the</td>
<td>• witness statement(s)/observation record(s)</td>
</tr>
<tr>
<td></td>
<td>performance of a CNC part program</td>
<td>• a draft part program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• an improved part programme</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• annotated photograph(s), part program/annotated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>screen dumps/annotated component drawing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• table of measurements/conformity checks.</td>
</tr>
<tr>
<td><strong>B</strong> Simulate a CNC part program and safely prepare a CNC machine for</td>
<td><strong>B1</strong> Simulate a CNC part program</td>
<td></td>
</tr>
<tr>
<td>manufacture</td>
<td><strong>B2</strong> Work safely while preparing to carry out a CNC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>process</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>B3</strong> Prepare a CNC machine for manufacture</td>
<td></td>
</tr>
<tr>
<td><strong>C</strong> Manufacture a component safely using a CNC machine</td>
<td><strong>C1</strong> Safely manufacture a component using a CNC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>machine</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>C2</strong> Quality control</td>
<td></td>
</tr>
</tbody>
</table>

**Key teaching areas in this unit include:**

### Sector skills

- Interpreting drawings and component specifications to produce part programs for component manufacture
- Preparing to carry out manufacturing activities using a CNC part program
- Carrying out manufacturing of a component safely using a CNC machine

### Knowledge

- Identification of part program features that could be improved to enhance CNC manufacture of components
- Recognising safety features when using a part program and CNC machine when machining a component

### Transferable skills/behaviours

- Problem solving
- Managing information
- Self-management and development
Unit content

Knowledge and sector skills

Learning aim A: Develop a CNC part program

A1 Part programs

- Writing a part program for a CNC machine, including:
  - machine type, e.g. lathe, milling machine, router
  - reference (datum) points
  - absolute and incremental coordinates
  - machine axes ($x$, $y$)
  - positional information using absolute and incremental systems of measurement
  - tool change positions
  - tool lengths
  - tool offsets
  - codes for preparatory and miscellaneous functions
  - safe use, e.g. appropriate cutting feeds and speeds for the machine and material being shaped, appropriate tool selection, component orientation.

- Enhancing features for a part program for a CNC machine, including:
  - cutter path change points
  - radius compensation.

A2 Measuring effectiveness and improving the performance of a CNC part program

- Measuring the effectiveness of a CNC part program using methods, including:
  - time taken to manufacture the component
  - quality of the finished component in terms of conformance to the design specification
  - quantity of waste material
  - costs, e.g. number of tools used and wear.

- Improving the performance of a CNC part program using methods, including:
  - reducing the distance travelled by tools/cutting path
  - reducing the number of tools needed to manufacture the component
  - optimising the tool speeds and material feeds
  - reducing the number of program instructions
  - reducing the volume of waste material.

Learning aim B: Simulate a CNC part program and safely prepare a CNC machine for manufacture

B1 Simulate a CNC part program

Using appropriate software, simulate a program using methods, including:

- simple methods (single block program run, dry run)
- complex methods, e.g. override controls, adjustments for tool compensation.
B2 Work safely while preparing to carrying out a CNC process
General safety awareness when carrying out a CNC process, including:
- emergency stop and override controls
- appropriate use of coolant
- identifying risks and appropriate control measures, e.g. risk assessment
- use of personal protective equipment (PPE) appropriate to the task
- clean and tidy work area.

B3 Prepare a CNC machine for manufacture
Preparing a CNC machine for manufacture, including:
- loading and securing the raw materials and workpiece safely
- setting appropriate guarding and interlocks
- loading, storing and retrieving a CNC program, e.g. manual data input (MDI) and edit functionality, storing and retrieving programs using portable media or networks, downloading via a computer interface.

Learning aim C: Manufacture a component safely using a CNC machine

C1 Safely manufacture a component using a CNC machine
Safely manufacture a component using a CNC machine:
- safely run a CNC part program to manufacture a component
- safely remove the finished component.

C2 Quality control
- Checking conformity of a machined component to the design, including:
  - direct measurement using appropriate instruments
  - unilateral and bilateral tolerances
  - using further measurement equipment to check conformity, e.g. micrometers, slip gauges, verniers.
- Recording inspection data, including:
  - dimensional inspection results checklist with ‘Yes/No’ criteria
  - visual inspection, e.g. surface finish.

Transferable skills

Problem solving and communication
- Finding out: obtaining time taken, costings, optimising tool movements and changes, reducing waste.

Managing information
- Writing the part program by interpreting the information on the component specification/drawing.

Self-management and development
- Confidence in using the simulation software and the CNC machine.
### Assessment criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning aim A: Develop a CNC part program</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.P1 Write a functional CNC part program for the machining of a given component.</td>
<td>A.M1 Write a CNC part program for the machining of a given component, including the use of enhanced features that improve its performance.</td>
<td>A.D1 Write an effective CNC part program for the machining of a given component, which justifies why and how enhanced features have influenced its performance and measurements of effectiveness.</td>
</tr>
<tr>
<td>A.P2 Carry out the measurement of effectiveness of a CNC part program and suggest improvements to its performance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim B: Simulate a CNC part program and safely prepare a CNC machine for manufacture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.P3 Demonstrate the correct use of CNC part program simulation by using simple methods.</td>
<td>B.M2 Demonstrate the correct use of CNC part program simulation by using simple and complex methods, amending as required, ensuring the CNC machine is ready for use in a safe manner.</td>
<td>B.D2 Demonstrate the correct use of CNC part program simulation methods, showing how simple and complex methods can be used to ensure that the component will conform to the specification and the CNC machine is ready for use in a safe manner.</td>
</tr>
<tr>
<td>B.P4 Safely prepare a CNC machine to manufacture a component.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim C: Manufacture a component safely using a CNC machine</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.P5 Operate a CNC program to manufacture a given component.</td>
<td>C.M3 Operate a CNC program safely to manufacture a given component that fully conforms to its specification.</td>
<td>C.D3 Operate a CNC program to manufacture a given component that fully conforms to its specification, justifying why it conforms.</td>
</tr>
<tr>
<td>C.P6 Carry out conformity checks on a CNC machined component and record results.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:
- write an effective CNC part program
- write a CNC part program that has its performance optimised through the use of improvement enhancing techniques. Learners will prepare screen dumps that show the full detail of the enhancements and improvements made
- provide detailed justification of how the use of enhanced features have improved the performance of the program, e.g. reducing the cycle time, improving tool life, reducing the idle time of cutting tools.

For merit standard, learners will:
- write a functional CNC part program, with enhanced features, that they have improved from their original draft part program
- write a CNC part program that has had its performance optimised through the use of improvement enhancing techniques. Learners will prepare screen dumps that show the full detail of the enhancements and improvements made.

For pass standard, learners will:
- write a functional CNC part program
- demonstrate a lack of confidence to write a part program
- suggest how the performance of their part program might be improved for future use.

Learning aim B

For distinction standard, learners will:
- carry out the simulation of their part program and safely set up the CNC machine
- use the full range of simulation methods and prepare screen dumps that show the full detail of the simulation of their program across all methods, and how they set up the CNC machine safely
- show clearly, using annotation on the component drawing, how their program was simulated, why amendments were made, and how the machine was set up. The annotated photographs will demonstrate a high level of safety awareness of the machine set-up.

For merit standard, learners will:
- carry out the simulation of their part program and safely set up the CNC machine
- use simple and complex simulation methods and prepare screen dumps that show the simulation of their program, and how they set up the CNC machine safely
- show, using annotation on the component drawing, how their program was simulated, and how the machine was set up. The annotated photographs will demonstrate an appropriate level of safety awareness of the machine set up. There may be a lack of detail in these forms of evidence.

For pass standard, learners will:
- carry out limited simulation of their part program and the safe setting up of the CNC machine
- use only simple simulation methods and prepare screen dumps that show the simulation of their program, and how they set up the CNC machine safely
- show, using annotation on the component drawing, how their program was simulated using simple methods, and how the machine was set up. The annotated photographs will demonstrate a level of safety awareness of the machine set up that needs checking. There will be a lack of detail in these forms of evidence.
Learning aim C

For distinction standard, learners will:

- produce a component that has been accurately measured and conforms fully to the drawing and specification, with the notes justifying why this is the case, e.g. comparing measured dimensions with those given in the drawing to see if they are within tolerance
- show clearly, using annotation on the component drawing, how their component conforms to the specification
- have witness statements/observation records that support how they worked on their own without third-party help, guidance and support.

For merit standard, learners will:

- produce a component that has been accurately measured and conforms fully to the drawing and specification
- show clearly, using annotation on the component drawing, how their component conforms to the specification
- have witness statements/observation records that support how they worked successfully with some third-party help, guidance and support. This record would show how they soon became independent after initial contact from a third party.

For pass standard, learners will:

- produce a component that has been measured but may not fully conform to the drawing and specification
- show, using annotation on the component drawing and the table of measurements, how their component mainly conforms to the specification. There may be a lack of detail in these forms of evidence
- have witness statements/observation records that support how they worked successfully with third-party help, guidance and support. This record would show how they struggled to work on their own, but after initial contact from a third party, were able to manufacture a component and carry out conformity checks.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

Suggested scenario

As an apprentice in a manufacturing company, you have been asked to make a prototype component that will be used in the Formula 1® car manufacturing industry. You will use drawings provided by your supervisor. The component will need to be manufactured safely and accurately within given tolerances if they are to fit the Formula 1 car being prototyped and allow it to function properly. You will have to write a CNC part program, and before making the component you will need to simulate the machining of it. You will need to keep a record of what you did.

You will be expected to carry out the following.

- Write a part program for the manufacture of the prototype component.
- Measure the performance of your part program using defined methods and make suggestions to improve it.
- Use a range of simulation methods for your part program.
- Prepare the CNC machine so it will be able to make your component safely.
- Accurately and safely use the CNC machine to make the features of your component within stated tolerances.
- Demonstrate a good understanding of safe working practices and general safety awareness at all times.

When carrying out these activities, you need to keep in close contact with your supervisor who will ensure they record what you did and how well you did it. You will still, however, need to carry out accuracy methods to prove how well your component has been made.

Your record will need to include the following.

- Your part programs, including draft and improved versions.
- Notes to justify why and how you made improvements from the methods used.
- A range of witness statements/observation records from your supervisor or another responsible person.
- Screen dumps and annotations from your part programs to show the progress of your simulation.
- A table of measurements to show how well your component meets its specification, together with annotations from the component drawings to show why the component conforms.
If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

You have just started work in an engineering company, working on traditional machines such as lathes and milling machines. The company has purchased some new CNC machines and you have shown interest in setting up and operating one of these machines. Your supervisor has asked you to demonstrate that you can make a component on the CNC machine using drawings that they will provide. This will need to be manufactured safely and accurately within given tolerances if you are to impress your supervisor. You will have to write a CNC part program, and before making the component you will need to simulate the machining of it. You will need to keep a record of what you did.

You will be expected to carry out the following.

• Write a part program for the manufacture of the component.
• Measure the performance of your part program using defined methods and make suggestions to improve it.
• Use a range of simulation methods for your part program.
• Prepare the CNC machine so it will be able to make your component safely.
• Accurately and safely use the CNC machine to make the features of your component within stated tolerances.
• Demonstrate a good understanding of safe working practices and general safety awareness at all times.

When carrying out these activities, you need to keep in close contact with your supervisor who will ensure they also record what you did and how well you did it. You will still, however, need to carry out accuracy methods to prove how well your component has been made.

Your record will need to include the following.

• Your part programs, including draft and improved versions.
• Notes to justify why and how you made improvements from the methods used.
• A range of witness statements/observation records from your supervisor or another responsible person.
• Screen dumps and annotations from your part programs to show the progress of your simulation.
• A table of measurements to show how well your component meets its specification, together with annotation on the component drawings to show why the component conforms.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

**Introduction to unit**
Tutors could introduce learners to CNC machines by showing videos of CNC machines in full operational mode.
A visit to the workshops in which the practical work required in this unit is to be carried out would be beneficial for learners at an early stage in the delivery of this unit. Learners should be introduced to each of the machine types they may be required to use. At this initial stage, the requirements for good safety awareness should be emphasised during the discussion and brief demonstration of each machine given. Emphasis should be on health and safety and the efficiency of CNC machines.
Examples of machined components should be available for learners to look at and inspect. These should include examples of turned and milled components.
A tutor-led discussion could introduce learners to the concepts of part programming when applied to engineering components and could include an overview of the CNC machines covered in the unit and methods of identifying accuracy.

