BTEC Level 2

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Specification

BTEC Firsts

Edexcel BTEC Level 2 Certificate, BTEC Level 2 Extended Certificate and BTEC Level 2 Diploma in Engineering (QCF)

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Contents

Qualification titles covered by this specification

Edexcel BTEC Level 2 Certificate in Engineering

Edexcel BTEC Level 2 Extended Certificate in Engineering

Edexcel BTEC Level 2 Diploma in Engineering

These qualifications have been accredited to the Qualifications and Credit Framework (QCF) and are eligible for public funding as determined by the Department for Children, Schools and Families (DCSF) under Sections 96 and 97 of the Learning and Skills Act 2000.

The qualification titles listed above feature in the funding lists published annually by the DCSF and the regularly updated website www.dcsf.gov.uk. The QCF Qualifications Accreditation Number should be used by centres when they wish to seek public funding for their learners. Each unit within a qualification will also have a QCF unit code.

The QCF qualification and unit codes will appear on learners' final certification documentation.

The QANs for the qualifications in this publication are:

Edexcel BTEC Level 2 Certificate in Engineering	500/7578/0
Edexcel BTEC Level 2 Extended Certificate in Engineering	500/7577/9
Edexcel BTEC Level 2 Diploma in Engineering	500/7576/7

These qualification titles will appear on learners' certificates. Learners need to be made aware of this when they are recruited by the centre and registered with Edexcel.

What are BTEC Firsts?

BTEC First qualifications are undertaken in further education and sixth-form colleges, schools and other training providers, and have been since they were introduced in 1983. Their purpose, approaches to teaching, learning and assessment are established and understood by teaching professionals, employers and learners alike.

The BTEC First qualifications within this specification have been revised to fit the new Qualifications and Credit Framework (QCF). As such the revised titles are:

- Edexcel BTEC Level 2 Certificate in Engineering
- Edexcel BTEC Level 2 Extended Certificate in Engineering
- Edexcel BTEC Level 2 Diploma in Engineering.

But for clarity and continuity they are referred to generically as BTEC First qualifications, where appropriate and maintain the same equivalences, benchmarks and other articulations (for example SCAAT points) as their predecessor qualifications. The following identifies the titling conventions and variations between the 'old' (NQF) and 'new' (QCF) specifications.

Predecessor BTEC Firsts (accredited 2006)	QCF BTEC Firsts (for delivery from September 2010)
Not applicable	Edexcel BTEC Level 2 Certificate
Edexcel Level 2 BTEC First Certificate	Edexcel BTEC Level 2 Extended Certificate
Edexcel Level 2 BTEC First Diploma	Edexcel BTEC Level 2 Diploma

BTEC Firsts are QCF Level 2 qualifications designed to provide specialist work-related qualifications in a range of sectors. They give learners the knowledge, understanding and skills that they need to prepare for employment. The qualifications also provide career development opportunities for those already in work. Consequently they provide a course of study for full-time or part-time learners in schools, colleges and training centres.

BTEC Firsts provide much of the underpinning knowledge and understanding for the National Occupational Standards for the sector, where these are appropriate. They are supported by the relevant Standards Setting Body (SSB) or Sector Skills Council (SSC). A number of BTEC Firsts are recognised as Technical Certificates and form part of the Apprenticeship Framework. They attract achievement and attainment points that equate to similar-sized general qualifications.

On successful completion of a BTEC First qualification, learners can progress to or within employment and/or continue their study in the same, or related vocational area.

It should be noted that the titling conventions for the revised QCF versions of the BTEC Nationals have also changed; see within the relevant BTEC National specifications on the website (www.edexcel.com).

The QCF is a framework which awards credit for qualifications and units and aims to present qualifications in a way that is easy to understand and measure. It enables learners to gain qualifications at their own pace along flexible routes.

There are three sizes of qualifications in the QCF:

- Awards (1 to 12 credits)
- Certificates (13 to 36 credits)
- Diplomas (37 credits and above).

Every unit and qualification in the framework will have a credit value.

The credit value of a unit specifies the number of credits that will be awarded to a learner who has achieved the learning outcomes of the unit.

The credit value of a unit is based on:

- one credit for those learning outcomes achievable in 10 hours of learning
- learning time is defined as the time taken by learners at the level of the unit, on average, to complete the learning outcomes of the unit to the standard determined by the assessment criteria
- the credit value of the unit will remain constant in all contexts, regardless of the assessment method used for the qualification(s) to which it contributes.

Learning time should address all learning (including assessment) relevant to the learning outcomes, regardless of where, when and how the learning has taken place.

Edexcel BTEC Level 2 Certificate – 15 credits

The 15-credit BTEC Level 2 Certificate offers a specialist qualification that focuses on particular aspects of employment within the appropriate vocational sector. The BTEC Level 2 Certificate is a qualification which can extend a learner's programme of study and provide a vocational emphasis. The BTEC Level 2 Certificate is broadly equivalent to one GCSE.

The BTEC Level 2 Certificate is also suitable for more mature learners, who wish to follow a vocational programme of study as part of their continued professional development or who want to move to a different area of employment.

Edexcel BTEC Level 2 Extended Certificate – 30 credits

The 30-credit BTEC Level 2 Extended Certificate extends the specialist work-related focus from the BTEC Certificate and covers the key knowledge and practical skills required in the appropriate vocational sector. The BTEC Level 2 Extended Certificate offers flexibility and a choice of emphasis through the optional units. It is broadly equivalent to two GCSEs.

The BTEC Level 2 Extended Certificate offers an engaging programme for those who are clear about the area of employment that they wish to enter. These learners may wish to extend their programme through the study of a related GCSE, a complementary NVQ or another qualification. These learning programmes can be developed to allow learners to study complementary qualifications without duplication of content.

For adult learners the BTEC Level 2 Extended Certificate can extend their experience of work in a particular sector. It is a suitable qualification for those wishing to change career or move into a particular area of employment following a career break.

The predecessor qualification to the BTEC Level 2 Extended Certificate is the Edexcel Level 2 BTEC First Certificate accredited onto the National Qualifications Framework, which has the same equivalences, overall size and focus to the revised QCF-accredited qualification.

Edexcel BTEC Level 2 Diploma – 60 credits

The 60-credit BTEC Level 2 Diploma extends the specialist work-related focus from the BTEC Level 2 Extended Certificate. There is potential for the qualification to prepare learners for employment in the appropriate vocational sector and it is suitable for those who have decided that they wish to enter a particular area of work. It is broadly equivalent to four GCSEs.

Some learners may wish to gain the qualification in order to enter a specialist area of employment or to progress to a Level 3 programme. Other learners may want to extend the specialism they studied on the BTEC Level 2 Certificate or the BTEC Level 2 Extended Certificate programme.

The predecessor qualification to the BTEC Level 2 Diploma is the Edexcel Level 2 BTEC First Diploma accredited onto the National Qualifications Framework, which has the same equivalences, overall size and focus to the revised QCF-accredited qualification.

Key features of the BTEC Firsts in Engineering

The BTEC Firsts in Engineering have been developed in the maintenance, manufacturing, electronic and general engineering sectors to:

- provide education and training for engineering employees
- give opportunities for engineering employees to achieve a nationally recognised Level 2 vocationally specific qualification
- give full-time learners the opportunity to enter employment in the engineering sector or to progress to vocational qualifications such as the Edexcel Level 3 BTEC Nationals in Manufacturing Engineering or Mechanical Engineering
- give learners the opportunity to develop a range of skills and techniques, personal skills and attributes essential for successful performance in working life.

Rationale for the BTEC Firsts in Engineering

The engineering sector continues to suffer from a skills gap and needs to keep up with rapidly developing technologies. The BTEC Firsts in Engineering have been designed to give new entrants to the engineering sector the underpinning knowledge and specific skills needed to meet the needs of modern engineering industries.

The BTEC Firsts in Engineering link to many of the National Occupational Standards in engineering and can contribute towards the knowledge, skills and understanding of one or more engineering NVQs. The content of the qualifications goes beyond that strictly required for an NVQ, and provides for progression into employment and to further education and qualifications such as the BTEC Nationals in Engineering. The qualifications are also expected to be recognised as technical certificates as part of apprenticeship schemes at Level 2.

The qualification structures include a wide range of units to provide opportunities for learners who intend progressing into technician roles as well as for those who are not yet based in industry and wish to gain an understanding of engineering.

The BTEC First Award and BTEC First Certificate in Engineering are nested qualifications within the Diploma and contribute to increasing the vocational focus in schools.

Centres may use the main title BTEC First Diploma in Engineering to address the requirement for multi-skilled technicians by selecting units from across the groups of specialist units. Alternatively, learners can study particular areas of engineering in depth (maintenance, manufacturing or electronics) by choosing to study one of the endorsed titles.

National Occupational Standards (NOS)

BTEC Firsts are designed to provide much of the underpinning knowledge and understanding for National Occupational Standards (NOS), as well as developing practical skills in preparation for work and possible achievement of NVQs in due course. NOS form the basis of National Vocational Qualifications (NVQs). BTEC Firsts do not purport to deliver occupational competence in the sector, which should be demonstrated in a work context.

Where relevant, each unit in the specification identifies links to elements of the NOS for engineering, as produced by the Sector Skills Council (SSC) for the sector, SEMTA.

Edexcel BTEC Level 2 Firsts in Engineering relate to the SEMTA NOS for the following NVQs:

- Level 2 NVQ in Performing Engineering Operations
- Level 2 NVQ in Performing Manufacturing Operations
- Level 2 NVQ in Mechanical Manufacturing Engineering
- Level 2 NVQ in Engineering Maintenance and Installation
- Level 2 NVQ in Materials Processing and Finishing
- Level 2 NVQ in Fabrication and Welding
- Level 2 NVQ in Business Improvement Techniques.