**Suggested time:** about 3 hours.

**Activity: Writing CNC part programs**
Learners could develop a greater understanding of writing CNC part programs by using a case study, a component drawing, part program, actual component and a tutor-led discussion about writing part programs.
Learners carry out research in order to prepare and deliver a presentation about the different CNC machines and their applications.
Learners practise writing programs.
Using a competition, learners write a program and get others to peer evaluate the program, identifying the values of effectiveness and how to improve the performance of the part program.

**Suggested time:** about 6 hours.

**Activity: Getting a CNC machine ready**
In the workshop, tutors demonstrate how to load a program and run the simulation, covering the single block program run and dry run methods. With the help of responsible workshop personnel, learners practise the skills of loading and simulating a program. It is important to cover a sufficient range of complex simulation methods, such as override controls, and adjustments for tool compensation.
Some of this could be carried out just using computer software, as the actual activity of preparing the CNC machine with tooling and components is not needed in this activity. Learners should make notes and record their activities from the simulation to remind themselves how to simulate their program before using the CNC machine.

**Suggested time:** about 10 hours.
Activity: Practise manufacturing a component on a CNC machine
Learners will need to develop the practical skills necessary to carry out CNC machining safely and accurately. Safe working practices are essential to the workshop safety of learners and their colleagues, and should be emphasised and discussed, including the use of guards, PPE and the position of emergency stop buttons. Learners should make notes and record their activities in a workshop logbook to help remind them how to set up and operate the CNC machine to make the component, and carry out checks to consider its compliance to the specification.

The safe use of the CNC machine should be demonstrated to learners, including setting up appropriate tooling, work-holding devices and positional aspects appropriate for the features and material being machined. Learners should perform some of these demonstrations under close supervision, once suitably familiar with the processes involved. This is a good way of improving learners’ confidence and independence needed for this part of the unit.

Learners should be asked to use appropriate measuring equipment to determine the accuracy and compliance of the features of the component used in the demonstrations.

Suggested time: about 15 hours.

Activity: Writing a CNC part program, setting up the machine and manufacturing a component on a CNC machine
In the workshop, using a previously unseen machining requirement for a component, learners write a part program, load the program and run the simulation using the single block program run and dry run methods. With the help of responsible workshop personnel, learners use a CNC machine, including setting up appropriate tooling, work-holding devices and positional aspects appropriate for the features and material of the component being machined. It is important that learners are supervised to ensure safety rules are abided by, and they can actually carry out the machining.

After manufacture, learners should use appropriate measuring equipment to determine the accuracy and compliance of the features of the component they machined.

Suggested time: about 22 hours.
Essential resources

For this unit, learners will need access to:
• suitable CNC machines with auxiliary equipment
• tooling and programming software. Industrial machines and equipment would be preferable but desktop versions are the minimum required.

Links to other units

This unit has strong links to:
• Unit 1: Engineering Principles
• Unit 4: Workshop Skills
• Unit 8: Electrical Components and Wiring
• Unit 9: Delivering Engineering Solutions.

Employer involvement

This unit would benefit from employer involvement in the form of:
• guest speakers from electrical engineering organisations, including technicians. Speakers could offer insight into how the operations and skills that learners are developing are part of a long chain that results in the manufacture of many different types of products
• work experience with an electrical engineering organisation where a range of activities can be experienced.
Unit 8: Electrical Components and Wiring

Level: 2
Unit type: Optional
Assessment type: Internal
Guided learning hours: 60

Unit in brief

Learners study the function and operation of the electrical components that they are likely to encounter when fault-finding and carrying out maintenance on electrical circuits.

Unit introduction

We are surrounded by and rely on electrical systems but few people understand how these systems function or how they should be tested and serviced safely.

In this unit, you will gain the skills necessary to carry out routine servicing and maintenance activities on electrical components and systems. You will learn how components come together to make simple electrical systems function and operate. You will explore the ways in which systems can be tested and serviced safely.

This unit will help to prepare you for employment as an apprentice, and then as a technician in the electrical engineering sector. Many of the skills you will gain are transferable and will allow you to progress to other engineering pathways, including, but not limited to, automotive or mechatronic sectors.

Learning aims

In this unit you will:

A Undertake routine operations on an electrical system using information sources
B Wire and terminate electrical components
C Undertake maintenance activities on electrical systems.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong></td>
<td>Undertake routine operations on an electrical system using information sources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A1 Electrical systems</td>
<td>A development log that includes:</td>
</tr>
<tr>
<td></td>
<td>A2 System components</td>
<td>• tutor observation records of risk assessments</td>
</tr>
<tr>
<td></td>
<td>A3 Information sources</td>
<td>• test and inspection reports</td>
</tr>
<tr>
<td></td>
<td><strong>B</strong> Wire and terminate electrical components</td>
<td>• learners’ own reflections.</td>
</tr>
<tr>
<td></td>
<td>B1 Preparing for wiring electrical circuits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B2 Wiring electrical circuits and components</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>C</strong> Undertake maintenance activities on electrical systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C1 Safety</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2 Identification of faults in an electrical system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3 Fault rectification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C4 Routine maintenance</td>
<td></td>
</tr>
</tbody>
</table>

### Key teaching areas in this unit include:

<table>
<thead>
<tr>
<th>Sector skills</th>
<th>Knowledge</th>
<th>Transferable skills/behaviours</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Practical fault-finding</td>
<td>• Health and safety</td>
<td>• Problem solving</td>
</tr>
<tr>
<td>• Wiring and termination</td>
<td>• Electrical theory</td>
<td>• Managing information</td>
</tr>
<tr>
<td>• Maintenance and rectification</td>
<td>• Reporting procedures</td>
<td>• Self-management and development</td>
</tr>
<tr>
<td>• Testing</td>
<td>• Interpreting information</td>
<td></td>
</tr>
<tr>
<td>• Completion of reports</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Unit content

Knowledge and sector skills

Learning aim A: Undertake routine operations on an electrical system using information sources

A1 Electrical systems
Function and operation of electrical systems, to include:
- lighting circuit
- alarm (fire, intruder)
- portable appliance
- motor and starter
- generator
- control circuit.

A2 System components
Function and operation of components, to include:
- electronic circuit board – capacitor, resistor, inductor, diode, transistor, integrated circuit, light-emitting diode (LED), sounder
- battery
- transformer, rectifier
- sensors, actuators, solenoids, relays
- circuit protection – circuit breaker, overload protection, fuses, residual current devices (RCDs)
- motor
- lamp holders and luminaires
- switch, cabling, connector
- mechanical fixings – nuts, bolts, screws, locking, retaining.

A3 Information sources
- Circuit information – block diagram, circuit diagram, system diagram, parts list.
- System information – system specification, assembly drawing.
- Component information – manufacturers’ catalogues, component data sheets.
- Regulations, e.g. Part P of the Building Regulations, relevant British Standard (BS) and other regulations.
BTEC LEVEL 2 TECHNICALS

UNIT 8: ELECTRICAL COMPONENTS AND WIRING

Learning aim B: Wire and terminate electrical components

B1 Preparing for wiring electrical circuits

Preparing for carrying out wiring and assembly activities:

- precautions – tidy working area, storage of tools and equipment, availability of resources such as electrical and air supplies
- preparation – specifications and wiring diagrams, availability of correct components, wiring and cables
- tools and equipment – availability of appropriate hand tools, test equipment and measuring equipment
- inspection – checking for broken or damaged insulation and housings, missing screws.

B2 Wiring electrical circuits and components

Wiring electrical circuits:

- types of circuit, including domestic lighting, domestic power, control, motor control, alarm circuits (fire, intruder), heating or air conditioning
- circuit components, including isolators, switches, sockets, lamp holders and luminaires, junction and terminal boxes, circuit breakers, fuses, RCDs, alarm devices, sensors/actuators/solenoids, consumer units, transformers, sub-assemblies
- selection and installation of components and equipment, including types of cable (PVC, flexible, single core, multiway, ribbon cables)
- preparing and securing cables – stripping outer coatings, stripping conductor insulation, using clips, strapping, harnessing, sleeving
- connection methods, including crimping (spade end, loops, tags, pins), mechanical/screwed/clamped connections, insulation displacement
- earthing procedures and circuit protection
- testing, including continuity test, insulation resistance test, visual inspection, polarity
- inspection and testing records and documentation:
  - visual records, e.g. colour coding of cables, identification tags
  - written records, e.g. voltage records, resistance logs, sign-off documents.

Learning aim C: Undertake maintenance activities on electrical systems

C1 Safety

- Safety awareness while carrying out maintenance on electrical systems, including:
  - risk assessments, including following risk assessments
  - hazards and risks, including people at risk
  - workplace hazards – incorrect isolation of electrical supplies, electrostatic and high voltages, pressurised systems, unfenced machinery, non-lockout of moving parts, badly maintained tools and equipment
  - control measures and their effectiveness
  - risk assessment documentation.

- Safe working practices:
  - using personal protective equipment (PPE)
  - personal safety, including wearing protective clothing, removal of loose clothing and jewellery
  - following safe working practices – permit to work, danger tags, warning notices, safety barriers, safe isolation, treatment for electric shock and other procedures in case of injury, accident reporting, approved working practices.
good housekeeping, including cleanliness of work area, removal of waste materials, storage of materials and tools, maintenance of access (clear walkways, emergency exits).

• Safe use of equipment, including:
  o soldering tools – soldering iron, de-soldering tool, side cutters, snips, pliers and crimping tools
  o hand tools.

**C2 Identification of faults in an electrical system**

• Types of fault – intermittent operation, partial failure/out-of-specification output, complete breakdown.

• Aids to determining faults – fault codes, previous fault/repair reports, functional and troubleshooting charts, final test and handover procedures, software-based records and data.

• Instruments – multimeter, insulation resistance tester, portable appliance tester.

• Fault-finding techniques, to include:
  o six point (collect evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system)
  o visual examination
  o half split
  o unit substitution.

**C3 Fault rectification**

Remove and replace faulty components, to include:

• components – remove, test, repair, source replacement, refit like-for-like component, retest
• procedures – solder, re-solder, remove mechanical fixings, unclip electrical connectors
• post-rectification tests and checks
• record actions – job card, checklist.

**C4 Routine maintenance**

• Inspection checks and tests – visual examination, measurement of electrical current and voltage, insulation.

• Maintenance procedures – adjustments, replace components, test against specification.

• Record actions – job card, checklist, routine maintenance report, sign-off documentation.

**Transferable skills**

**Problem solving and communication**

• Finding out: developing research and analysis skills through obtaining information about components, gaining analytical skills as necessary to identify trends and patterns, and applying to interpreting data to identify faults.

**Managing information**

• Interpreting data as a result of analysing test readings, gaining experience of completing documentation through the recording of values and findings on pro formas.

**Self-management and development**

• Development of self-management skills that can be applied to problem-solving tasks, taking into account time and resources that are available.
**Assessment criteria**

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning aim A: Undertake routine operations on an electrical system using information sources</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.P1 Select and use appropriate information sources when carrying out routine operations on a given electrical system.</td>
<td>A.M1 Use information sources effectively and accurately when carrying out routine operations on a given electrical system.</td>
<td>A.D1 Justify the appropriateness of information sources when carrying out routine operations on a given electrical system with precision.</td>
</tr>
<tr>
<td><strong>Learning aim B: Wire and terminate electrical components</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.P3 Select and use tools, equipment and components for a given wiring activity.</td>
<td>B.M2 Carry out a wiring activity safely using appropriate tools and equipment, and completing accurate documentation.</td>
<td>B.D2 Carry out a wiring activity safely to a professional standard, completing detailed sign-off documentation.</td>
</tr>
<tr>
<td>B.P4 Demonstrate safe working practices when carrying out an electrical wiring activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Learning aim C: Undertake maintenance activities on electrical systems</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.P5 Carry out maintenance activities competently on a given electrical system.</td>
<td>C.M3 Carry out a maintenance activity, safely showing good skill on a given electrical system and completing accurate documentation.</td>
<td>C.D3 Carry out a maintenance activity safely and independently on a given electrical system to a professional standard, completing a detailed maintenance report.</td>
</tr>
<tr>
<td>C.P6 Demonstrate safe working practices when carrying out maintenance activities on a given electrical system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.P7 Record actions completed when carrying out maintenance activities on a given electrical system.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:
- justify the appropriateness of the information sources that they have used when carrying out routine operations on electrical systems. This will include a consideration of the information sources that they have used when carrying out fault-finding tasks, fault-rectification tasks and maintenance activities. They will reference the accuracy and validity of information sources, e.g. whether they are contemporary and up to date, industry-specific regulations, relevance to local conditions.

For merit standard, learners will:
- select and use a range of appropriate sources of information when carrying out a series of activities that will include fault-finding, fault-rectification and routine maintenance. They will use the information sources effectively and accurately so that they complete operations correctly.

For pass standard, learners will:
- select and use information sources in order to carry out fault-finding, fault-rectification and maintenance activities. The sources of information may not always be fully appropriate but will be sufficient to allow the activities to be completed. There may be some need for guidance towards more appropriate forms of information, however learners will demonstrate that they are able to complete an appropriate range of routine operations on electrical systems.

Learning aim B

For distinction standard, learners will:
- work safely, complying with given safe working procedures when carrying out a wiring activity
- explain how they ensured that the wiring activity was carried out safely, the reasons for their selection of circuit components and the precautions they have taken to make sure that the wiring installation will not become damaged when in use
- ensure documentation is correct, accurate and in an appropriate format, e.g. continuity and insulation resistance test figures are correctly and accurately recorded
- evidence and support their work using photographic evidence of maintenance activities
- confirm with the assessor, before starting on the practical activity, that the proposed actions are safe and appropriate, and then work independently. Learners may use a checklist to go through with the assessor before they start
- select and organise appropriate tools and equipment in their work area to a professional standard in preparation for the wiring activity, e.g. ensuring that tools are organised correctly and clearly in a safe and precise manner, and that they are fit for purpose.

For merit standard, learners will:
- complete a wiring activity safely, making use of an appropriate range of tools, equipment and components. Learners may require some help and guidance
- follow approved safe working procedures for the majority of the time and will select appropriate tools and equipment for the wiring tasks, however these may not be the most suitable in all instances. Some minor errors may be made during the wiring activity, however these will not affect the operation of the installation
- evidence and support their work using photographic evidence of maintenance activities
UNIT B: ELECTRICAL COMPONENTS AND WIRING

- confirm with the assessor that the proposed actions are safe and appropriate before starting on the practical activity, but having done this they may need to check the appropriateness of their actions. Learners may use a checklist to go through with the assessor before they start.

For pass standard, learners will:
- demonstrate safe working practices when carrying out an electrical wiring activity. These will be appropriate to the task being carried out but may not be fully compliant with given working procedures and tutor guidance may be necessary
- select and use appropriate tools and equipment to carry out the wiring activity, however these may not always be the most suitable and effective in the situation. There may be some errors in the wiring activity, however the completed activity will conform to a given specification
- seek support and guidance, if required
- provide documentation that may not be accurate or official.

Learning aim C

For distinction standard, learners will:
- carry out one routine maintenance activity, e.g. changing the brushes on an electric motor; and one fault-finding/fault-rectification activity, e.g. a control system fault on a conveyor belt
- identify the key features of the different types of information, comparing their uses and how the different types of information are likely to be used in conjunction with each other to ensure that activities are carried out skilfully and with precision. Learners will refer to the documentation they have used when carrying out fault-finding, fault-rectification and maintenance tasks and will consider how these have enabled them to carry out the tasks with precision
- work with independence and precision when carrying out each of the fault-finding, fault-rectification and maintenance tasks
- record the findings of post-rectification and post-maintenance inspections and tests in detail. They should make any adjustments and record them while carrying out operations, explaining in their written notes how these adjustments ensure that the electrical systems will subsequently function according to their specifications
- reflect on the activities they have carried out. They must reflect on their own achievements and assess their own levels of safety and compliance to safe working practices, standards and working requirements. They will reflect on their practical ability when carrying out a range of activities. Learners should consider what went well, opportunities to develop skills and how they ensured systems functioned as intended
- evidence and support their work using photographic evidence of maintenance activities.

For merit standard, learners will:
- carry out one routine maintenance activity, e.g. changing the brushes on an electric motor; and one fault-finding/fault-rectification activity, e.g. a control system fault on a conveyor belt
- have a secure understanding of the procedures that they need to follow and consistently work safely and accurately when carrying out and recording fault-finding, fault-rectification and maintenance activities. Learners are unlikely to need guidance, although may need some prompting when facing an unfamiliar situation
- follow safe working procedures for the majority of the time, although there may be some instances of errors being made when working on electrical systems, such as using an inappropriate tool for a task, or the incorrect replacement of a component. Errors will, however, be minimal, and will not affect the safe completion of the task or the safe operation of the system
• record the results of post-rectification and post-maintenance tests, although these may contain minor errors or be lacking in full details
• evidence and support their work using photographic evidence of maintenance activities.

For pass standard, learners will:
• carry out one routine maintenance activity, e.g. changing the brushes on an electric motor; and one fault-finding/fault-rectification activity, e.g. a control system fault on a conveyor belt
• work safely in order to complete fault-finding, fault-rectification and maintenance activities
• generally follow safe working procedures, although their selection and use of tools may be at times inappropriate and they may need guidance in order to complete tasks fully
• record the actions they have carried out during fault-finding and maintenance tasks, however these may contain errors and be incomplete. They are unlikely to fully record the findings of tests, however, these will have been carried out to ensure systems are safe to use.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

Suggested scenario

You are working in the electrical engineering sector as a technician. You need to develop your skills in maintenance and wiring so that you can demonstrate your awareness of safe working practices when carrying out fault-finding, fault-rectification, maintenance and wiring tasks. You need to demonstrate that you can follow approved working practices, including identifying hazards and risks, and methods to ensure that activities are carried out safely. You need to show that you can identify and use the correct tools, equipment and components when carrying out a range of tasks, and that you can use them skilfully and safely. Tasks should include a routine maintenance exercise, and a fault-finding, fault-rectification, and wiring and termination exercise. When carrying out these tasks, your supervisor will be monitoring the accuracy of your work and your ability to make sure that work conforms to the operational requirements of the system.

If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

You have been asked by your supervisor to demonstrate the types of activity that an electrical engineer would carry out as a part of their daily routine to a small group of potential apprentices from a local school. You need to demonstrate to them the safe and skilful completion of a range of tasks that will include fault-finding, fault rectification, routine maintenance, and a wiring and termination exercise. You should demonstrate to them how tools and equipment are used safely and skilfully to ensure that a system will perform as specified, and that the selection of components is equally important to make sure that a circuit functions as intended.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

**Introduction to unit**
A tutor-led workshop activity to investigate and explore a range of different types of electrical systems, equipment and components that learners will gain experience of working with. This would be carried out alongside discussions to identify the hazards associated with the workplace/workshop environment, and in particular activities involving electricity.

Learners complete worksheets to identify potential hazards in the workshop/workplace and how the risk from these hazards has been minimised through good practice.

It would be appropriate to make use of a guest speaker, either an apprentice or a technician, who could explain to learners the various duties that they carry out as an electrical engineer, and the importance of working safely.

A visit to a workshop to investigate the health and safety requirements for an electrical workshop environment, including the personal safety, personal health, working procedures and safe working practices that should be followed. This could then be followed by individual exercises or exercises carried out in pairs, to complete a walk around of the environment so that learners can familiarise themselves with the centre workshop and the procedures that should be followed. Learners should be familiar with the local safety rules and procedures they will be expected to follow in the workplace.

**Suggested time:** about 3 hours.

**Activity: Types of electrical circuit and components**
A tutor-led workshop demonstration of different electrical systems and circuits to explain the operation of each, using live systems as appropriate. This should be accompanied by the relevant operational and isolation procedures for the particular system. Tutors should explain how documentation can be used to identify information about circuits, components and devices.

Learners complete worksheets to describe the function of the systems that they have seen during demonstrations, and how safe working is achieved before, during and after the circuit has been in operation.

Learners develop their skills in interpreting diagrams associated with electrical systems. This could be achieved by providing them with a circuit diagram for a domestic power or lighting circuit that they need to interpret and then describe the operation of the components. They could then use further sources of information to identify key features of the components and produce a block diagram to represent the system and its components. Additionally, a visit to an industrial electrical engineering workshop would be beneficial to learners as they could gain further understanding of the importance of diagrams when producing circuits and how these are interpreted to produce working systems.

**Suggested time:** about 8 hours.
Activity: Fault-finding and rectification of faults in electrical circuits
If possible, this aspect of the unit could be introduced through the use of a work-shadowing activity where learners can observe an electrical engineer carrying out fault-finding and rectification activities. Otherwise, a tutor-led practical demonstration and discussion to explain fault-finding theory, related safety, and use of aids and instruments would be appropriate. This should then be followed by a demonstration of the application of fault-finding theory to relevant systems/circuits. Tutors should demonstrate to learners a range of approaches, including system/equipment dismantling, assembly and functional check/test techniques, along with related safety precautions. Learners should become familiar with the use of manufacturers’ and other maintenance documentation that they will use when carrying out system component removal, fit/replacement and system functional tests.

Learners practise their fault-finding and fault-rectification skills. This should be supported through the use of a range of aids, instruments, techniques and appropriate maintenance documentation/manuals. Learners should practise equipment dismantling, assembly and testing, along with removal/fit and/or replacement of identified faulty components. Learners should carry out appropriate post-assembly functional checking/testing.

Suggested time: about 13 hours.

Activity: Maintenance activities for electrical circuits
A tutor-led workshop demonstration of routine maintenance theory. A tutor-led discussion, including benefits of carrying out maintenance and consideration of the activities associated with maintenance and the related safety issues.

Tutors give a practical demonstration of inspection/checks of electronic wiring, cabling, fixtures, fittings, terminations and soldered joints. Learners should be aware of potential causes of faults such as wear, chaffing, fouling, security of attachment, mechanical damage and fire damage.

Tutor demonstration of how to carry out adjustments and tests for the correct operation of component/equipment/system tests. This should be followed by a demonstration of how to complete maintenance documentation, either in a workshop setting or by a practicing electrical engineer, while on an industrial visit.

Learners could then carry out a range of routine maintenance activities, following best safe practice and completing maintenance documents once the activities have been completed. These activities could be carried out while on a work experience placement, where learners would have a range of different activities to carry out on varied circuits.

Suggested time: about 12 hours.

Activity: Wiring and terminating components
Tutor-led discussion about the importance of good preparation before beginning a wiring activity, to include good practice that should be followed in the electrical workshop.

Learners work individually or in pairs to prepare for and set up equipment for a wiring activity. Learners complete worksheets regarding safety and safe working procedures for wiring and terminating components.

This could be followed by a further tutor-led demonstration of electrical wiring activities covering a range of different types of wiring and termination types.

Individual activity to practise producing electrical wiring assemblies, with appropriate tutor guidance until learners show a reasonable level of competence and safety.

Suggested time: about 10 hours.
**Essential resources**

For this unit, learners will need access to:

- a workshop environment suitable for carrying out maintenance activities
- electrical systems, which have faults that are straightforward to identify and can be rectified by substitution of components
- test instruments, tools and safety equipment
- relevant manufacturers’ service manuals, data sheets, component lists, drawings and diagrams
- British/International Standards, health and safety publications and local workshop safety documentation and procedures

**Links to other units**

This unit has strong links to:

- Unit 1: Engineering Principles
- Unit 4: Workshop Skills
- Unit 6: PCB Components and Soldering
- Unit 9: Delivering Engineering Solutions.

**Employer involvement**

This unit would benefit from employer involvement in the form of:

- guest speakers from electrical engineering organisations, including technicians, to talk about the use of information sources, how these have changed and how these may continue to change in the work environment. Speakers could also give talks on the importance of safety procedures in an electrical engineering workplace
- work experience with an electrical engineering organisation where a range of activities can be experienced
- visits to electrical engineering workshops to encounter real-life working practices and safety procedures.
Unit 9: Delivering Engineering Solutions

Level: 2
Unit type: Optional
Assessment type: Internal
Guided learning hours: 60

Unit in brief

Learners draw together the knowledge and understanding they have gained from the units studied in this qualification to interpret a project plan, carry out and then review an engineering activity.