Rules of combination for Edexcel BTEC Level 2 First qualifications

The rules of combination specify the:

- total credit value of the qualification
- the minimum credit to be achieved at the level or above the level of the qualification
- the mandatory unit credit
- the optional unit credit
- the maximum credit that can come from other QCF BTEC units.

When combining units for a BTEC First qualification, it is the centre's responsibility to ensure that the following rules of combination are adhered to.

Edexcel BTEC Level 2 Certificate

1. Qualification credit value: a minimum of 15 credits.
2. Minimum credit to be achieved at, or above, the level of the qualification: 8 credits.
3. Mandatory unit credit: 5 credits.
4. Optional unit credit: 10.
5. This qualification is not designed to include credit from other QCF BTEC units.

Edexcel BTEC Level 2 Extended Certificate

1. Qualification credit value: a minimum of 30 credits.
2. Minimum credit to be achieved at, or above, the level of the qualification: 16 credits.
3. Mandatory unit credit: 10 credits.
4. Optional unit credit: 20.
5. This qualification is not designed to include credit from other QCF BTEC units.

Edexcel BTEC Level 2 Diploma

1. Qualification credit value: a minimum of 60 credits.
2. Minimum credit to be achieved at, or above, the level of the qualification: 31 credits.
3. Mandatory unit credit: 15 credits.
4. Optional unit credit: 45.
5. A maximum of 10 optional credits can come from other QCF BTEC units to meet local needs.

Edexcel BTEC Level 2 Certificate in Engineering

The Edexcel BTEC Level 2 Certificate in Engineering is a 15-credit and 90-guided-learning-hour (GLH) qualification that consists of one mandatory unit **plus** optional units that provide for a combined total of 15 credits.

Edexcel BTEC Level 2 Certificate in Engineering			
Unit	**Mandatory units**	**Credit**	**Level**
1	Working Safely and Effectively in Engineering	5	2
Unit	**Optional units**		
2	Interpreting and Using Engineering Information	5	2
3	Mathematics for Engineering Technicians	5	2
4	Applied Electrical and Mechanical Science for Engineering	5	2
5	Engineering Maintenance Procedures	5	2
6	Preparing and Controlling Engineering Manufacturing Operations	5	2
7	Electronic Devices and Communication Applications	10	2
8	Selecting Engineering Materials	5	2
10	Using Computer Aided Drawing Techniques in Engineering	10	2
11	Operation and Maintenance of Mechanical Systems and Components	10	2
12	Operation and Maintenance of Electrical Systems and Components	10	2
13	Operation and Maintenance of Electronic Systems and Components	10	2
14	Selecting and Using Secondary Machining Techniques to Remove Material	10	2
15	Part Programming CNC Machines	10	2
16	Application of Welding Processes	10	2
17	Fabrication Techniques and Sheet Metal Work	10	2
18	Engineering Marking Out	5	2
19	Electronic Circuit Construction	10	2
21	Production Planning for Engineering	5	2
24	Operation and Maintenance of Fluid Power Systems and Components	10	2

Edexcel BTEC Level 2 Extended Certificate in Engineering

The Edexcel BTEC Level 2 Extended Certificate in Engineering is a 30-credit and 180-guided-learning-hour qualification (GLH) that consists of two mandatory units **plus** optional units that provide for a combined total of 30 credits.

Edexcel BTEC Level 2 Extended Certificate in Engineering			
Unit	**Mandatory units**	**Credit**	**Level**
1	Working Safely and Effectively in Engineering	5	2
2	Interpreting and Using Engineering Information	5	2
Unit	**Optional units**		
3	Mathematics for Engineering Technicians	5	2
4	Applied Electrical and Mechanical Science for Engineering	5	2
5	Engineering Maintenance Procedures	5	2
6	Preparing and Controlling Engineering Manufacturing Operations	5	2
7	Electronic Devices and Communication Applications	10	2
8	Selecting Engineering Materials	5	2
10	Using Computer Aided Drawing Techniques in Engineering	10	2
11	Operation and Maintenance of Mechanical Systems and Components	10	2
12	Operation and Maintenance of Electrical Systems and Components	10	2
13	Operation and Maintenance of Electronic Systems and Components	10	2
14	Selecting and Using Secondary Machining Techniques to Remove Material	10	2
15	Part Programming CNC Machines	10	2
16	Application of Welding Processes	10	2
17	Fabrication Techniques and Sheet Metal Work	10	2
18	Engineering Marking Out	5	2
19	Electronic Circuit Construction	10	2
21	Production Planning for Engineering	5	2
24	Operation and Maintenance of Fluid Power Systems and Components	10	2

Edexcel BTEC Level 2 Diploma in Engineering

The Edexcel BTEC Level 2 Diploma in Engineering is a 60-credit and 360-guided-learning-hour (GLH) qualification that consists of three mandatory units **plus** optional units that provide for a combined total of 60 credits (where at least 31 credits must be at Level 2 or above).

Edexcel BTEC Level 2 Diploma in Engineering			
Unit	**Mandatory units**	**Credit**	**Level**
1	Working Safely and Effectively in Engineering	5	2
2	Interpreting and Using Engineering Information	5	2
3	Mathematics for Engineering Technicians	5	2
Unit	**Optional units**		
4	Applied Electrical and Mechanical Science for Engineering	5	2
5	Engineering Maintenance Procedures	5	2
6	Preparing and Controlling Engineering Manufacturing Operations	5	2
7	Electronic Devices and Communication Applications	10	2
8	Selecting Engineering Materials	5	2
9	Engineering Assembly Methods and Techniques	5	2
10	Using Computer Aided Drawing Techniques in Engineering	10	2
11	Operation and Maintenance of Mechanical Systems and Components	10	2
12	Operation and Maintenance of Electrical Systems and Components	10	2
13	Operation and Maintenance of Electronic Systems and Components	10	2
14	Selecting and Using Secondary Machining Techniques to Remove Material	10	2
15	Part Programming CNC Machines	10	2
16	Application of Welding Processes	10	2
17	Fabrication Techniques and Sheet Metal Work	10	2
18	Engineering Marking Out	5	2
19	Electronic Circuit Construction	10	2
20	Using Specialist Secondary Machining Techniques	5	2
21	Production Planning for Engineering	5	2
22	Application of Quality Control and Measurement in Engineering	10	2
23	Casting and Moulding Engineering Components	10	2
24	Operation and Maintenance of Fluid Power Systems and Components	10	2
25	Applying Continuous Improvement and Problem-solving Techniques	10	2
26	Workplace Organisation and Standard Operating Procedures	10	2
27	PC Hardware and Software Installation and Configuration	10	2
28	Mobile Communications Technology	5	2
29	Mathematics for Engineering Technicians	10	3

Edexcel BTEC Level 2 Diploma in Engineering (Maintenance)

The Edexcel BTEC Level 2 Diploma in Engineering (Maintenance) is a 60-credit and 360-guided-learning-hour (GLH) qualification that consists of three mandatory units **plus** optional units that provide for a combined total of 60 credits (where at least 31 credits must be at Level 2 or above). A minimum of 20 credits must be taken from *Optional units – group A*.

Edexcel BTEC Level 2 Diploma in Engineering (Maintenance)			
Unit	**Mandatory units**	**Credit**	**Level**
1	Working Safely and Effectively in Engineering	5	2
2	Interpreting and Using Engineering Information	5	2
3	Mathematics for Engineering Technicians	5	2
Unit	**Optional units – group A** **Select units to a value of at least 20 credits**		
4	Applied Electrical and Mechanical Science for Engineering	5	2
5	Engineering Maintenance Procedures	5	2
9	Engineering Assembly Methods and Techniques	5	2
11	Operation and Maintenance of Mechanical Systems and Components	10	2
12	Operation and Maintenance of Electrical Systems and Components	10	2
13	Operation and Maintenance of Electronic Systems and Components	10	2
24	Operation and Maintenance of Fluid Power Systems and Components	10	2
Unit	**Optional units – group B**		
8	Selecting Engineering Materials	5	2
10	Using Computer Aided Drawing Techniques in Engineering	10	2
16	Application of Welding Processes	10	2
18	Engineering Marking Out	5	2
19	Electronic Circuit Construction	10	2
29	Mathematics for Engineering Technicians	10	3

Edexcel BTEC Level 2 Diploma in Engineering (Manufacturing)

The Edexcel BTEC Level 2 Diploma in Engineering (Manufacturing) is a 60-credit and 360-guided-learning-hour (GLH) qualification that consists of three mandatory units **plus** optional units that provide for a combined total of 60 credits (where at least 31 credits must be at Level 2 or above). A minimum of 20 credits must be taken from *Optional units – group A*.

Edexcel BTEC Level 2 Diploma in Engineering (Manufacturing)			
Unit	**Mandatory units**	**Credit**	**Level**
1	Working Safely and Effectively in Engineering	5	2
2	Interpreting and Using Engineering Information	5	2
3	Mathematics for Engineering Technicians	5	2
Unit	**Optional units – group A** **Select units to a value of at least 20 credits**		
4	Applied Electrical and Mechanical Science for Engineering	5	2
6	Preparing and Controlling Engineering Manufacturing Operations	5	2
8	Selecting Engineering Materials	5	2
10	Using Computer Aided Drawing Techniques in Engineering	10	2
14	Selecting and Using Secondary Machining techniques to Remove Material	10	2
15	Part Programming CNC Machines	10	2
20	Using Specialist Secondary Machining Techniques	5	2
21	Production Planning for Engineering	5	2
25	Applying Continuous Improvement and Problem-solving Techniques	10	2
26	Workplace Organisation and Standard Operating Procedures	10	2
Unit	**Optional units – group B**		
9	Engineering Assembly Methods and Techniques	5	2
16	Application of Welding Processes	10	2
17	Fabrication Techniques and Sheet Metal Work	10	2
18	Engineering Marking Out	5	2
19	Electronic Circuit Construction	10	2
23	Casting and Moulding Engineering Components	10	2
29	Mathematics for Engineering Technicians	10	3

Edexcel BTEC Level 2 Diploma in Engineering (Electronics)

The Edexcel BTEC Level 2 Diploma in Engineering (Electronics) is a 60-credit and 360-guided-learning-hour (GLH) qualification that consists of three mandatory units **plus** optional units that provide for a combined total of 60 credits (where at least 31 credits must be at Level 2 or above). A minimum of 20 credits must be taken from *Optional units – group A*.