Unit introduction

Have you ever wondered how a car, with all its parts, systems and sub-systems, can be manufactured so quickly, and with such precision and quality? Have you considered why engineering workshops are laid out in a particular way? Or why so many complex engineering products are reliable and work well? These questions can only be answered if the production engineer has the correct knowledge and experience of production planning, manufacturing and quality issues. Planning, manufacturing and reviewing are necessary functions for any organisation that produces engineered products.

In this unit, you will draw on the knowledge and skills developed in Units 1, 2, 3 and 4, as well as selecting and combining skills gained in the optional units by applying them to a range of contexts. You will gain experience of production planning before moving on to manufacture the engineered product you have planned and finally reviewing the effectiveness of the plan and outcome of your actions. You will learn that production planning is essential in ensuring that activities and resources are coordinated over time to achieve targets or goals with as little resource consumption as possible, without compromising on product quality.

This unit will prepare you for a range of roles in an engineering organisation, including roles in planning, manufacturing and quality control. You will gain the skills required to interpret and use a range of documentation that you are likely to encounter as an engineering technician. You will develop a range of transferable skills that you will be able to use when working in different engineering environments.

Learning aims

In this unit you will:

A Interpret a product specification to produce a production plan
B Undertake a manufacturing operation in a safe manner according to defined procedures
C Review the processes used to engineer a product and reflect on personal performance.
## Unit summary

<table>
<thead>
<tr>
<th>Learning aim</th>
<th>Key teaching areas</th>
<th>Summary of suggested assessment evidence</th>
</tr>
</thead>
</table>
| A Interpret a product specification to produce a production plan | A1 Interpreting a product specification  
A2 Production plans | A portfolio of evidence, including:  
• a production plan for a given product  
• observation records  
• annotated photographs  
• checklists  
• notes  
• inspection and test results  
• quality control table  
• personal reflection about own performance. |
| B Undertake a manufacturing operation in a safe manner according to defined procedures | B1 Preparing the work area  
B2 Carrying out a manufacturing operation safely  
B3 Collecting and using data  
B4 Using measuring equipment  
B5 Manufacturing operations  
B6 Operating in a safe manner |  |
| C Review the processes used to engineer a product and reflect on personal performance | C1 Reviewing procedures used  
C2 Reviewing own skills and progression |  |

### Key teaching areas in this unit include:

<table>
<thead>
<tr>
<th>Sector skills</th>
<th>Knowledge</th>
<th>Transferable skills/behaviours</th>
</tr>
</thead>
</table>
| • Interpreting engineering drawings and diagrams  
• Interpreting specifications and work instructions  
• Preparing to carry out engineering activities  
• Carrying out work activities safely  
• Quality control testing | • Identification and understanding of drawing conventions  
• Application of quality control checks | • Problem solving and communication  
• Managing information  
• Self-management and development |
Unit content

Knowledge and sector skills

Learning aim A: Interpret a product specification to produce a production plan

A1 Interpreting a product specification
Features of a product specification, including information required for product manufacture:
- production drawings
- production quantities and delivery rates
- quality specifications
- parts and materials to be used
- processing methods specified in the design.

A2 Production plans
Features, modifications and applications of outline production plans, including details required for an engineering activity:
- sequence of activities/processes
- drawings and specifications needed
- raw and consumable materials to be used
- bought-in components needed
- tools and equipment needed
- speeds and feeds
- quality and inspection needs
- health and safety precautions
- environmental or legislative requirements.

Learning aim B: Undertake a manufacturing operation in a safe manner according to defined procedures

B1 Preparing the work area
- Preparing and maintaining an engineering work area in readiness for carrying out a manufacturing operation, including:
  - procedures for the receipt and removal of materials
  - procedures for the receipt and removal of tooling
  - freedom from obstructions and hazards
  - correct equipment and tooling layout
  - equipment/tool operating instructions, e.g. machinery, process plant, tools, material handling, equipment specific to the operation.
- Overcoming problems when preparing a work area, including:
  - quality and availability of raw materials
  - serviceability of equipment and tooling
  - general condition of work area, e.g. lighting, ventilation, temperature, noise levels.
B2 Carrying out a manufacturing operation safely

• Using operation procedures, including:
  o production plan
  o job instructions
  o equipment/tool operating instructions, e.g. machinery, process plant, hand-held and portable tools, material handing
  o making adjustments from data.

• Controlling the manufacturing operation, including:
  o dealing with problems, e.g. variation from specification, discrepancies
  o using collected data to influence decisions, e.g. making adjustments to the manufacturing operation.

B3 Collecting and using data

Collecting data about the manufacturing operation, including:

• quality of finished product, e.g. dimensional accuracy, surface finish, conformity to specification

• effective use of raw materials

• use of consumables, e.g. cutting tools, lubricants, cleaning fluids

• condition of machinery/equipment/tools

• achieving production targets.

B4 Using measuring equipment

• Measurement of manufactured products and checking against specification:
  o dimensional – length, diameter, depth, flatness, parallelism, angle
  o geometrical – profiles, roundness, concentricity, accuracy of form
  o surface texture/roughness.

• Measuring equipment as applicable to the component feature to be measured, e.g.:
  o micrometers – internal, external, depth
  o steel rules
  o vernier calipers
  o vernier height gauge
  o surface plate
  o straight edge
  o engineer’s try square
  o bevel protractors
  o combination sets
  o roughness comparison specimens (Rubert gauges).

B5 Manufacturing operations

Using a type of production method, e.g.:

• hand-manufacturing operation

• manually operated machine tool

• automated machine tool

• combined manufacturing operation.
B6 Operating in a safe manner
Operating safely in an engineering work area, including:

• adhering to health and safety legislation – Health and Safety at Work etc. Act 1974
• adhering to environmental regulations – Workplace (Health, Safety and Welfare) Regulations 1992
• adhering to safe working practices, e.g. personal protective equipment (PPE), Manual Handling Operations Regulations (MHOR) 1992, Control of Substances Hazardous to Health (COSHH) Regulations 2002.

Learning aim C: Review the processes used to engineer a product and reflect on personal performance

C1 Reviewing procedures used
Reviewing the manufacturing operation by identifying problems and making adjustments, including:

• process effectiveness, e.g. operational sequence, production time
• process characteristics, e.g. quality, accuracy of the finished product
• material utilisation, e.g. raw materials, consumables
• operational safety.

C2 Reviewing own skills and progression

• Reviewing performance while carrying out an engineering activity, including:
  o methods of reviewing skills to show progress has been made, e.g. using feedback from supervisors, meeting given standards, self-review of activities carried out
  o reviewing skills gained, e.g. sector skills, self-management, teamwork, time management, problem solving
  o reviewing transferable skills, e.g. positive attitude, being supportive of others, responding to feedback, taking advice/direction
  o areas for development, e.g. more/less support needed, better time management, different approach to planning production, use of different tools/equipment/processes, better preparation.

• Setting developmental goals and targets, including identifying:
  o areas for personal development
  o methods for improving skills.

Transferable skills

Problem solving and communication

• Finding out: developing the skills to carry out research and investigations through obtaining costings, pricings, and estimations for similar engineering activities, developing skills in interpreting information by analysing given documentation to identify production requirements.

Managing information

• Interpreting documents and drawings, including the use and application of referencing as a result of interpreting documentation to assemble a fabricated structure accurately.

Self-management and development

• Development of self-management skills that can be applied to problem-solving tasks, taking into account time and resources that are available.
## Assessment criteria

<table>
<thead>
<tr>
<th>Pass</th>
<th>Merit</th>
<th>Distinction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning aim A: Interpret a product specification to produce a production plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A.P1</strong> Produce an outline production plan from a given product specification.</td>
<td><strong>A.M1</strong> Produce a mostly complete production plan from a given product specification, explaining why the features are suitable for production.</td>
<td><strong>A.D1</strong> Produce a detailed and accurate production plan from a given product specification, justifying why the features are suitable for production.</td>
</tr>
<tr>
<td>Learning aim B: Undertake a manufacturing operation in a safe manner according to defined procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B.P2</strong> Safely prepare a work area in readiness for carrying out a manufacturing operation.</td>
<td><strong>B.M2</strong> Prepare for and carry out a manufacturing operation, explaining any adjustments made during manufacturing as problems are identified.</td>
<td><strong>B.D2</strong> Prepare for and carry out a manufacturing operation, justifying the need for adjustments to ensure the components meet specifications.</td>
</tr>
<tr>
<td><strong>B.P3</strong> Demonstrate competent and safe use of tools, equipment and techniques in the manufacture of an engineered product, identifying some problems and making adjustments as required.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning aim C: Review the processes used to engineer a product and reflect on personal performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C.P4</strong> Assess the effectiveness of the engineering processes used to plan and engineer a product.</td>
<td><strong>C.M3</strong> Recommend improvements to the processes used, and to the behaviours applied, throughout the planning and manufacturing process.</td>
<td><strong>C.D3</strong> Justify improvements to the processes used, and to the behaviours applied, throughout the planning and manufacturing process.</td>
</tr>
<tr>
<td><strong>C.P5</strong> Identify how personal behaviours were applied throughout the planning and manufacturing process.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Essential information for assessment decisions

Learning aim A

For distinction standard, learners will:
- produce an accurate, feasible and effective production plan that is appropriate for the production of the given product, making full reference to the product specification. The given specification should have sufficient information about materials and parts lists to enable learners to calculate processing times, plant, labour, material and component costs.

For merit standard, learners will:
- produce a production plan that includes an appropriate manufacturing plan but may not consider full processing times, or the costs associated with manufacturing. The plan will be realistic for large-scale manufacturing of the product.

For pass standard, learners will:
- produce an outline production plan that includes activity sequences, tools and equipment, speeds and feeds, quality requirements, and health and safety precautions. The production plan may be suitable for small scales of production but would not be appropriate for larger manufacturing runs.

Learning aim B

For distinction standard, learners will:
- demonstrate a consistently high level of safety awareness, accuracy and independence
- produce a product that fully meets the brief. They will use a range of information, selecting the most relevant and appropriate processes required to meet the brief
- correctly apply skills gained from the other units studied in the programme; these skills are not just practical, e.g. using tools to process a component, but must encompass everything an engineer does when making a product to meet the requirements of a given specification
- reflect on their work as they make progress and make any correctional adjustments that may be necessary to ensure that individual component parts meet the given product specification. They will show initiative in solving problems and may provide more than one solution to the engineering brief
- justify the need for any necessary adjustments required to ensure the components meet original specifications
- assess their own levels of safe working; this should be achieved through the use of annotated photographs or short written reports relating to all of the activities that have been completed to manufacture the product.

For merit standard, learners will:
- demonstrate confident, correct and safe working procedures when preparing for and carrying out the manufacturing activity
- produce mostly accurate work, although there may be some errors and inaccuracies. The product will function as intended, although some aspects will not comply with the product specification
- use tools and equipment safely and with confidence, performing both manufacturing operations appropriately and with limited guidance
- explain the need for any adjustments made during manufacturing as and when problems are identified
- observe safe working practices and use a range of techniques confidently to produce a product.
UNIT 9: DELIVERING ENGINEERING SOLUTIONS

For pass standard, learners will:

- prepare a work area for the effective manufacturing of a product
- manufacture the product with some guidance and demonstrate competency in safe working practices
- resolve problems that occur during manufacture in a straightforward manner.

Learning aim C

For distinction standard, learners will:

- present a detailed review of how they planned and carried out the manufacture of an engineered product. They will consider the effectiveness of their plan and whether it could be improved on if they were to repeat the manufacture of the product. They will pick up on problems encountered, e.g. machined features that were out of tolerance, and make valid statements about how they overcame problems and how to prevent them in a future production
- gather accurate measurement data and reference this to the requirements of specifications, e.g. dimensional data in a drawing of the product being manufactured
- make detailed suggestions about how they would improve the manufacturing operations for future production so that the product is produced more effectively, e.g. quicker, higher accuracy, less waste produced, better use of tools and equipment, improved skill levels
- inspect their product for compliance against the specification, with regards to criteria such as dimensional, geometric and surface texture requirements given in the product specification, and they will use this data to reflect on the effectiveness of their engineering skills
- consider the reasons for non-compliance, considering the relative impacts of both major and minor compliance issues
- reflect on their own achievement, making reference to the skills that they have gained and identifying an action plan for their own further personal development, considering how skills and personal behaviours can be improved on.

For merit standard, learners will:

- reflect on the importance of following correct procedures and keeping well-maintained work areas to achieve effective production and safe working
- inspect their products for compliance against the specification, with regards to criteria such as the dimensional, geometric and surface-texture requirements given in the product specification
- reflect on their own achievement, making reference to the skills they have gained and identifying an action plan for their own further personal development, identifying weaknesses and considering how skills can be improved. They may relate these to planning or production, e.g. identifying features where there is evidence of non-compliance, however they will not consider the causes of them in detail.

For pass standard, learners will:

- use a range of measuring equipment to inspect dimensional and geometric features of the product to ensure they have been produced to meet the defined levels of accuracy given in the product specification
- reflect on the skills they have gained, and those they have developed during the planning and manufacturing stages, identifying areas for future development
- reflect on their own achievement, making reference to the skills they have gained and identifying an action plan for their own further personal development, considering how skills can be improved.
Assessment activity

The summative assessment activity takes place after learners have completed their formative development. The activity should be practical, be set in a realistic scenario and draw on learning from the unit, including the transferable skills. You will need to give learners a set period of time and number of hours in which to complete the activity. Section 6 gives information on setting assignments and there is further information on our website.

A suggested structure for summative assessment is shown in the Unit summary section, along with suitable forms of evidence. This is for illustrative purposes only and can therefore be adapted to meet local needs or to assess across units where suitable opportunities exist. The information in the Links to other units section will be helpful in identifying opportunities for assessment across units.

The following scenario could be used to produce the required evidence for this unit. Centres are free to use comparable scenarios or other forms of evidence, provided that they meet the assessment requirements of the unit.

There is potential in this unit for centres to provide assessments set with employer input. Local employers could offer assessment support by providing specifications and drawings for engineered products that could be used for assessment purposes to plan production. Employers could provide feedback to learners on the quality of their work, which would help them reflect on the effectiveness of the engineering skills employed in the assessment task.

Suggested scenario

Your supervisor is impressed with the work you have completed in a range of different roles in the organisation and would like to check to see if you have a good understanding of all aspects of the production process. Your supervisor has given you a product specification for an engineered product and has asked you to produce a production plan for a one-off prototype of the product. Your supervisor is expecting you to manufacture the product safely and to inspect and review the outcome against the product specification, as well as review your own performance throughout the planning and production process.

When demonstrating your skills, your performance will be observed by either your employer or tutor (who will take on the role of your supervisor).

In completing the task, you should draw on the learning from the other units you have completed in the qualification and identify and select those that are most relevant to the task set. You can select a product to engineer from either of the optional units chosen as part of the qualification.

If a retake is necessary, an alternative example must be used. The following is an example of a retake assessment activity.

The production manager of a local engineering company is looking at methods to ensure that the new intake of apprentices have the skills needed to fulfil a range of roles in the workplace. They have approached you to check that their plan for an assessment is suitable and challenging. They have asked you to select one of the product specifications used by the organisation. You are then to manufacture and inspect a one-off prototype version of the product using the tools, machinery and equipment available in the workshop where the assessment will take place.
Further information for tutors and assessors

Delivery guidance

The following are examples of practical activities and workshops that tutors could use when developing sector and transferable skills in the delivery of this unit. Wherever possible, practical activities should be used to help learners develop both personal and sector skills in preparation for the final assessment. These suggestions are not intended as a definitive guide to cover the full GLH of the unit.

### Introduction to unit

A tutor-led problem-solving activity to introduce and explain the different scales of production and different types of equipment that are used in engineering. This could be in the form of an investigation activity, giving learners typical examples, and then asking them to explain the key stages of production and show how they can be represented in a block diagram. This could then be followed by a tutor-led practical investigation into typical material and components that are used in engineering, along with a review of preparation processes, and assembly and finishing processes that are used in both small- and large-scale production.

Tutors could explain quality control procedures that relate to small and large scales of production, before asking learners to investigate the different types of equipment used in the production of one-off products and larger-scale production. This could be linked to either industrial visits to organisations that produce bespoke customised products and to organisations in a similar sector that have larger production runs, or visiting speakers from such organisations.

**Suggested time:** about 4 hours.

### Activity: Production planning

A tutor-led practical activity to examine a range of documents and sources of information in order to identify the production needs for a given engineering activity. This could be linked to prior learning from other units and draw on learners’ experience in order to understand the different types of information required for an engineering activity.

Learners should investigate the purpose of process plans/specifications and the information that they contain. This could be followed by reinforcement of the skills necessary to interpret and use engineering drawings.

Tutors could give learners case studies, either provided by industrial partners and supported by visits, or related to familiar products. Learners could identify the possible scales and key stages of production from the given case studies. This should then be developed into identifying a possible parts list and possible processing methods for given products. Learners should be introduced to the costings related to the manufacture of engineered products, including the direct and indirect cost of plant, labour, materials and components. This could be followed by activities requiring estimations of the total manufacturing unit costs from given data, which could be completed individually or in pairs.

Learners could be given a range of typical production-plan formats, including those provided by industrial partners, in order to identify similarities between them and the information contained within. Tutors should discuss health and safety precautions that might need to be included in a production plan and explain and demonstrate the calculation of processing time and production costs.

This could be followed by a discussion that considers the changes to the plan that are needed if the scale of production is to be increased to repeated batch production. Learners could be given an activity to produce a block diagram representing the key stages in the production of a given product, where only a small quantity is required, and a further diagram to represent larger-scale manufacturing. Learners should produce a production plan for a given product and calculate processing times and production costs.

**Suggested time:** about 15 hours.
### Activity: Preparing for and carrying out manufacturing

A tutor-led workshop demonstration of safe working practices in an engineering workshop. The demonstration should include how to set tools up for use, safe working procedures and methods to close down a work area as required for the activities to be carried out.

Learners could investigate a range of production methods in relation to scales of production and different engineering activities, explaining the safe working practices associated with the range of production methods.

Learners could carry out a practical activity to investigate the work area to ensure that safety is maintained. They should gain experience in the use of PPE, the procedures for cleaning and storing tools and equipment, in addition to the safe carrying out of engineering activities. This could be supported through the use of visiting speakers, potentially apprentices or technicians, who could explain the duties they carry out, or through suitable work-experience placements.

Learners should identify and explain job instruction documents for a simple engineering activity; they should use them to identify the tools and equipment needed to complete a task. This could be supported by the use of equipment/tool operating instructions and followed by a tutor demonstration of process-monitoring techniques before learners use the tools and equipment themselves. Tutors should discuss the methods that can be used to accommodate changes to the manufacturing programme and give learners appropriate practical activities to apply such changes.

Learners should carry out a range of practical activities that will give them an opportunity to practise and develop their skills in carrying out a range of manufacturing techniques, to monitor production and to apply suitable methods to accommodate changes that occur during manufacturing.

**Suggested time:** about 25 hours.

### Activity: Testing for compliance

A tutor-led practical activity to safely use a range of measuring equipment to measure dimensional and geometrical attributes of engineered products. Learners should be given items that have a range of features to measure and compare, and be given appropriate documents and drawings to check the quality and conformity of the items. These could be produced by an industrial partner, or be manufactured by learners themselves while on work placements.

Learners should measure dimensional and geometrical attributes of engineered products. It would be appropriate for learners to carry out an industrial visit to gain experience of how measuring equipment is used in industry; this could also be achieved during a work experience placement or a work-shadowing activity.

A tutor demonstration could be used to introduce learners to the use of comparator types of equipment and gauges to measure dimensional and geometrical attributes of engineered products. Learners could then carry out a range of practical investigations to gain experience of using comparators and gauges to check quality of products.

Learners should develop their skills in checking the accuracy and conformity of dimensional, geometric and surface-texture features of engineered products against given specifications and related documentation.

**Suggested time:** about 10 hours.

### Activity: Self-assessment

Learners should be introduced to the concepts relating to the review of their own progress, both for planning activities and the practical skills that they have applied to manufacture and subsequently test for compliance. Tutors should introduce learners to a range of employability skills that they will need to demonstrate in a workplace, such as reliability, positive attitude, motivation, as well as making a contribution to engineering activities, responding to feedback and taking advice or direction from peers and supervisors.

This could be followed by a group discussion to consider methods of keeping records of successes and failures, so that areas for development can be identified and linked to practical experiences, including any that may be completed during their work experience visits or while in industrial settings.
Tutors should encourage learners to consider reflection as a continuous process, which they should continue throughout their assessment activities. Tutors could introduce methodologies for reflecting on their production plans and practical activities, which learners can then apply when reviewing and assessing their own progress. Tutors should encourage learners to consider their career pathways and goals as a method of determining their development plans; this could include highlighting those areas where they need to improve their skills and devising an action plan that can be followed for developmental purposes.

**Suggested time:** about 6 hours.

### Essential resources

For this unit, learners will need access to:
- a range of production plans, product specifications, data handbooks, drawings and manufacturers’ information manuals
- a workshop environment where manufacturing operations take place
- the range of tools required to mark out, measure, manufacture and test compliance of engineering components, including comparator equipment (essential).

### Links to other units

This unit has strong links to:
- Unit 1: Engineering Principles
- Unit 2: Processes and Materials
- Unit 3: Business Improvement Techniques
- Unit 4: Workshop Skills
- Unit 5: Machining Techniques
- Unit 6: PCB Components and Soldering
- Unit 7: Computer Numerical Control
- Unit 8: Electrical Components and Wiring.

### Employer involvement

This unit would benefit from employer involvement in the form of:
- local employers who can offer assessment support by providing specifications and drawings for engineered products that could be used for assessment purposes to plan production. Employers set the task, assess the brief and provide feedback to learners on the quality of their work
- work experience in an appropriate engineering organisation, offering the opportunity to carry out a range of activities as described in the unit content
- local business to provide their own engineered artefacts as exemplars for testing, measuring and comparison activities.
4 Planning your programme

Is there a learner entry requirement?
As a centre, it is your responsibility to ensure that recruited learners have a reasonable expectation of success on the programme. There are no formal entry requirements but we expect learners to have qualifications at or equivalent to Level 1.
Learners are most likely to succeed if they have:
- three or four GCSEs at intermediate grades and/or
- BTEC qualification(s) at Level 1 or Level 1/2
- Level 1 equivalent achievement in English and mathematics through GCSE or Functional Skills.
Learners may demonstrate ability to succeed in various ways. For example, learners may have relevant work experience or specific aptitude shown through diagnostic tests or non-education experience.

What is involved in becoming an approved centre?
All centres must be approved before they can offer this qualification – so that you are ready to assess learners and so that we can provide the support needed. Further information is given in Section 8 Administrative arrangements.

What level of sector knowledge is needed to deliver this qualification?
We do not set any requirements for tutors but expect centres to assess the overall skills and knowledge of the teaching team to ensure that they are relevant and up to date with current industry practice. This will give learners a rich programme to prepare them for progression.

What resources are required to deliver this qualification?
As part of your centre approval, you will need to show that the necessary material resources and workspaces are available to deliver the qualification. For some units, specific resources are required.

What makes good vocational teaching?
The approach to vocational teaching must be led by what is right for the particular sector. Therefore, each unit includes delivery guidance and suggested assessment tasks. Using the delivery guidance and suggested assessment tasks and our additional free delivery guidance and assignment briefs, you can build a course that contextualises learning in real-life and/or employment scenarios. This will naturally draw in the kind of broader attributes valued in the sector, for example attention to detail, as well as the more general skills needed in work that fit well with project-based learning, for example teamwork, independent learning.

What are the requirements for meaningful employer involvement?
This qualification has been designed as a Technical Certificate qualification and as an approved centre you are required to ensure that during their study, every learner has access to meaningful activity involving employers. See Section 2 Structure for the requirements for employer involvement.
**Support for employer involvement**

It is important that you give learners opportunities that are of a high quality and which are directly relevant to their study. We will support you in this through guidance materials and by giving you examples of best practice. See *Section 11 Resources and support* for details of the support available, including the Work Experience Toolkit.

**What support is available for delivery and assessment?**

We provide a wealth of support materials, including schemes of learning, delivery plans, assignment briefs, additional papers for external assessments and examples of marked learner work.

To support you with planning your assessments, you will be allocated a Standards Verifier early in the planning stage. There will be extensive training programmes and support from our Subject Advisor team.

For further details see *Section 11 Resources and support*.