Edexcel BTEC Level 2 Diploma in Engineering (Electronics)			
Unit	**Mandatory units**	**Credit**	**Level**
1	Working Safely and Effectively in Engineering	5	2
2	Interpreting and Using Engineering Information	5	2
3	Mathematics for Engineering Technicians	5	2
Unit	**Optional units – group A** **Select units to a value of at least 20 credits**		
4	Applied Electrical and Mechanical Science for Engineering	5	2
7	Electronic Devices and Communication Applications	10	2
13	Operation and Maintenance of Electronic Systems and Components	10	2
19	Electronic Circuit Construction	10	2
27	PC Hardware and Software Installation and Configuration	10	2
28	Mobile Communications Technology	5	2
Unit	**Optional units – group B**		
8	Selecting Engineering Materials	5	2
9	Engineering Assembly Methods and Techniques	5	2
10	Using Computer Aided Drawing Techniques in Engineering	10	2
12	Operation and Maintenance of Electrical Systems and Components	10	2
29	Mathematics for Engineering Technicians	10	3

Assessment and grading

In BTEC Firsts all units are internally assessed.

All assessment for BTEC First qualifications is criterion referenced, based on the achievement of all the specified learning outcomes.

Each unit within the qualification has specified assessment grading criteria which are to be used for grading purposes. A summative unit grade can be awarded at pass, merit or distinction:

- to achieve a 'pass' a learner must have satisfied **all** the pass criteria
- to achieve a 'merit' a learner must additionally have satisfied **all** the merit criteria
- to achieve a 'distinction' a learner must additionally have satisfied **all** the distinction criteria.

A grading scale of pass, merit and distinction is applied to all units.

Grading domains

The assessment and grading criteria are developed in relation to grading domains which are exemplified by a number of indicative characteristics at the level of the qualification.

There are four BTEC First grading domains:

- application of knowledge and understanding
- development of practical and technical skills
- personal development for occupational roles
- application of generic skills.

Please refer to *Annexe B* which shows the merit and distinction indicative characteristics.

Guidance

The purpose of assessment is to ensure that effective learning has taken place to give learners the opportunity to:

- meet the assessment and grading criteria; and
- achieve the learning outcomes within the units.

All the assignments created by centres should be reliable and fit for purpose, and should be built on the unit assessment and grading criteria. Assessment tasks and activities should enable learners to produce valid, sufficient and reliable evidence that relates directly to the specified criteria. Centres should enable learners to produce evidence in a variety of different forms, including written reports, graphs and posters, along with projects, performance observation and time-constrained assessments.

Centres are encouraged to emphasise the practical application of the assessment and grading criteria, providing a realistic scenario for learners to adopt, and making maximum use of practical activities and work experience. The creation of assignments that are fit for purpose is vital to achievement and their importance cannot be over-emphasised.

The assessment and grading criteria must be clearly indicated in the fit-for-purpose assignments. This gives learners focus and helps with internal verification and standardisation processes. It will also help to ensure that learner feedback is specific to the assessment and grading criteria.

When looking at the unit assessment and grading criteria grids and designing assignments, centres are encouraged to identify common topics and themes.

The units include guidance on appropriate assessment methodology. A central feature of vocational assessment is that it allows for assessment to be:

- current, ie to reflect the most recent developments and issues
- local, ie to reflect the employment context of the delivering centre
- flexible to reflect learner needs, ie at a time and in a way that matches the learner's requirements so that they can demonstrate achievement.

Calculation of the qualification grade

Pass qualification grade

Learners who achieve the minimum eligible credit value specified by the rule of combination will achieve the qualification at pass grade (see *Rules of combination for Edexcel BTEC Level 2 First qualifications*).

Qualification grades above pass grade

Learners will be awarded a merit or distinction or distinction* qualification grade by the aggregation of points gained through the successful achievement of individual units. The number of points available is dependent on the unit level and grade achieved, and the credit size of the unit (as shown in the 'points available for credits achieved at different QCF Levels and unit grades' below).

Points available for credits achieved at different QCF Levels and unit grades

The table below shows the **number of points scored per credit** at the unit level and grade.

Unit QCF level	Points per credit		
	Pass	Merit	Distinction
Level 1	3	4	5
Level 2	**5**	**6**	**7**
Level 3	7	8	9

Learners who achieve the correct number of points within the ranges shown in the 'qualification grade' table below will achieve the qualification merit or distinction or distinction* grade.

Qualification grade

Qualification	Points range above pass grade		
	Merit	Distinction	Distinction*
BTEC Level 2 Certificate	85–94	95–99	100 and above
BTEC Level 2 Extended Certificate	170–189	190–199	200 and above
BTEC Level 2 Diploma	340–379	380–399	400 and above

Please refer to *Annexe G* for examples of calculation of qualification grade above pass grade.

Quality assurance of centres

Edexcel's qualification specifications set out the standard to be achieved by each learner in order to be awarded the qualification. This is covered in the statement of learning outcomes and assessment and grading criteria in each unit. Further guidance on delivery and assessment is given in the *Essential guidance for tutors* section in each unit. This section is designed to provide additional guidance and amplification related to the unit to support tutors, deliverers and assessors and to provide for a coherence of understanding and a consistency of delivery and assessment.

Approval

Centres that have not previously offered BTEC qualifications will first need to apply for, and be granted, centre approval before they can apply for approval to offer the programme.

When a centre applies for approval to offer a BTEC qualification they are required to enter into an approvals agreement.

The approvals agreement is a formal commitment by the head or principal of a centre to meet all the requirements of the specification and any linked codes or regulations. Sanctions and tariffs may be applied if centres do not comply with the agreement. Ultimately, this could result in the suspension of certification or withdrawal of approval.

Centres will be allowed 'accelerated approval' for a new programme where the centre already has approval for a programme that is being replaced by the new programme.

The key principles of quality assurance are that:

- a centre delivering BTEC programmes must be an approved centre and must have approval for programmes or groups of programmes that it is operating
- 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
- Edexcel makes available to approved centres a range of materials and opportunities 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; planning, monitoring and recording of assessment processes; and for dealing with special circumstances, appeals and malpractice.

The approach of quality assured assessment is made through a partnership between an approved centre and Edexcel. Edexcel is committed to ensuring that it follows best practice and employs appropriate technology to support quality assurance processes where practicable. Therefore, the specific arrangements for working with centres will vary. Edexcel seeks to ensure that the quality assurance processes that it uses do not place undue bureaucratic processes on centres and works to support centres in providing robust quality assurance processes.

Edexcel monitors and supports centres in the effective operation of assessment and quality assurance. The methods which it uses to do this for BTEC First and National programmes accredited under the Qualifications and Credit Framework (QCF) include:

- ensuring that all centres have completed appropriate declarations at the time of approval, undertaking approval visits to centres where necessary
- requiring all centres to appoint a lead internal verifier for designated groups of programmes and to ensure that this person is trained and supported in carrying out that role
- requiring that the lead internal verifier completes compulsory online standardisation related to assessment and verification decisions for the designated programme
- assessment sampling and verification, through requested samples of assessments, completed assessed learner work and associated documentation
- overarching review and assessment of a centre's strategy for assessing and quality assuring its BTEC programmes.

Edexcel Quality Assurance Handbook

Centres should refer to the *Handbook for Quality Assurance for BTEC QCF qualifications*, issued annually, for detailed guidance.

An approved centre must make certification claims only when authorised by Edexcel and strictly in accordance with requirements for reporting.

Centres that do not fully address and maintain rigorous approaches to quality assurance will be prevented from seeking certification for individual programmes or for all BTEC First and National programmes. Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

Programme design and delivery

BTEC First qualifications consist of mandatory units and optional units. Optional units are designed to provide a focus to the qualification and give more specialist opportunities in the sector.

In BTEC Firsts each unit has a number of guided learning hours.

Guided learning hours are defined as all the times when a tutor, trainer or facilitator is present to give specific guidance towards the learning aim being studied on a programme. This definition includes lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. It also includes time spent by staff assessing learners' achievements. It does not include time spent by staff in day-to-day marking of assignments where the learner is not present.

Centres are advised to consider this definition when planning the programme of study associated with this specification.

Mode of delivery

Edexcel does not define the mode of study for BTEC Firsts. Centres are free to offer the qualifications using any mode of delivery (such as full-time, part-time, evening only, distance learning) that meets their learners' needs. Whichever mode of delivery is used, centres must ensure that learners have appropriate access to the resources identified in the specification and to the subject specialists delivering the units. This is particularly important for learners studying for the qualification through open or distance learning.

Learners studying for the qualification on a part-time basis bring with them a wealth of experience that should be utilised to maximum effect by tutors and assessors. The use of assessment evidence drawn from learners' work environments should be encouraged. Those planning the programme should aim to enhance the vocational nature of the qualification by:

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

Resources

BTEC Firsts are designed to prepare learners for employment in specific occupational sectors. Physical resources need to support the delivery of the programme and the proper assessment of the learning outcomes, and should therefore normally be of industry standard. Staff delivering programmes and conducting the assessments should be familiar with current practice and standards in the sector concerned. Centres will need to meet any specific resource requirements to gain approval from Edexcel.

Where specific resources are required these have been indicated in individual units in the *Essential resources* sections.

Delivery approach

It is important that centres develop an approach to teaching and learning that supports the specialist vocational nature of BTEC First qualifications and the mode of delivery. Specifications give a balance of practical skill development and knowledge requirements, some of which can be theoretical in nature. Tutors and assessors need to ensure that appropriate links are made between theory and practical application and that the knowledge base is applied to the sector. This requires the development of relevant and up-to-date teaching materials that allow learners to apply their learning to actual events and activity within the sector. Maximum use should be made of the learner's experience.

An outline learning plan is included in every unit as guidance which demonstrates one way in planning the delivery and assessment of the unit. The outline learning plan can be used in conjunction with the programme of suggested assignments.

Where the qualification has been designated and approved as a Technical Certificate and forms part of an Apprenticeship scheme, particular care needs to be taken to build strong links between the learning and assessment for the BTEC First qualification and the related NVQs and Functional Skills that also contribute to the scheme.

Meeting local needs

Centres should note that the qualifications set out in this specification have been developed in consultation with centres and employers and the Sector Skills Councils or the Standards Setting Bodies for the relevant sector. Centres should make maximum use of the choice available to them within the optional units to meet the needs of their learners, and local skills and training needs.

In certain circumstances, units in this specification might not allow centres to meet a local need. In this situation, Edexcel will ensure that the rule of combination allows centres to make use of units from other standard QCF BTEC specifications. Centres are required to ensure that the coherence and purpose of the qualification is retained and to ensure that the vocational focus is not diluted.

Limitations on variations from standard specifications

The flexibility to import standard units from other QCF BTEC Level 1 to 3 qualifications is limited to a total of 25 per cent of the qualification credit value (see *Rules of combination for Edexcel BTEC Level 2 First qualifications*).

These units cannot be used at the expense of the mandatory units in any qualification.

Additional and specialist learning

Additional and specialist learning (ASL) consists of accredited qualifications at the same level as, or one level above, the Diploma course of study. The ASL may include BTEC qualifications which are also available to learners not following a Diploma course of study.

Qualifications for ASL must be selected from the ASL catalogue through the National Database of Accredited Qualifications (NDAQ). The catalogue includes qualifications which have the approval of the Diploma Development Partnership (DDP) and will expand over time as more qualifications are approved. To access the catalogue go to www.ndaq.org.uk and select 'Browse Diploma Qualifications'.

Further units may be added to qualifications within the catalogue and centres undertaking, or preparing to undertake, ASL should refer regularly to the Edexcel website for information regarding additions.

Functional Skills

BTEC Firsts give learners opportunities to develop and apply Functional Skills.

Functional Skills are offered as stand-alone qualifications at Level 2. See individual units for opportunities to cover ICT, Mathematics and English Functional Skills.

Personal, learning and thinking skills

Opportunities are available to develop personal, learning and thinking skills (PLTS) within a sector-related context. PLTS are identified in brackets after the unit pass criteria to which they are associated and they are also mapped in *Annexe C*. Further opportunities for learners to demonstrate these skills may also be apparent as learners progress throughout their learning.

Access and recruitment

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

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

Centres are required to recruit learners to BTEC qualifications with integrity. This will include ensuring that applicants have appropriate information and advice about the qualifications and that the qualification will meet their needs. Centres should take appropriate steps to assess each applicant's potential and make a professional judgement about their ability to successfully complete the programme of study and achieve the qualification. This assessment will need to take account of the support available to the learner within the centre during their programme of study and any specific support that might be necessary to allow the learner to access the assessment for the qualification. Centres should consult Edexcel's policy on learners with particular requirements.

Centres will need to review the entry profile of qualifications and/or experience held by applicants, considering whether this profile shows an ability to progress to a Level 2 qualification. For learners who have recently been in education, the profile is likely to include one of the following:

- a BTEC Level 1 qualification in engineering or a related vocational area
- a standard of literacy and numeracy supported by a general education equivalent to four GCSEs at grade D-G
- other related Level 1 qualifications
- related work experience.

More mature learners may present a more varied profile of achievement that is likely to include experience of paid and/or unpaid employment.

Restrictions on learner entry

Most BTEC First qualifications are accredited on the QCF for learners aged 14 years and over.

In particular sectors the restrictions on learner entry might also relate to any physical or legal barriers, for example people working in health, care or education are likely to be subject to police checks.

Edexcel BTEC Level 2 Firsts are listed on the DCSF funding lists Section 96 and Section 97.

Access arrangements and special considerations

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

Further details are given in the policy document *Access Arrangements and Special Considerations for BTEC and Edexcel NVQ Qualifications*, which can be found on the Edexcel website (www.edexcel.com). This policy replaces the previous Edexcel policy (Assessment of Vocationally Related Qualification: Regulations and Guidance Relating to Learners with Special Requirements, 2002) concerning learners with particular requirements.

Recognition of Prior Learning

Recognition of Prior Learning (RPL) is a method of assessment (leading to the award of credit) that considers whether a learner can demonstrate that they can meet the assessment requirements for a unit through knowledge, understanding or skills they already possess and so do not need to develop through a course of learning.

Edexcel encourages centres to recognise learners' previous achievements and experiences whether at work, home and at leisure, as well as in the classroom. RPL provides a route for the recognition of the achievements resulting from continuous learning.

RPL enables recognition of achievement from a range of activities using any valid assessment methodology. Provided that the assessment requirements of a given unit or qualification have been met, the use of RPL is acceptable for accrediting a unit, units or a whole qualification. Evidence of learning must be sufficient, reliable and valid.

Unit format

All units in Edexcel BTEC Level 2 First qualifications have a standard format. The unit format is designed to give guidance on the requirements of the qualification for learners, tutors, assessors and those responsible for monitoring national standards.

Each unit has the following sections.

Unit title

The unit title is accredited on the QCF and this form of words will appear on the learner's Notification of Performance (NOP).

QCF level

All units and qualifications within the QCF will have a level assigned to them, which represents the level of achievement. There are nine levels of achievement, from Entry Level to Level 8. The level of the unit has been informed by the QCF level descriptors and, where appropriate, the National Occupational Standards (NOS) and/or other sector/professional benchmarks.

Credit value

Each unit in BTEC National qualifications has a credit value; learners will be awarded credits for the successful completion of whole units.

A credit value specifies the number of credits that will be awarded to a learner who has achieved all the learning outcomes of the unit.

Guided learning hours

Guided learning hours are defined as all the times when a tutor, trainer or facilitator is present to give specific guidance towards the learning aim being studied on a programme. This definition includes lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. It also includes time spent by staff assessing learners' achievements. It does not include time spent by staff in day-to-day marking of assignments or homework where the learner is not present.

Aim and purpose

The aim provides a clear summary of the purpose of the unit and is a succinct statement that summarises the learning outcomes of the unit.

Unit introduction

The unit introduction gives the reader an appreciation of the unit in the vocational setting of the qualification, as well as highlighting the focus of the unit. It gives the reader a snapshot of the unit and the key knowledge, skills and understanding gained while studying the unit. The unit introduction also highlights any links to the appropriate vocational sector by describing how the unit relates to that sector.

Learning outcomes

Learning outcomes state exactly what a learner should 'know, understand or be able to do' as a result of completing the unit.

Unit content

The unit content identifies the breadth of knowledge, skills and understanding needed to design and deliver a programme of learning to achieve each of the learning outcomes. This is informed by the underpinning knowledge and understanding requirements of the related NOS. The content provides the range of subject material for the programme of learning and specifies the skills, knowledge and understanding required for achievement of the pass, merit and distinction grading criteria.

Each learning outcome is stated in full and then the key phrases or concepts related to that learning outcome are listed in italics followed by the subsequent range of related topics.

Relationship between content and assessment criteria

The learner must have the opportunity within the delivery of the unit to cover all of the unit content.

It is not a requirement of the unit specification that all of the content is assessed. However, the indicative content will need to be covered in a programme of learning in order for learners to be able to meet the standard determined in the assessment and grading criteria. The merit and distinction grading criteria enable the learner to achieve higher levels of performance in their acquisition of knowledge, understanding and skills.

Content structure and terminology

The information below shows the unit content is structured and gives the terminology used to explain the different components within the content.

- Learning outcome: this is shown in bold at the beginning of each section of content.
- Italicised sub-heading: it contains a key phrase or concept. This is content which must be covered in the delivery of the unit. Colons mark the end of an italicised sub-heading.
- Elements of content: the elements are in plain text and amplify the sub-heading. The elements must be covered in the delivery of the unit. Semi-colons mark the end of an element.
- Brackets contain amplification of elements of content which must be covered in the delivery of the unit.
- 'eg' is a list of examples, used for indicative amplification of an element (that is, the content specified in this amplification could be covered or could be replaced by other, similar material).

Assessment and grading grid

Each grading grid gives the assessment and grading criteria used to determine the evidence that each learner must produce in order to receive a pass, merit or distinction grade. It is important to note that the merit and distinction grading criteria require a qualitative improvement in a learner's evidence and not simply the production of more evidence at the same level.

Essential guidance for tutors

This section gives tutors additional guidance and amplification to aid understanding and a consistent level of delivery and assessment. It is divided into the following sections.

- *Delivery* – explains the content's relationship with the learning outcomes and offers guidance about possible approaches to delivery. This section is based on the more usual delivery modes but is not intended to rule out alternative approaches.
- *Outline learning plan* – the outline learning plan demonstrates has been included in every unit as guidance and demonstrates one way in planning the delivery and assessment of a unit. The outline learning plan can be used in conjunction with the programme of suggested assignments.
- *Assessment* – gives amplification about the nature and type of evidence that learners need to produce in order to pass the unit or achieve the higher grades. This section should be read in conjunction with the grading criteria.
- *Suggested programme of assignments* – the table shows how the suggested assignments match and cover the assessment grading criteria.
- *Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications* – sets out links with other units within the qualification. These links can be used to ensure that learners make connections between units, resulting in a coherent programme of learning. The links show opportunities for integration of learning, delivery and assessment.
- *Essential resources* – identifies any specialist resources needed to allow learners to generate the evidence required for each unit. The centre will be asked to ensure that any requirements are in place when it seeks approval from Edexcel to offer the qualification.
- *Employer engagement and vocational contexts* – gives a short list of agencies, networks and other useful contacts for employer engagement and for sources of vocational contexts.
- *Indicative reading for learners* – gives a list of learner resource material that benchmarks the level of study.