**How will my learners become more employable through this qualification?**

Learners will be acquiring the key technical and sector knowledge, and practical and technical skills that employers need. Employability skills, such as team working and entrepreneurialism, and completing realistic tasks have also been built into the design of the learning aims and content. This gives tutors the opportunity to use relevant contexts, scenarios and materials to enable learners to develop a portfolio of evidence that demonstrates the breadth of their skills and knowledge in a way that equips them for employment.
5 Assessment structure

The Pearson BTEC Level 2 Technical Diploma in Engineering is assessed using a combination of internal assessments, which are set and marked by tutors, and external assessments, which are set and marked by Pearson.

We have taken great care to ensure that the assessment method chosen is appropriate to the content of the unit and in line with requirements from employers.

In developing an overall plan for delivery and assessment for the programme you will need to consider the order in which you deliver units, whether delivery is over short or long periods and when assessment can take place.

One internally-assessed unit in the qualification is defined as synoptic (see Section 2 Structure). A synoptic assessment is one that a learner should take later in a programme and in which they will be expected to apply learning from a range of units. As such, you must plan the assignments that learners can demonstrate learning from across their programme.

We have addressed the need to ensure that the time allocated to final assessment of internally- and externally-assessed units is reasonable so that there is sufficient time for teaching and learning, formative assessment and development of transferable skills.

In administering internal and external assessment, the centre needs to be aware of the specific procedures and policies that apply, for example to registration, entries and results. An overview with signposting to relevant documents is given in Section 8 Administration arrangements.
6 Internal assessment

This section gives an overview of the key features of internal assessment and how you, as an approved centre, can offer it effectively. The full requirements and operational information are given in the Pearson Quality Assurance Handbook available on our website. All members of the assessment team need to refer to this document.

For this qualification, it is important that you can meet the expectations of stakeholders and the needs of learners by providing a programme that is practical and applied. You can tailor programmes to meet local needs and use links with local employers and the wider vocational sector.

When internal assessment is operated effectively, it is challenging, engaging, practical and up to date. It must also be fair to all learners and meet national standards.

Principles of internal assessment

Our approach to internal assessment for this qualification offers flexibility in how and when you assess learners, provided that you meet assessment and quality assurance requirements. You will need to take account of the requirements of the unit format, which we explain in Section 3 Units, and the requirements for delivering assessment given in Section 8 Administrative arrangements.

Operating internal assessment

The assessment team

It is important that there is an effective team for internal assessment so that all assessment is planned and verified. For this qualification it is likely that the team will be small but it is still necessary to ensure that the assessment process is followed. Full information is given in the Pearson Quality Assurance Handbook.

The key roles are:

- the Lead Internal Verifier (Lead IV) for the qualification has responsibility for the planning, record keeping and standard setting for the qualification. The Lead IV registers with Pearson annually and organises training using our support materials
- Internal Verifiers (IVs) check that assignments and assessment decisions are valid and that they meet our requirements. In a small team, all people will normally be assessors and IVs. No one can verify their own actions as an assessor.
- assessors set or use assignments to assess learners to national standards.

Planning and record keeping

The Lead IV should make sure that there is a plan for assessment of the internally-assessed units and maintain records of assessment undertaken. The key records are:

- verification of assignment briefs
- learner authentication declarations
- assessor decisions on assignments, with feedback given to learners
- verification of assessment decisions.

Examples of records and further information are given in the Pearson Quality Assurance Handbook.
Effective organisation

Internal assessment needs to be well organised so that learners’ progress can be tracked and so that we can monitor that assessment is being carried out in line with national standards. We support you through, for example, providing training materials and sample documentation. Our online myBTEC service can help support you in planning and record keeping. Further information on using myBTEC can be found in Section 11 Resources and support and on our website.

It is particularly important that you manage the overall assignment programme and deadlines to make sure that learners are able to complete assignments on time.

Learner preparation

To ensure that you provide effective assessment for your learners, you need to make sure that they understand their responsibilities for assessment and the centre’s arrangements.

From induction onwards, you will want to ensure that learners are motivated to work consistently and independently to achieve the requirements of the qualifications. Learners need to understand how assignments are used, the importance of meeting assignment deadlines, and that all the work submitted for assessment must be their own.

You will need to give learners a guide that explains how assignments are used for assessment, how assignments relate to the teaching programme, and how learners should use and reference source materials, including what would constitute plagiarism. The guide should also set out your approach to operating assessment, such as how learners must submit work and request extensions.

You are encouraged to employ a range of formative assessment approaches before putting learners through to the assignments to formally assess the units. Formative assessment supports teaching and learning, and should be ongoing throughout the learning process. It enables tutors to enhance learning by giving learners constructive feedback so that they can identify their strengths and weaknesses, and to put measures in place to target areas that need work. Formative assessment approaches that incorporate reflective learning and regular skills assessment are important in encouraging self-development and reflective practice, to ensure that learners progress.

Setting assignments

An assignment is issued to learners as an assignment brief with a defined start date, a completion date and clear requirements for the evidence that they need to provide. This assignment will be separate from the practice and exploration activities that have been used during the learning period, and learners must understand that the assignment is being used to judge the learning aims. There may be specific observed practical components during the assignment period. Assignments can be divided into tasks and may require several forms of evidence. A valid assignment will enable a clear and formal assessment outcome, based on the assessment criteria.

When setting your assignments, you need to work with the information given in the Essential information for assessment decisions and the Assessment activity sections of the units. You can choose to use the suggested scenarios or to adapt them to take account of local circumstances, provided that assignments are verified.
In designing your own assignment briefs you should bear in mind the following points:

- A learning aim must always be assessed as a whole and must not be split into two or more tasks.
- Assignments must be structured to allow learners to demonstrate the full range of achievement at all grade levels. Learners need to be treated fairly by being given the opportunity to achieve a higher grade if they have the ability.
- Learners should be given clear tasks, activities and structures for evidence; the criteria should not be given as tasks.
- You must ensure that assignments for synoptic assessment are designed to enable learners to draw on the specific units identified and demonstrate that they can identify and use effectively an appropriate selection of skills, techniques, concepts, theories and knowledge in an integrated way. Assignments for the synoptic unit will be monitored at programme level as part of the standards verification process to ensure that they encourage learners to select and apply their learning from across the qualification in an integrated way.
- Where there is a requirement for assessment to be conducted in the real work environment (mandatory work placement), assignments must be designed to facilitate this. Where there is no mandatory requirement for workplace assessment but learners will be in work placement or work experience settings as a part of the programme, then it would be worthwhile if these assignments were also designed for completion in the real work environment. You must ensure that the work placement or work experience setting gives learners the opportunity to achieve at all grade levels.

As assignments provide a final assessment, they will draw on the specified range of teaching content for the learning objective. The specified teaching content is compulsory. The evidence for assessment need not cover every aspect of the teaching content as learners will normally be given particular examples, case studies or contexts in their assignments. For example, if a learner is carrying out a practical performance, then they must address all the relevant range of content that applies in that instance.

An assignment brief should have:

- a vocational scenario or context that motivates the learner to apply their learning through the assignment
- an audience or purpose for which the evidence is being provided
- clear instructions to the learner about what they are required to do, normally set out through a series of tasks.

**Forms of evidence**

The units allow for a variety of forms of evidence to be used, provided that they are suited to the type of learning aim and the learner being assessed. For most units, the practical demonstration of skills is necessary. The units give you information on suitable forms of evidence and that would give learners the opportunity to apply a range of transferable and sector skills. Centres may choose to use different suitable forms for evidence to those proposed. Overall, learners should be assessed using varied forms of evidence.

The main forms of evidence include:

- observation and recordings of practical tasks or performance in the workplace with supporting evidence
- projects
- recordings of role play, interviews and other types of simulated activities
- oral or written presentations with assessor questioning
- work logbooks, reflective journals.
It is important to note that an observation record is a source of evidence and does not confer an assessment decision. It must be sufficiently detailed to enable others to make a judgement about the quality and sufficiency of the performance and must clearly document the rationale for the assessment decision. Observation records should be accompanied by supporting evidence, which may take the form of videos, audio recordings, photographs, preparation notes, learner logs and other similar types of record.

The form(s) of evidence selected must allow:
- the learner to provide all the evidence required for the learning aim(s) and the associated assessment criteria at all grade levels
- the learner to produce evidence that is their own independent work
- a verifier to independently reassess the learner to check the assessor’s decisions.

Centres need to take particular care in ensuring that learners produce independent work.

**Making valid assessment decisions**

**Assessment decisions through applying unit-based criteria**

Assessment decisions for this qualification are based on the specific criteria given in each unit and set at each grade level. The way in which individual units are written provides a balance of assessment of sector-specific knowledge, technical and practical skills, and transferable skills appropriate to the purpose of the qualification.

Pass, Merit and Distinction criteria all relate to individual learning aims. The assessment criteria for a unit are hierarchical and holistic where in satisfying the M criteria a learner would also have satisfied the P criteria. The unit assessment grid shows the relationships among the criteria so that assessors can apply all the criteria to the learner’s evidence at the same time.

Assessors must show how they have reached their decisions using the criteria in the assessment records. When a learner has completed all the assessment for a unit then the assessment team will give a grade for the unit. This is given according to the highest level for which the learner is judged to have met all the criteria. Therefore:

- to achieve a Distinction, a learner must have satisfied all the Distinction criteria (and all the Pass and Merit criteria); these define outstanding performance across the unit as a whole
- to achieve a Merit, a learner must have satisfied all the Merit criteria (and all the Pass criteria) through high performance in each learning aim
- to achieve a Pass, a learner must have satisfied all the Pass criteria for the learning aims, showing coverage of the unit content and therefore attainment at Level 2 of the national framework.

The award of a Pass is a defined level of performance and cannot be given solely on the basis of a learner completing assignments. Learners who do not satisfy the Pass criteria should be reported as Unclassified.
Making assessment decisions using criteria

As an assessor, you review authenticated learner work and make judgements on standards using the assessment criteria and the supporting information provided in units and training materials. The evidence from a learner can be judged using all the relevant criteria at the same time. The assessor needs to make a judgement against each criterion that evidence is present and sufficiently comprehensive.

Assessors should use the following information and support in reaching assessment decisions:

- the Essential information for assessment decisions section in each unit
- your Lead IV and assessment team’s collective experience, supported by the standardisation materials we provide.

Once the team has agreed the outcome, a formal assessment decision is recorded and reported to learners. The information given:

- must show the formal decision and indicate where criteria have been met
- may show where attainment against criteria has not been demonstrated
- avoid giving direct, specific instructions on how the learner can improve the evidence to achieve a higher grade.

Authenticity of learner work

Assessors must ensure that evidence is authentic to a learner through setting valid assignments and supervising them during the assessment period. Assessors must take care not to provide direct input, instructions or specific feedback that may compromise authenticity.

Once an assessment has begun, learners must not be given feedback that relates specifically to their evidence and how it can be improved, learners must work independently.

An assessor must assess only learner work that is authentic, i.e. learners’ own independent work. Learners must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work.

Assessors must complete a declaration that:

- the evidence submitted for this assignment is the learner’s own
- the learner has clearly referenced any sources used in the work
- they understand that false declaration is a form of malpractice.

Centres can use Pearson templates or their own templates to document authentication.

During assessment, an assessor may suspect that some or all of the evidence from a learner is not authentic. The assessor must then take appropriate action using the centre’s policies for malpractice. Further information is given in Section 8 Administrative arrangements.
Resubmission of improved evidence

An assignment provides the final assessment for the relevant learning aims and is normally a final assessment decision, except where the Lead IV approves one opportunity to resubmit improved evidence based on the completed assignment brief.

The Lead IV has the responsibility to make sure that resubmission is operated fairly. This means:

- checking that a learner can be reasonably expected to perform better through a second submission, for example that the learner has not performed as expected
- making sure that giving a further opportunity does not give an unfair advantage over other learners, for example through the opportunity to take account of feedback given to other learners
- checking that the learner will be able to provide improved evidence without further guidance and that the original evidence submitted remains valid.

Once an assessment decision has been given to the learner, the resubmission opportunity must have a deadline within 15 working days in the same academic year.

For assessment to be fair, it is important that learners are all assessed in the same way and that some learners are not advantaged by having additional time or the opportunity to learn from others. Therefore, learners who did not complete assignments by your planned deadline or an authorised extension deadline, if one was given for specific circumstances, may not have the opportunity to subsequently resubmit. Similarly, learners who submit work that is not their own should not be given an opportunity to resubmit.

The outcome of any resubmission of the assignment by the learner is then recorded as the final decision.

A learner who has not achieved their expected level of performance in the relevant learning aims after resubmission of an assignment may be offered a single retake opportunity using a new assignment. The highest grade that may be awarded is a Pass.

The Lead IV must authorise a retake with a new assignment only in exceptional circumstances and where it is necessary, appropriate and fair to do so. For further information on offering a retake opportunity you should refer to the BTEC Centre Guide to Assessment available on our website. We provide information on writing assignments for retakes on our website (www.btec.co.uk/keydocuments).
7 External assessment

A summary of the type and availability of external assessment for this qualification is given below. These external assessments assess units that are 25% of the total qualification GLH and are weighted to contribute the same proportion of the overall qualification grade. The external assessments for these qualifications are available so that learners may be assessed at any suitable point in their programme.

See the units and sample assessment materials for more information.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Type</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unit 1: Engineering Principles</strong></td>
<td>Onscreen test set and marked by Pearson.</td>
<td>On demand First assessment March 2018</td>
</tr>
<tr>
<td></td>
<td>75 minutes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 marks.</td>
<td></td>
</tr>
<tr>
<td><strong>Unit 2: Processes and Materials</strong></td>
<td>Onscreen test set and marked by Pearson.</td>
<td>On demand First assessment March 2018</td>
</tr>
<tr>
<td></td>
<td>75 minutes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 marks.</td>
<td></td>
</tr>
</tbody>
</table>

For **Unit 1** and **Unit 2**, onscreen tests are available on demand with **Unit 1** starting from January 2018 and **Unit 2** starting from March 2018. These tests use a range of question types, including examiner-marked. As tests have a full marking process, results for individual learners will be released once the process is complete and the time to results issue will vary.

Learners must be prepared for external assessment by the time they undertake it. In preparing learners for assessment, you will want to take account of required learning time, the relationship with any other external assessments and opportunities for resits. Learners who take an external assessment and who do not perform as expected may have one further opportunity using a later external assessment. Learners cannot take a further assessment until they have a result from the first assessment.

Learners who attempt an external assessment twice will have the better of the grades achieved used in the final grade calculation for the qualification.

**Units**

The externally-assessed units have a specific format which we explain in **Section 3 Units**. The content of units will be sampled across external assessments over time through appropriate papers. The ways in which learners are assessed are shown through the assessment outcomes and grading descriptors.
Sample assessment materials

Each externally-assessed unit has a set of sample assessment materials (SAMs) that accompanies this specification. The SAMs are there to give you an example of what the external assessment will look like in terms of the feel and level of demand of the assessment.

The SAMs show the range of possible activity types that may appear in the actual assessments and give you a good indication of how the assessments will be structured. While SAMs can be used for practice with learners, as with any assessment, the content covered and specific details of the activities will vary in each assessment.

These sample assessments can be downloaded from our website.

Conducting external assessments

Centres must make arrangements for the secure delivery of external assessments. You need to ensure that learners are aware that they need to work independently and be aware of the requirements for any external assessment.

Each external assessment has a defined degree of control under which it must take place.

We define degrees of control as follows.

**High control**

This is the completion of assessment in formal invigilated examination conditions. This applies to onscreen tests.

Further information on responsibilities for conducting external assessment is given in the document *Instructions for Conducting External Assessments*, available on our website.
8 Administrative arrangements

Introduction

This section focuses on the administrative requirements for delivering a BTEC qualification. It will be of value to Quality Nominees, Lead IVs, Programme Leaders and Examinations Officers.

Learner registration and entry

Shortly after learners start the programme of learning, you need to make sure that they are registered for the qualification and that appropriate arrangements are made for internal and external assessment. You need to refer to our Information Manual for information on making registrations for the qualification and entries for external assessments.

Learners can be formally assessed only for a qualification on which they are registered. If learners’ intended qualifications change, for example if a learner decides to choose a different pathway specialism, then the centre must transfer the learner appropriately.

Access to assessment

Both internal and external assessments need to be administered carefully to ensure that all learners are treated fairly, and that results and certification are issued on time to allow learners to progress to chosen progression opportunities.

Our equality policy requires that all learners have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every learner. We are committed to making sure that:

- learners with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to learners who do not share that characteristic
- all learners achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational Qualifications.
Administrative arrangements for internal assessment

Records
You are required to retain records of assessment for each learner. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information can be found in our Information Manual. Records must be maintained as specified as we may ask to audit them.

Reasonable adjustments to assessment
To ensure that learners have fair access to demonstrate the requirements of the assessments, a reasonable adjustment is one that is made before a learner takes an assessment. You are able to make adjustments to internal assessments to take account of the needs of individual learners. In most cases this can be achieved through a defined time extension or by adjusting the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. You need to plan for time to make adjustments if necessary.

Further details on how to make adjustments for learners with protected characteristics are given on our website in the document Supplementary guidance for reasonable adjustment and special consideration in vocational internally assessed units.

Special consideration
Special consideration is given after an assessment has taken place for learners who have been affected by adverse circumstances, such as illness. You must operate special consideration in line with our policy (see previous paragraph). You can provide special consideration related to the period of time given for evidence to be provided or for the format of the assessment if it is equally valid. You may not substitute alternative forms of evidence to that required in a unit, or omit the application of any assessment criteria to judge attainment. Pearson can consider applications for special consideration only in line with the policy.

Appeals against assessment
Your centre must have a policy for dealing with appeals from learners. These appeals may relate to assessment decisions being incorrect or assessment being conducted unfairly. The first step in such a policy could be a consideration of the evidence by a Lead IV or other member of the programme team. The assessment plan should allow time for potential appeals after assessment decisions have been given to learners. If there is an appeal by a learner you must document the appeal and its resolution. Learners have a final right of appeal to Pearson but only if the procedures that you have put in place have not been followed. Further details are given in our policy Enquiries and appeals about Pearson Vocational Qualifications.
Administrative arrangements for external assessment

Entries and resits
For information on the timing of assessment and entries, please refer to the annual examinations timetable on our website. Learners are permitted to have one resit of an external assessment.

Access arrangements requests
Access arrangements are agreed with Pearson before an assessment. They allow learners with special educational needs, disabilities or temporary injuries to:
• access the assessment
• show what they know and can do without changing the demands of the assessment.
Access arrangements should always be processed at the time of registration. Learners will then know what type of arrangements are available in place for them.

Granting reasonable adjustments
For external assessment, a reasonable adjustment is one that we agree to make for an individual learner. A reasonable adjustment is defined for the individual learner and informed by the list of available access arrangements.
Whether an adjustment will be considered reasonable will depend on a number of factors to include the:
• needs of the learner with the disability
• effectiveness of the adjustment
• cost of the adjustment; and
• likely impact of the adjustment on the learner with the disability and other learners.
Adjustment may be judged unreasonable and not approved if it involves unreasonable costs, timeframes or affects the integrity of the assessment.

Special consideration requests
Special consideration is an adjustment made to a learner’s mark or grade after an external assessment to reflect temporary injury, illness or other indisposition at the time of the assessment. An adjustment is made only if the impact on the learner is such that it is reasonably likely to have had a material effect on that learner being able to demonstrate attainment in the assessment.
Centres are required to notify us promptly of any learners who they believe have been adversely affected and request that we give special consideration. Further information can be found in the special requirements section on our website.
Dealing with malpractice in assessment

Malpractice means acts that undermine the integrity and validity of assessment, the certification of qualifications, and/or that may damage the authority of those responsible for delivering the assessment and certification.

Pearson does not tolerate actions (or attempted actions) of malpractice by learners, centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on learners, centre staff or centres where incidents (or attempted incidents) of malpractice have been proven.

Malpractice may arise or be suspected in relation to any unit or type of assessment within the qualification. For further details regarding malpractice and advice on preventing malpractice by learners please see Pearson’s Centre Guidance: Dealing with Malpractice, available on our website.

The procedures we ask you to adopt vary between units that are internally assessed and those that are externally assessed.

Internally-assessed units

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Learners must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. The Centre Guidance: Dealing with Malpractice document gives full information on the actions we expect you to take.

Pearson may conduct investigations if we believe that a centre is failing to conduct internal assessment according to our policies. The above document gives further information, examples and details the penalties and sanctions that may be imposed.

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

Externally-assessed units

External assessment means all aspects of units that are designated as external in this specification, including preparation for tasks and performance. For these assessments, centres must follow the JCQ procedures set out in the latest version of JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures (www.jcq.org.uk).

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

Learner malpractice

Heads of Centres are required to report incidents of any suspected learner malpractice that occur during Pearson external assessments. We ask that centres do so by completing a JCQ Form M1 (available at www.jcq.org.uk/exams-office/malpractice) and emailing it and any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc.) to the Investigations Team at candidatemalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on learners lies with Pearson.

Learners must be informed at the earliest opportunity of the specific allegation and the centre’s malpractice policy, including the right of appeal. Learners found guilty of malpractice may be disqualified from the qualification for which they have been entered with Pearson.
Teacher/centre malpractice

Heads of Centres are required to inform Pearson’s Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. Heads of centres are requested to inform the Investigations Team by submitting a JCQ Form M2(a) (available at www.jcq.org.uk/exams-office/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff or anonymous informants), the Investigations Team will conduct the investigation directly or may ask the head of centre to assist.

Incidents of maladministration (accidental errors in the delivery of Pearson qualifications that may affect the assessment of learners) should also be reported to the Investigations Team using the same method.

Heads of Centres/Principals/Chief Executive Officers or their nominees are required to inform learners and centre staff suspected of malpractice of their responsibilities and rights; see Section 6.15 of the JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures document.

Pearson reserves the right in cases of suspected malpractice to withhold the issuing of results and/or certificates while an investigation is in progress. Depending on the outcome of the investigation results and/or certificates may be released or withheld.

You should be aware that Pearson may need to suspend certification when undertaking investigations, audits and quality assurances processes. You will be notified within a reasonable period of time if this occurs.

Sanctions and appeals

Where malpractice is proven we may impose sanctions or penalties.

Where learner malpractice is evidenced, penalties may be imposed such as:

- mark reduction for external assessments
- disqualification from the qualification
- being barred from registration for Pearson qualifications for a period of time.

If we are concerned about your centre’s quality procedures we may impose sanctions such as:

- working with you to create an improvement action plan
- requiring staff members to receive further training
- placing temporary blocks on your certificates
- placing temporary blocks on registration of learners
- debarring staff members or the centre from delivering Pearson qualifications
- suspending or withdrawing centre approval status.

The centre will be notified if any of these apply.

Pearson has established procedures for centres that are considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from heads of centres (on behalf of learners and/or members or staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in our Enquiries and Appeals policy, which is on our website. In the initial stage of any aspect of malpractice, please notify the Investigations Team by email via pqsmalpractice@pearson.com who will inform you of the next steps.
Certification and results

Once a learner has completed all the required units for a qualification, even if final results for external assessments have not been issued, then the centre can claim certification for the learner, provided that quality assurance has been successfully completed. For the relevant procedures please refer to our Information Manual. You can use the information provided on qualification grading to check overall qualification grades.

Results issue

Results for external assessment will be issued once marking is complete. Qualification results will be issued once a learner has completed all components of the qualification and you have claimed certification. The result will be in the form of a grade. You should be prepared to discuss performance with learners, making use of the information we provide and post-results services.

Post-assessment services

Once results for external assessments are issued, you may find that the learner has failed to achieve the qualification or to attain an anticipated grade. It is possible to transfer or reopen registration in some circumstances. Our Information Manual gives further information.

Changes to qualification requests

Where a learner who has taken a qualification wants to resit an externally-assessed unit to improve their qualification grade, you firstly need to decline their overall qualification grade. You must decline the grade before the certificate is issued. For a learner receiving their results in August, you should decline the grade by the end of September if the learner intends to resit an external assessment.

Additional documents to support centre administration

As an approved centre, you must ensure that all staff delivering, assessing and administering the qualifications have access to this documentation. These documents are reviewed annually and are reissued if updates are required.