Units

Unit 1: Working Safely and Effectively in Engineering

Unit code: M/600/0377
QCF Level 2: BTEC First
Credit value: 5
Guided learning hours: 30

Aim and purpose

This unit aims to give learners an understanding of statutory regulations and organisational safety requirements to enable them to work safely, efficiently and effectively in engineering.

Unit introduction

The ability to work safely in an engineering environment is essential for the wellbeing of oneself and others. The aim of this unit is to deal with the essential working practices of engineering to ensure that learners appreciate potential hazards. This way, learners can enjoy all the challenges that an engineering profession can offer without undue fear for their own safety or for that of others.

The unit starts by considering how materials and equipment should be handled and the most appropriate personal protective equipment (for example eye or hand protection) to use when undertaking particular engineering activities. Learners will examine the hazards and risks associated with an engineering activity including the working environment (for example working at height), the use of tools and equipment and working with materials and substances that may cause harm. A key focus of the unit is learners acquiring an awareness of the dangers of not working within appropriate legislation and procedures. In the event of an incident, it is essential that learners know how to respond. The unit will take learners through typical incidents that they may have to deal with at some point in their career (for example contacting the first aider, sounding alarms, stopping machinery).

The unit will enable learners to develop the skills and understanding required to carry out a range of engineering tasks. Because most work in engineering requires the cooperation of others, the unit also develops the skill of maintaining good working relationships with colleagues and other relevant people who will support learners in their tasks.

The unit is an essential tool kit for learners entering an engineering environment. The skills and knowledge gained through studying this unit will be put to good use in other areas of study and everyday working life.

Learning outcomes

On completion of this unit a learner should:

1 Be able to apply statutory regulations and organisational safety requirements

2 Be able to work efficiently and effectively in engineering.

Unit content

1 Be able to apply statutory regulations and organisational safety requirements

Materials and equipment handling: own and others' roles and responsibilities eg under the Health and Safety at Work Act 1974 and other current and relevant legislation applicable to the working environment, management of health and safety at work regulations, workplace health and safety and welfare regulations, personal and protective equipment at work regulations, manual handling operations regulations; identification of warning signs for the seven main groups of hazardous substances eg defined by classification, packaging and labelling of dangerous substances regulations; sources of information and guidance within an organisation; using equipment safely eg mechanical, electrical, fluid power equipment; lifting and carrying techniques; housekeeping eg tidy workspace, protecting others from harm eg as a result of work being carried out by self or others

Personal protective equipment (PPE): appropriate to task undertaken eg overalls, protective footwear, eye protection, masks/respirators

Hazards and risks: working environment eg working at height, electricity, confined spaces, hot work; tools and equipment; materials and substances; dangers of not working to laid down procedures

Emergency procedures: engineering workshop incidents (accident/injury, work hazards, fire); identification of appropriate qualified persons eg first aider, fire warden; actions in the event of an accident or emergency eg use of fire extinguishers (types and applications), types and sounding/initiating emergency alarm, evacuation procedure and escape routes; reporting routines eg at assembly point, hazards and malfunctions, injury, near miss occurrences

2 Be able to work efficiently and effectively in engineering

Engineering work activity: types of activity eg commissioning/installing equipment or systems, machining/manufacturing a product or component, servicing/maintenance of plant or equipment, construction/testing of circuits etc; prepare work environment eg area free from hazards, safety procedures implemented, PPE and tools obtained and checked (safe and usable condition); prepare for activity eg all necessary drawings, specifications, job instructions, materials/components obtained, storage arrangements for work, authorisation to carry out work; complete work activity eg complete all tasks and documentation, return drawings/work instructions and tools, dispose of unusable tools, equipment, components and waste materials (oil, soiled rags, swarf/off cuts)

Working relationships: contributing to organisational issues eg improvements in work practices/methods, quality, safety, customer service, internal communications, teamwork; dealing with problems affecting engineering processes eg access to materials/tools/equipment/drawings/job specifications, quality, people; working with others eg colleagues (familiar and unfamiliar), management/supervisor, external (customers/suppliers/contractors)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	handle materials and equipment in an engineering workplace in a safe and approved manner [SM4]	**M1**	carry out a risk assessment on an engineering workplace to make recommendations on the safety of materials and equipment handling, use of personal protective equipment and the potential hazards in the area	**D1**	prepare a safety policy for an engineering work area including references to relevant legislation
P2	select and use appropriate personal protective equipment when undertaking a given engineering activity	**M2**	make recommendations for improvement of an organisation's emergency procedure	**D2**	identify strengths and areas for improvement in a working relationship.
P3	identify hazards and risks associated with an engineering activity [IE3, EP2, EP4]	**M3**	identify how a work activity could be improved.		
P4	describe the emergency procedures to be followed in response to a given incident in an engineering workplace				
P5	prepare for and carry out an engineering work activity [SM2, SM3]				
P6	maintain good working relationships with colleagues and other relevant people when carrying out an engineering work activity. [TW1]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using lectures, tutor demonstrations and practical engineering activities. During the delivery of the unit, centres must ensure sufficient coverage of the learning outcomes and content. Examples are given in the content to give centres an idea of the typical range of areas that might be covered. For example, in the section on emergency procedures, it suggests 'the identification of appropriate qualified persons eg first aider, fire warden'. For assessment purposes, one of these would be sufficient. However, when preparing the delivery strategy it is expected that learners will be provided with the skills to identify the appropriately qualified person(s) for both injuries and fire.

It would not be appropriate for this unit to be taught without any practical application. For example, identifying hazards and the risks associated with an engineering activity from an image (eg drawing, sketch, photograph) does not have the same value that real practical experience in a working environment can bring. Centres are encouraged to find innovative ways of bringing the unit to life, giving it true relevance for the learner. This will generally be achieved through the use of practical, hands-on experience, which can be achieved during workshop activities or through actual workplace experience.

Delivery of the engineering work activity will require access to an engineering workshop environment and relevant tools and equipment. Learners could be provided with a range of simple engineering tasks that will enable them to practise their skills and during which support and guidance can be given. Each task should be designed so that it requires the learners to prepare the work environment, prepare for the activity and then complete the work activity. The opportunity to work with individuals during the delivery of this practical work can be used to good effect to underpin learning. In particular, it can be used to reinforce working practices/skills, help them to deal with problems affecting engineering processes or support them when they need to work with others more effectively in order to achieve the task.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • health and safety induction, college tour including workshops • to introduce the Health and Safety at Work Act and other current and relevant legislation to include management of health and safety at work regulations, workplace health and safety and welfare regulations • explain the responsibilities, under the Health and Safety at Work Act and other current and relevant legislation, of employees and employers. Group activity: • investigate the Health and Safety at Work Act 1974 and identify duties under sections 2, 3 and 7. Whole-class teaching: • explain the importance of adherence to approved working practices, personal hygiene and reporting of injuries.
Whole-class teaching: • introduction to materials and equipment handling • explain sources of safety information and guidance within an organisation, consider manual handling regulations and demonstrate lifting and carrying techniques. Group activity: • examine COSHH regulations and identify warning signs for the seven main groups of hazardous substances. Practical workshop activity/tutor demonstration: • safe use of equipment and importance of good housekeeping • materials and equipment handling techniques • positions and use of electrical isolation switches and cut-outs.
Whole-class teaching: • introduction to personal protective equipment (PPE) • explain the requirements of the PPE at work regulations and consider personal and protective equipment appropriate to a range of engineering tasks. Practical workshop activity/tutor demonstration: • use of PPE to include overalls, protective footwear, eye protection, masks/respirators • learners select most appropriate PPE for given engineering tasks Whole-class teaching: • explain the hazards associated with the working environment, the dangers of working at height and in confined spaces including permit to work procedures and electrical isolation. Practical workshop activity: • learners carry out a hazard identification and risk assessment. Whole-class teaching: • explain the dangers of not working to laid down procedures.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the emergency procedures as a result of engineering workshop incidents including types of fire extinguisher and their uses, incident reporting routines, identification of appropriate qualified persons. Practical workshop activity/tutor demonstration: • identification and safe operation of fire fighting equipment • alarms and evacuation procedures • identification and location of warning signs and notices.
Prepare for and carry out Assignment 1 (P1, P2, P3, P5, M1, M3 and D1).
Whole-class teaching: • explain the importance of preparation for work activities, including: • environment, relevant safety procedures and equipment requirements • preparation requirements and documentation for work activity • authorisation, drawings, specifications, job instructions • materials and components. Practical workshop activity: • obtain all necessary drawings and equipment to carry out selected work activity.
Whole-class teaching: • explain how working relationships contribute to improvements in work practices, quality and safety • describe the importance of good working relationships, communication and team work • explain the importance of maintaining good customer relationships and internal communications. Group activity: • identify problems affecting engineering process and suggest solutions.
Practical workshop activity: • learners to have access to workshops and machinery to carry out engineering work activities (continued). Tutor demonstration: • quality inspection methods. Group activity: • discussion on work practice improvements.
Prepare for and carry out Assignment 2 (P4, P6, M2 and D2).
Feedback on assessment, unit evaluation and close.

Assessment

Much of the assessment evidence for this unit could come from practical activities. These can be carried out solely for the purpose of this unit but, equally, could be the activities associated with other units or from work-based evidence.

To achieve the pass grade, the materials and equipment handling criterion (P1) may require a combined approach with the use of testing for roles and responsibilities plus the identification of the seven main groups of hazardous substance warning signs. In addition, practical applications of using equipment safely, lifting and carrying techniques and housekeeping are necessary to achieve the criterion and these could be assessed through tutor/witness observation. A similar approach of written work and practical activities could be applied to the remaining criteria but, in the main, they are more practical.

Centres will need to consider how to support the process evidence (eg tutor/witness observation, oral questioning) with product evidence. For example, the use of a task sheet/logbook/diary in which the learner can note the PPE they have selected for the engineering task undertaken and the identification of the hazards and risks associated with that task. It would then be possible for the tutor, through observation and/or oral questioning, to easily verify this product evidence. Simulation may be appropriate in some cases to cover the range of content (eg emergency procedures – reporting routines) as these things may not always occur naturally and even if they did, assessment would not be the highest priority at the time!

To achieve a merit, learners are required to be more proactive in their approach to their working environment and work task. The criteria require them to think through the consequences of possible situations or actions. The risk assessment criterion (M1) could be achieved through either an inspection of part of the centre's workshops or through work-based evidence. The important aspect of the evidence is the learner's ability to make recommendations based on their practical experiences, the safety of materials and equipment handling, the use of personal protective equipment and the potential hazards in a new and possibly, but not necessarily, unfamiliar area (eg the activity to cover P2, P3 and P5 was a fitting task but M1 is carried out in a machine shop area). Again, the second criterion (M2) is about the learner's ability to move from an understanding of how they should respond to thinking about whether that response could be improved. This could be achieved either in practice using an actual organisation's procedures or through simulation. Either way, centres must ensure that the emergency procedure to be considered does have opportunities for the learner to identify improvement. Evidence containing a negative response to this criterion (eg no improvements could be found) would not be acceptable. With the final merit criterion, a similar approach to M2 is required. Either an actual task that has/is being undertaken or a simulated work activity should be used that can be evaluated by the learner to identify how it could be improved.

To achieve a distinction, the learner must prepare a safety policy for an engineering work area including references to relevant legislation (D1). It should be noted that this is only for a work area and not an organisation as a whole. The final distinction criterion (D2), requires the learner to examine a working relationship to identify strengths and areas for improvement. This criterion is about the learner's ability to reflect on how they (the learner) interact within the organisation and with their colleagues in the organisation. It will be important to keep the learner focused in this task, and the content for P6 should be the starting point for this. For example, what are the strengths and areas for improvement that establish trust and support when contributing to organisational issues, etc? Actual experience of working with others is considered the best approach but simulation or case studies can also be considered if necessary.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P5, M1, M3, D1	Preparing for and Carrying out an Engineering Activity	A practical activity requiring learners to prepare for and carry out a selected engineering work activity.	Tutor observation record of materials handled and equipment used safely plus PPE selected and used. A report containing a description of the activity undertaken and a record of the PPE requirements and the hazards and risks associated with the activity. Tutor observation record of the preparation for and completed task. A report of the risk assessment undertaken and identification of how work activity can be improved. A safety policy for the engineering work area with references back to relevant legislation.
P4, P6, M2, D2	Emergency Procedures and Working Relationships	A written activity requiring learners to identify emergency procedures in response to a given engineering activity. An activity requiring learners to investigate factors leading to good working relationships.	A report containing written responses identification of appropriate qualified persons, actions to be taken and reporting routines required for a given incident during an engineering activity. A report making recommendations for improvements in an emergency procedure. A written report evaluating working relationships and identifying factors that lead to and maintain good working relationships.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Engineering Maintenance Procedures	Health and Safety in the Engineering Workplace
	Preparing and Controlling Engineering Manufacturing Operations	
	Engineering Assembly Methods and Techniques	
	Operation and Maintenance of Mechanical Systems and Components	
	Operation and Maintenance of Electrical Systems and Components	
	Operation and Maintenance of Electronic Systems and Components	
	Selecting and Using Secondary Machining Techniques to Remove Material	
	Application of Welding Processes	
	Fabrication Techniques and Sheet Metal Work	
	Electronic Circuit Construction	
	Using Specialist Secondary Machining Techniques	

This unit covers some of the knowledge and understanding associated with Unit 1: Complying with Statutory Regulations and Organisational Safety Requirements and Unit 3: Working Efficiently and Effectively in Engineering from the Level 2 SEMTA National Occupational Standards units.

It also contributes towards the 2008 Level 3 SEMTA National Occupational Standards Unit 3: Carrying Out Engineering Activities Efficiently and Effectively and the Level 2 NVQ in Performing Engineering Operations Unit 1: Working Safely in an Engineering Environment.

Essential resources

Access to a workshop environment and the range of tools required to carry out engineering work activities will be essential. Learners will also need access to relevant legislation applicable to the working environment, emergency procedures and policies.

It is also essential that learners have access to computers and the internet to enable them to access current legislation and regulations as required.

Employer engagement and vocational contexts

The use of vocational context is essential in the delivery and assessment of this unit. Learners will require access to workshops equipped with modern machines and equipment to enable them to gain a practical awareness and enable them to apply their knowledge and understanding in a practical situation.

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

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

Indicative reading for learners

Textbooks

Boyce A, Clarke S, Darbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book* (Pearson, 2010) ISBN 9781846907234

Boyce A, Clarke S, Darbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907258

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

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

Website

www.hse.org – health and safety executive

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	exploring hazards and risks associated with an engineering activity from different perspectives
Self-managers	anticipating, taking and managing risks when handling materials and equipment in an engineering workplace in a safe and approved manner working towards an engineering work activity showing initiative, commitment and perseverance organising time, resources and prioritising actions to prepare for and carry out an engineering work activity
Effective participators	presenting an effective case for action when identifying hazards and risks associated with an engineering activity. identifying improvements that benefit others as well as themselves when avoiding the hazards and risks associated with an engineering activity
Team workers	collaborating with others when carrying out an engineering work activity.

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

Skill	When learners are …
Effective participators	discussing issues of concern with respect to relevant health and safety legislation seeking resolution with colleagues/tutor where needed
Reflective learners	reviewing progress during practical activities and acting on the outcomes
Creative thinkers	questioning their own and others' ideas during group work activities on the assessment of hazards and risks.

Functional Skills – Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking and listening to colleagues and others when carrying out an engineering work activity
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading current safety legislation to select the information required enabling the learners to complete tasks safely reading information to enable identification of warning signs and emergency procedures
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing a report to describe the emergency procedures to be followed in response to a given incident.

Unit 2: Interpreting and Using Engineering Information

Unit code: T/600/0378

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit aims to give learners the knowledge and skills needed to use engineering information such as drawings and working instructions to carry out manufacturing or engineering process operations.

Unit introduction

The ability to access and use information is probably one of the most critical skills required in engineering. This unit will enable learners to understand how to make effective use of textual, numeric and graphical information when working with engineering drawings, technical manuals, reference tables, specifications, charts or electronic displays, in accordance with approved procedures. Learners will consider how best to extract information from engineering drawings and related documents and also how to use drawings and related documentation to establish the work that needs to be done, carry out the work requirements and check their own work output.

A good, well-documented product, is generally more useful and more successful than an excellent product that has been poorly documented. But simply creating engineering drawings and recording engineering data is insufficient. To be useful, engineering drawings and related documentation must be stored, reviewed and approved, published and maintained. Document control for engineering drawings comprises document attributes as well as a clearly defined control process.

This unit will enable learners to identify, work within and comply with appropriate organisational policies and procedures for obtaining and using the documentation that applies to given activities. It is expected that learners will be able do this with minimum supervision, taking responsibility for their own actions and the quality and accuracy of the work that they undertake.

The first learning outcome takes the learner through the steps required to extract information from a range of given sources to enable specified tasks to be carried out. The second learning outcome requires that the learner makes use of the information from the view of their own activity/work output, identifying the information required to enable them to both carry out and check their own work. This second learning outcome also requires the learner to consider the care, control and security of information.

The unit can be delivered and assessed in a range of engineering settings and disciplines depending upon the learner's circumstances. However, it is important that the information used by the learner is relevant, realistic and current for a typical engineering context.

Learning outcomes

On completion of this unit a learner should:

1 Know how to interpret drawings and related documentation

2 Be able to use information from drawings and related documentation.

Unit content

1 Know how to interpret drawings and related documentation

Information: materials or components eg location/orientation of parts, connections to be made, circuit characteristics (pressure, flow, current, voltage, speed); dimensional detail eg imperial and metric systems of measurement, physical dimensions, tolerances, fixed reference points, surface texture; manufacturing/production detail eg processes or treatments, assembly sequence or installation requirements; symbols and abbreviations eg surface finish, electronic components, weld symbols, linear and geometric tolerances, pressure and flow characteristics, torque values

Engineering drawings: working drawings eg component, general assembly/sub-assembly, fabrication, welding, repair/modification, fluid power, installation, wiring/circuit diagrams; graphical representations eg sketches, schematic diagrams, flow charts, physical layout diagrams, illustrations from manufacturers' manuals

Related documentation: working instructions eg operation sheets/job cards, test schedules, manufacturers' manuals for assembly/test/installation, weld procedure specifications; quality control information eg national, international and organisational standards, reference tables/charts

Tasks: relevant to a manufacturing or engineering process operation eg product manufacture or modification, equipment installation or repair, system or service planning

Other information: sources relevant to task eg electronic component pin configuration specifications, standard reference charts for limits and fits, tapping drill reference charts, bend allowances required for material thickness, metal specifications, manufacturers' data for the use of welding rods/bonding/finishing materials

2 Be able to use information from drawings and related documentation

Work output: manufacturing or engineering process operation eg product manufacture/assembly/design, maintenance planning or procedure

Production documentation: relevant to manufacturing or process operation eg job cards, test reports, quality control documentation

Drawing and document care and control: location and security eg storage conditions, access points and return procedures, reporting discrepancies in data and documents; physical handling eg damage and effects from graffiti, cleanliness, folding methods; document control eg issue and amendment dates, part/pattern numbers, reporting of loss/damage

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 extract information from engineering drawings and related documentation to enable a given task to be carried out [IE4]	**M1** identify gaps or deficiencies in the information obtained that need to be resolved to enable a given task to be carried out	**D1** justify valid solutions to meet identified gaps or deficiencies with the information obtained.
P2 select and use other information sources to support and check information provided [IE4]	**M2** identify improvements in the care and control procedures used for drawings and related documentation.	
P3 identify and obtain relevant drawings and related documentation to carry out and check own work output [IE4]		
P4 complete all necessary production documentation related to own work output		
P5 describe the care and control procedures for the drawings and related documentation used when carrying out and checking own work output.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should provide learners with a formal introduction to the selection and use of a range of engineering information sources such as drawings and related documentation. It is intended that the unit should be delivered in the order of the learning outcomes. That is, to first introduce the learner to the typical range of information required to carry out specific tasks, the way that engineering drawings are produced and used, and the information that they can convey and other related documentation. Second, to use this understanding of the range of information available and apply it to specific engineering tasks.