- Pearson Quality Assurance Handbook: this sets out how we will carry out quality assurance of standards and how you need to work with us to achieve successful outcomes.
- Information Manual: this gives procedures for registering learners for qualifications, transferring registrations, entering for external assessments and claiming certificates.
- Lead Examiners’ Reports: these are produced after each series for each external assessment and give feedback on the overall performance of learners in response to tasks or questions set.
- Instructions for the Conduct of External Assessments: explains our requirements for the effective administration of external assessments, such as invigilation and submission of materials.
- Regulatory policies: our regulatory policies are integral to our approach and explain how we meet internal and regulatory requirements. We review the regulated policies annually to ensure that they remain fit for purpose. Policies related to this qualification include:
  - adjustments for candidates with disabilities and learning difficulties, access arrangements and reasonable adjustments for general and vocational qualifications
  - age of learners
  - centre guidance for dealing with malpractice
  - recognition of prior learning and process.

This list is not exhaustive and a full list of our regulatory policies can be found on our website.
9 Quality assurance

Centre and qualification approval

As part of the approval process, your centre must make sure that the resource requirements listed below are in place before offering the qualification.

- Centres must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualification.
- Staff involved in the assessment process must have relevant expertise and/or occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by learners.
- Centres must deliver the qualification in accordance with current equality legislation.
- Centres should refer to the teacher guidance section in individual units to check for any specific resources required.

Continuing quality assurance and standards verification

On an annual basis, we produce the Pearson Quality Assurance Handbook. It contains detailed guidance on the quality processes required to underpin robust assessment, internal verification and planning of appropriate employer involvement.

The key principles of quality assurance are that:

- a centre delivering BTEC programmes must be an approved centre, and must have approval for the programmes or groups of programmes that it is delivering
- the centre agrees, as part of gaining approval, to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; it must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres a range of materials and opportunities, through online standardisation, intended to exemplify the processes required for effective assessment, and examples of effective standards. Approved centres must use the materials and services to ensure that all staff delivering BTEC qualifications keep up to date with the guidance on assessment
- an approved centre must follow agreed protocols for standardisation of assessors and verifiers, for the planning, monitoring and recording of assessment processes, and for dealing with special circumstances, appeals and malpractice.

The approach of quality-assured assessment is through a partnership between an approved centre and Pearson. We will make sure that each centre follows best practice and employs appropriate technology to support quality-assurance processes, where practicable. We work to support centres and seek to make sure that our quality-assurance processes do not place undue bureaucratic processes on centres. We monitor and support centres in the effective operation of assessment and quality assurance.
The methods we use to do this for BTEC Technical Certificate and Diploma qualifications include:

- making sure that all centres complete appropriate declarations at the time of approval
- undertaking approval visits to centres
- making sure that centres have effective teams of assessors and verifiers who are trained to undertake assessment
- undertaking an overarching review and assessment of a centre’s strategy for ensuring sufficient and appropriate engagement with employers at the beginning of delivery of any BTEC programme(s)
- undertaking a review of the employer involvement planned at programme level to ensure its appropriateness at a time when additional activities can be scheduled where necessary
- assessment sampling and verification, through requested samples of assessments, completed assessed learner work and associated documentation
- an overarching review and assessment of a centre’s strategy for delivering and quality assuring its BTEC programmes.

Centres that do not fully address and maintain rigorous approaches to delivering, assessing and quality assurance cannot seek certification for individual programmes or for the BTEC Technical Certificate and Diploma qualifications. An approved centre must make certification claims only when authorised by us and strictly in accordance with requirements for reporting.

Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.
10 Understanding the qualification grade

Awarding and reporting for the qualification

This section explains the rules that we apply in providing an overall qualification grade for each learner. The final grade awarded for a qualification represents a holistic performance across all of the qualification. As the qualification grade is an aggregate of the total performance, there is some element of compensation in that a higher performance in some units will be balanced by a lower outcome in others.

Eligibility for an award

In order to be awarded the qualification, a learner must complete all units and achieve a Pass or above in all units. See the structure in Section 2 Structure for full details.

To achieve the qualification grade, learners must:

- achieve and report a grade (D, M or P) for all units within a valid combination
- achieve the minimum number of points at a grade threshold.

Where there are optional units in a qualification, it is the responsibility of the centre to ensure that a correct unit combination is adhered to. Learners who do not pass all the required units shown in the structure will not achieve the qualification. For example, learners who have not passed the required external units or who have not taken enough mandatory or optional units will not achieve that qualification even if they have enough points.

Calculation of the qualification grade

The final grade awarded for a qualification represents an aggregation of a learner’s performance across the qualification. As the qualification grade is an aggregate of the total performance, there is some element of compensation in that a higher performance in some units may be balanced by a lower outcome in others.

In the event that a learner achieves more than the required number of optional units (where available), the mandatory units along with the optional units with the highest grades will be used to calculate the overall result, subject to the eligibility requirements for that particular qualification title.

The qualification is awarded at the grade ranges shown in the table below.

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Available grade range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diploma</td>
<td>PP to DD</td>
</tr>
</tbody>
</table>

The Calculation of qualification grade table, shown further on in this section, shows the minimum thresholds for calculating these grades. The table will be kept under review over the lifetime of the qualification. The most up to date table will be issued on our website.

Pearson will monitor the qualification standard and reserves the right to make appropriate adjustments.

Learners who do not meet the minimum requirements for a qualification grade to be awarded will be recorded as Unclassified (U) and will not be certificated. They may receive a Notification of Performance for individual units. Our Information Manual gives full information.
Points available for internal units
The table below shows the number of points available for internal units. For each internal unit, points are allocated depending on the grade awarded.

<table>
<thead>
<tr>
<th>Unit size</th>
<th>30 GLH</th>
<th>60 GLH</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pass</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Merit</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Distinction</td>
<td>16</td>
<td>32</td>
</tr>
</tbody>
</table>

Points available for the external units
Raw marks from the external units will be awarded points based on performance in the assessment. The points scores available for each external unit at grade boundaries are as follows.

<table>
<thead>
<tr>
<th>Unit size</th>
<th>45 GLH</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>0</td>
</tr>
<tr>
<td>Pass</td>
<td>12</td>
</tr>
<tr>
<td>Merit</td>
<td>18</td>
</tr>
<tr>
<td>Distinction</td>
<td>24</td>
</tr>
</tbody>
</table>

We will automatically calculate the points for each external unit once the external assessment has been marked and grade boundaries have been set. For more details about how we set grade boundaries in the external assessment please go to our website.
Claiming the qualification grade
Subject to eligibility, we will automatically calculate the qualification grade for your learners when the internal unit grades are submitted and the qualification claim is made. Learners will be awarded qualification grades for achieving the sufficient number of points within the ranges shown in the relevant calculation of qualification grade table for the cohort.

**Calculation of qualification grade table**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Points threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP</td>
<td>96</td>
</tr>
<tr>
<td>MP</td>
<td>112</td>
</tr>
<tr>
<td>MM</td>
<td>128</td>
</tr>
<tr>
<td>DM</td>
<td>152</td>
</tr>
<tr>
<td>DD</td>
<td>176</td>
</tr>
</tbody>
</table>

The table is subject to review over the lifetime of the qualification. The most up-to-date version will be issued on our website.
### Examples of grade calculations based on table applicable to registrations from September 2017

**Example 1:** Achievement of a Diploma with a PP grade

<table>
<thead>
<tr>
<th>Unit</th>
<th>GLH</th>
<th>Type</th>
<th>Grade</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45</td>
<td>External</td>
<td>Pass</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>External</td>
<td>Pass</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>Internal</td>
<td>Pass</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>Internal</td>
<td>Pass</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>Internal</td>
<td>Pass</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>Internal</td>
<td>Merit</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>Internal</td>
<td>Pass</td>
<td>16</td>
</tr>
<tr>
<td><strong>360</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>104</strong></td>
</tr>
</tbody>
</table>

The learner has sufficient points for a PP grade.

**Example 2:** Achievement of a Diploma with a DD grade

<table>
<thead>
<tr>
<th>Unit</th>
<th>GLH</th>
<th>Type</th>
<th>Grade</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45</td>
<td>External</td>
<td>Merit</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>External</td>
<td>Merit</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>Internal</td>
<td>Distinction</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>Internal</td>
<td>Distinction</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>Internal</td>
<td>Distinction</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>Internal</td>
<td>Distinction</td>
<td>32</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>Internal</td>
<td>Distinction</td>
<td>32</td>
</tr>
<tr>
<td><strong>360</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>180</strong></td>
</tr>
</tbody>
</table>

The learner has sufficient points for a DD grade.
**Example 3:** Achievement of a Diploma with an Unclassified result

<table>
<thead>
<tr>
<th>Unit</th>
<th>GLH</th>
<th>Type</th>
<th>Grade</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45</td>
<td>External</td>
<td>Merit</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>External</td>
<td>Merit</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>Internal</td>
<td>Unclassified</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>Internal</td>
<td>Pass</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>Internal</td>
<td>Pass</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>60</td>
<td>Internal</td>
<td>Pass</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>Internal</td>
<td>Distinction</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>360</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U</td>
<td></td>
<td></td>
<td>116</td>
</tr>
</tbody>
</table>

The learner has a U in Unit 3.

The learner has sufficient points for a MP but has not met the requirement for a Pass, or above, in all Units.
11 Resources and support

Our aim is to give you support to enable you to deliver Pearson BTEC Level 2 Technicals with confidence. You will find resources to support teaching and learning, assessing, and professional development on our website.

Support for setting up your course and preparing to teach

Schemes of Learning
Our free Schemes of Learning give you suggestions and ideas for how to deliver the units in the qualifications, including opportunities to develop employability skills, tips on embedding mathematics and English, and how to link units through holistic assessments.

Delivery planner
High-level models showing how the course can be delivered over different timescales, for example six months, one year or two years.

myBTEC
myBTEC is a free, online toolkit that lets you plan and manage your BTEC provision from one place. It supports the delivery, assessment and quality assurance of BTEC qualifications in centres and supports teachers with the following activities:
• checking that a programme is using a valid combination of units
• creating and verifying assignment briefs (including access to a bank of assignment briefs that can be customised)
• creating assessment plans and recording assessment decisions
• tracking the progress of every learner throughout their programme.
To find out more about myBTEC, visit the myBTEC page on the support services section of our website.

Support for teaching and learning

Work Experience Toolkit
Our free Work Experience Toolkit gives guidance for tutors, assessors, work-based supervisors and learners on how to make the most of work placements and work experience.

Pearson Learning Services provides a range of engaging resources to support BTEC qualifications. Teaching and learning resources may also be available from a number of other publishers. Details of Pearson’s own resources and of all endorsed resources are on our website.

Support for assessment

Sample assessment materials for externally-assessed units
Sample assessment materials (SAMs) are available for externally-assessed units and can be downloaded from the Pearson Qualifications website. An additional set of sample assessment materials for externally-assessed units will also be available, giving your learners further opportunities for practice.

Sample assessment materials for internally-assessed units
We do not prescribe the assessments for the internally-assessed units. Rather, we allow you to set your own, according to your learners’ preferences.

We provide assignment briefs which are approved by Pearson Standards Verifiers.
Sample marked learner work
To support you in understanding the expectation of the standard at each grade, examples of sample marked learner work will be made available on our website.

Training and support from Pearson

People to talk to
There are lots of people who can support you and give you advice and guidance on delivering your Pearson BTEC Level 2 Technicals. They include the following.

- Standards Verifiers – they can support you with preparing your assignments, ensuring that your assessment plan is set up correctly, in preparing learner work and providing quality assurance through sampling.
- Subject Advisors – available for all sectors. They understand all Pearson qualifications in their sector and so can answer sector-specific queries on planning, teaching, learning and assessment.
- Curriculum Development Managers (CDMs) – they are regionally based and have a full overview of the BTEC qualifications and of the support and resources that Pearson provides. CDMs often run network events.
- Customer Services – the ‘Support for You’ section of our website gives the different ways in which you can contact us for general queries. For specific queries, our service operators can direct you to the relevant person or department.

Training and professional development
We provide a range of training and professional development events to support the introduction, delivery, assessment and administration of the Pearson BTEC Level 2 Technicals

These sector-specific events, developed and delivered by specialists, are available both face to face and online.
BTEC Level 2 Technical Diploma in ENGINEERING

Like what you see?

• Discover the full range of BTEC Level 2 Technicals available.
• Explore free course materials and training events.
• Get your questions answered by our subject experts.

All this and more at: quals.pearson.com/btecl2techENG

@TeachBTEC @PearsonTeachDT TeachingEngineering@pearson.com