The setting of this unit will be determined in part by the focus of the qualification (for example operations and maintenance, mechanical/manufacture, electronic engineering) but also the particular needs of the local industries that centres work with. The relevance of the unit may be significantly enhanced through the centre's ability to link with these local industries to obtain working examples of engineering data and documentation.

As far as possible, centres should deliver the unit through practical application rather than theory and to achieve this the unit can be linked effectively with other practical units (eg *Unit 5: Engineering Maintenance Procedures and Planning*, *Unit 9: Engineering Assembly Techniques*, *Unit 19: Electronic Circuit Construction and Testing*). The practical activities undertaken in these units could then provide a focus for the 'interpretation' required by learning outcome 1 and the context for the learner's 'own work output' related skills of learning outcome 2.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to the unit content, method of working and assessment • introduction to the use of engineering drawings and related documentation • explain the methods and range of use of engineering drawings and related documentation in manufacturing and process operations. Group work: • activities to examine examples of different types of engineering drawing and related documentation.
Whole-class teaching: • introduction to interpretation of engineering drawings. Consider the style and presentation of drawings and graphical representations and the information that they convey. Group work: • activities to investigate given engineering drawings and present findings.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to engineering documentation. Consider the documentation used for working instructions and quality control information. Group work: • activities to investigate the documentation used to support and control given manufacturing and engineering process operations.
Preparation for and carry out assignment 1 (P1, P2, M1 and D1).
Whole-class teaching: • introduction to the use of drawings and related documentation to carry out and check own work • whole-class teaching – use of production drawings and associated documentation. Group work: • investigation of manufacturing case study. Presentation of findings to the group. Industry visit or guest speaker: • to gain first-hand experience of production drawings and associated documentation in use.
Whole-class teaching: • introduction drawing and document care and control. Explore methods used for the location and security of drawings and related documentation, physical handling of drawing and impact of damage/loss and document control techniques. Group work: • investigation of drawing and document control case studies. Presentation of findings to the group. Industry visit or guest teacher: • gain first-hand experience of drawing and document control. Group work: • carry out simple engineering tasks using drawings and related documentation and following document control procedures.
Preparation for and carry out assignment 2 (P3, P4, P5 and M2).
Feedback on assessment, unit evaluation and close.

Assessment

The assessment and grading criteria of this unit are all closely linked and as such, the summative assessment of the unit could possibly be achieved through one 'project style' activity. However, a staged approach could also be adopted using two assignments. The first assignment could consider the interpretation of engineering drawings and related documentation for learning outcome 1 (covering P1, P2, M1 and D1). The assignment would involve the extraction of information from the engineering drawings as well as the production of notes, annotation and sketches identifying specific features extracted from drawings and associated documentation. In addition, the learner would need to make relevant references to other information sources. It may be appropriate to use tutor observation and/or oral questioning to capture this evidence of the use of other information sources to ensure authenticity.

The second assignment, covering P3, P4, P5 and M2, could be based around a specified task that enables the learner to use information from drawings and related documentation to carry out the task and check their own work output. It will be necessary to have a sample of the learners own work output together with associated drawings, specifications and other documentation.

Whichever approach is used, single project or two assignments, it is important that the activities provide sufficient scope to cover the depth and breadth defined by the content.

To achieve a merit grade, the learner will need to identify gaps or deficiencies in the information obtained and which need to be resolved to enable a given task to be carried out. Learners will also need to identify improvements in the drawings and related documentation care and control procedures used. Centres will need to consider how best to prepare the learner for these two criteria. Both are strongly linked to the skills at pass level but they require the learner to be able to apply a higher level of analysis and evaluation. Activities chosen for summative assessment will need to be carefully chosen to provide suitable opportunities for these two criteria to be achieved. For example, important dimensions not provided in drawings, components missed-off or additional to the drawing's parts list information, incorrect parts given, damaged/poor quality/graffiti-covered drawings or data books, or out-of-date information provided. The delivery methods used by the centre and, in particular, formative assessment can help in the development of these merit-level skills.

To achieve a distinction grade, the learner needs to demonstrate the ability to justify valid solutions to meet identified gaps or deficiencies with the information obtained. This will be reflected by the learner's ability to work with limited supervision and solve problems independently. The assessment activities will need to have these opportunities built into them to be effective in the same way as the merit criteria, as it would be wrong for centres to leave this to chance.

It is likely that the assessments will need to be carried out under controlled conditions and adequate time should be allowed for this within the learning programme. Tutors will also need to ensure that learners can access all of the relevant information required. Such information might consist of a library of drawings and other diagrams, specifications, manuals, job cards and other production documentation as appropriate to the context. Computer-based information sources and a technical library should be made available to learners as well as relevant standards available from BSI.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Engineering Drawings and Documentation	An activity requiring learners to investigate, select, use, and extract information from a range of engineering drawings and related information.	A report containing written responses about the information extracted from engineering drawings and related documentation to enable a manufacturing or engineering process operation to be carried out. Tutor observation record of the learner's use of sources relevant to the task. Report to include specific mention of any gaps or deficiencies in the information clearly indicating how these problems were resolved in order to carry out the task.
P3, P4, P5, M2	Using Engineering Information	An activity requiring learners to identify, obtain and make appropriate use of relevant drawings and documentation in order to check their own work output, completing all of the associated production documentation and observing appropriate care and control procedures.	A report containing written responses about the manufacturing or engineering process operation undertaken together with completed production documentation and a description of the documentation care and control procedures. Report identifying any improvements that could be made to the procedures.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Engineering Maintenance Procedures	Engineering Project
	Engineering Assembly Methods and Techniques	Engineering Design
	Using Computer Aided Drawing Techniques in Engineering	Engineering Drawing for Technicians
	Electronic Circuit Construction	Computer Aided Drafting in Engineering

The also unit supports aspects of the SEMTA Level 2 National Occupational Standards, particularly Unit 2: Using and Interpreting Engineering Data and Documentation and Unit 3: Using and Communicating Technical Information from the Level 2 NVQ in Performing Engineering Operations.

Essential resources

Learners will need access to sources of information (eg drawings, charts, tables, manuals) as defined by the content section. Wherever possible, centres should ensure that this data is relevant to the learner's current or expected work-based experience. Centres will need to have their own drawing/document storage facilities as an example of a typical care and control process for drawings and related documentation.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Case studies should be drawn from an appropriate range of different engineering contexts. For example, drawings and related documentation should not be restricted to a particular production sector and wherever possible learners should, as a minimum, be introduced to materials that support production in a range of different sectors including mechanical components and assemblies, electrical/electronic components and assemblies as well as hydraulic/pneumatic components and systems. In addition, both learning outcomes can be enhanced by industry visits and visiting speakers that can bring the subject to life by providing sector specific examples of the use and interpretation of engineering information.

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

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

Indicative reading for learners

Textbooks

Boyce A, Clarke S, Darbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book* (Pearson, 2010) ISBN 9781846907234

Boyce A, Clarke S, Darbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907258

Barclay J and Griffiths B – *Engineering Drawing for Manufacture* (Butterworth Heinemann, 2002) ISBN 9781857180336

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

Websites

British Standards and associated publications – www.standardsuk.com

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

The American Society for Engineering Education – www.asee.org

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information from engineering drawings, related documentation and other sources of information to judge its relevance for carrying out a given task analysing and evaluating information from relevant drawings and related documentation to judge its value when carry out and checking own work output.

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

Skill	When learners are …
Reflective learners	evaluating their experiences and learning so that they can describe the care and control procedures for the drawings and related documentation used when carrying out and checking own work output
Self-managers	working towards goals, showing initiative, commitment and perseverance when carrying out and checking own work
Team work	collaborating with others in group work to extract information from drawing and other sources.

Functional Skills – Level 2

Skill	When learners are …
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	extracting information from engineering drawings, related documentation and other sources to enable a given task to be carried out
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	accessing, selecting and using other information sources, that are considered fit for purpose, to support and check information provided
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading engineering drawings, related documentation and other sources to gather sufficient information to enable a given task to be carried out reading relevant drawings and related documentation to gather information to carry out and check own work output
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing about the care and control procedures for the drawings and related documentation used to carry out and check own work output.

Unit 3: Mathematics for Engineering Technicians

Unit code: K/600/0409

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit gives learners the underpinning knowledge and opportunity to solve engineering problems using mathematical techniques.

Unit introduction

One of the main functions of an engineer is to solve problems, many of which require the use of mathematical formulae and equations. This unit is designed to provide learners with the skills and knowledge to solve such problems. Many of the scientific principles and concepts such as Ohm's Law and Newton's Laws of motion can all be expressed in the form of an algebraic equation such as $V = IR$ and $F = ma$.

The unit will help learners to work with equations and manipulate them when required. For example, when using Ohm's Law to find the value of voltage (V) when given the values of current (I) and resistance (R). More importantly to find the value of I given values of V and R requires the equation to be transposed.

Another aspect of engineering problems is how one quantity varies in relation to another. For example, what happens to the current in a circuit if the voltage changes; how does the distance of a moving object vary with time? These problems can often be visualised by first plotting a graph of the relationships and then interpreting the graph to find the solution to the question. The unit will provide understanding of how to draw graphs and then use them to solve linear and non-linear problems.

Mensuration is another important tool, with engineers often required to determine areas of regular and compound shapes together with volumes of regular and compound solid bodies, for instance, when evaluating costs and quantities of material needed for particular projects.

Finally, trigonometry is covered in the unit, another powerful problem-solving tool for the engineer used to solve problems such as the resolution of forces.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use arithmetic, algebraic and graphical methods to solve engineering problems

2 Be able to use mensuration and trigonometry to solve engineering problems.

Unit content

1 Be able to use arithmetic, algebraic and graphical methods to solve engineering problems

Arithmetic methods: addition, subtraction, multiplication and division of whole and decimal numbers; ratio eg scales of drawings and maps; proportion eg stress/strain; percentage eg accuracy of ammeter/voltmeter reading; use of the brackets, order, division, multiplication, addition, subtraction (BODMAS) rule; powers and roots of a number; expressing numbers using standard form and scientific notation eg 5.6×10^{5}, 12×10^3W and 12kW; ensure answers to numerical problems are reasonable eg approximations, significant figures, decimal places

Algebraic methods: transpose and evaluate simple equations including bracketed terms, roots and powers eg $V = IR$, $P = VI$, $pV = c$, $v = u + at$, $s = ½(u + v)t$, $P = I^2R$; complex formulae eg $s = ut + ½at^2$, $v^2 = u^2 + 2as$, $V=V_0 \text{Sin}2\pi \text{ ft}$, $X_c = 1/2\pi fC$; combining formulae eg $½mv^2 = mgh$ find v, $½QV = ½CV^2$ find V

Graphical methods: plot linear relationships eg determining gradient, intercept, distance travelled, linear acceleration, work done; plot and use non-linear relationships eg inverse relationships, exponential growth and decay; basic principles (including scales, axes, straight line graphs, construction and plotting of curves from given data)

2 Be able to use mensuration and trigonometry to solve engineering problems

Area: areas of regular shapes eg squares, rectangles, triangles, circles; area of compound shapes eg L-shapes, parallelograms

Volume: regular solid bodies eg right rectangular prisms, cylinders, cones, spheres; compound solid bodies eg truncated prisms, cylinders with spherical ends

Trigonometry: Pythagoras' theorem; acute angle ratios; sine, cosine, tangent ratios; $\text{Sin}\theta/\text{Cos}\theta = \text{Tan}\theta$ relationship to solve right angle triangle problems, triangles within a compound area or volume; complex shape eg a combined rectangle and triangle or pyramid; use trigonometry to solve unknown dimensions

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	use arithmetic methods to evaluate two engineering problems ensuring answers are reasonable [IE4]	**M1**	transpose and evaluate complex formulae	**D1**	transpose and evaluate combined formulae
P2	use algebraic methods to transpose and evaluate simple formulae [IE4]	**M2**	identify the data required and determine the area of two compound shapes	**D2**	carry out chained calculations using an electronic calculator.
P3	plot a graph for linear and non-linear relationships from given data	**M3**	identify the data required and determine the volume of two compound solid bodies		
P4	determine the area of two regular shapes from given data	**M4**	use trigonometry to solve complex shapes.		
P5	determine the volume of two regular solid bodies from given data [IE4]				
P6	solve right-angled triangles for angles and lengths of sides using basic Pythagoras' theorem, sine, cosine and tangent functions.				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

It is probable that the group will contain learners from a number of engineering disciplines, such as electrical, mechanical etc. It is important that delivery of the content is placed within an appropriate context to meet the individual needs of each learner.

Delivery of the unit would be best completed in the order of the two learning outcomes but it may be necessary to mix and match to coincide with theoretical concepts being considered in Unit 3. One way to deliver this unit is to provide a new problem, which will be of interest to learners at each session and encourage them in finding the solution. For example, how to design a 30 second timer circuit for an alarm using a 5 kilohm resistor and the equation $L = CR$. Learners should then be able to appreciate the value of the mathematical technique and realise that there is a real purpose to it and not just mathematics for mathematics sake.

Throughout the delivery of the unit learners should be encouraged to make full use of an electronic scientific calculator. They should be made familiar with the basic functions eg add, subtract, multiply and divide whole numbers and decimal fractions. At the appropriate stage learners should be able to use the special function keys in order to determine sine, cosine, tangent ratios, powers, roots; enter and read numbers in standard form and scientific notation eg 5.6×10^5, 12×10^3W and 12kW. Finally, when accurately evaluating equations such as $V = \sqrt{(n^2 + 2as)}$ or similar, learners should be taught how to use their calculator in one continuous calculation.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area of topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to the unit content, scheme of work and assessment strategy • tutor-led revision of manual procedures for addition, subtraction, multiplication, division and calculation of ratio, proportion and percentage • explain and apply BODMAS rule. Individual learner activity: • exercises in arithmetical calculation • exercises in use of electronic scientific calculator.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain powers and roots of a number and the rules of indices followed by explanation of how to express numbers in standard form and scientific notation • explain approximating answers and expressing numbers of significant figures/decimal places • tutor demonstration of use of electronic scientific calculator for basic functions and special function keys eg EXP and ENG • explain direct proportional and linear relationships followed by how to choose suitable scales and plot graphs from given data • tutor demonstration of calculation of the gradient explaining the significance of both the gradient and intercept in the formation of the equation for a linear graph • tutor demonstration of the calculation of the area under a graph and its significance in practical applications eg velocity-time graph, voltage-current graph. Individual learner activity: • exercises in plotting linear graphs. Whole-class teaching: • describe and discuss typical inversely proportional relationships • explain exponential growth and decay, its occurrence and lead learners in choosing suitable scales and plotting graphs from given data. Individual learner activity: • exercises in plotting non-linear graphs.
Prepare for and carry out assignment 1 (P1, P3).
Whole-class teaching: • explain application of transposition and evaluation of simple formulae. Individual learner activity: • exercises in transposition and evaluation of simple formulae. Whole-class teaching: • explain and discuss transposition rules and procedures for more complex formulae • tutor demonstration of transposition and evaluation of complex and combined formulae involving powers and roots. Individual learner activity: • exercises in transposition and evaluation of formulae.
Prepare for and carry out assignment 2 (P2, D1, D2).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain and demonstrate the use of standard formulae; for calculation of area of squares, rectangles, and triangles • explain and demonstrate the use of standard formulae in terms of radius and diameter for the calculation of area of circles • explain and demonstrate calculation of area of compound shapes. Individual learner activity: • exercise in calculation of areas. Whole-class teaching: • explain and demonstrate the use of standard formulae for calculation of volume. Individual learner activity: • exercises in calculation of volumes. Whole-class teaching: • explain and demonstrate the use of standard formulae for calculation of volume of compound solid bodies. Individual learner activity: • exercises in calculation of volumes of compound solid bodies.
Prepare for and carry out assignment 3 (P4, P5, M2, M3).
Whole-class teaching: • explain and demonstrate use of Pythagoras' theorem in solution of right angle triangles. Define tangent of an acute angle and explain use of TAN and TAN^{-1} function key on electronic calculators • tutor demonstration of determination of acute angles in given right angle triangles and calculation of opposite and adjacent sides to an acute angle in given right angle triangles. Individual learner activity: • exercises involving solution of right angle triangles. Whole-class teaching: • define sine and cosine of an acute angle and explain use of SIN, SIN^{-1}, COS and COS^{-1} function keys on electronic calculators. Tutor demonstration showing determination of acute angles in given right angle triangles and solution of right angle triangles using appropriate trigonometrical ratio and Pythagoras' theorem. Individual learner activity: • exercises involving solution of right angle triangles. Whole-class teaching: • prove the relationship $SIN\theta / COS\theta = TAN\theta$ and demonstrate calculation of dimensions within complex shapes containing right angle triangles. Individual learner activity: • exercises involving calculation of dimensions.
Prepare for and carry out assignment 4 (P6).
Feedback on all assessment tasks, guidance on remedial action if necessary. Unit evaluation and close.

Assessment

The assessment strategy applied will need to cover all the learning outcomes and associated pass criteria but not necessarily all the topics included in the content.

For P1 there must be evidence that learners can use arithmetic methods to evaluate two engineering problems and ensure that the answers are reasonable.

P2 requires learners to provide evidence that they can evaluate formulae (eg find the value for V given values for I and R for the equation $V=IR$) and transpose and evaluate formulae (eg find the value for t given values for v, u and a, and the formula $v=u+at$).

P3 can be assessed by using data to plot a graph of a linear relationship (eg results from an Ohm's law experiment or a velocity-time relationship. Learners must then provide evidence that they can plot a graph of a non-linear relationship (eg results from a Boyle's law experiment).

For P4, learners must provide evidence of being able to calculate the area of at least two irregular shapes.

P5 requires learners to provide evidence of calculating the volume of at least two regular solid bodies.

P6 requires learners to provide evidence of solutions to right-angled triangle problems that include the use of Pythagoras' theorem (eg find the length of the hypotenuse given the length of the other two sides) and the sine, cosine and tangent relationships (eg find the length of the hypotenuse and opposite sides, given the value of the angle and the length of the adjacent side) and find the values of angles within the triangle.

The following merit criteria are intended to further develop the learner's skills.;

For M1 learners must transpose and evaluate complex formulae (eg find a value for a, given values for s, u and t and the formula $s = ut + \frac{1}{2}at^2$).

M2 requires learners to provide evidence of calculating the area of at least two compound shapes. The learner should be able to identify the data required to perform the calculation (eg from a drawing).

For M3 learners must provide evidence of calculating the volume of at least two solid bodies. Learners should be able to identify the data required to perform the calculation (eg from a drawing).

For M4 learners must select triangles from compound shapes or volumes and use trigonometry to find unknown dimensions.

To achieve a distinction grade learners must be able to use appropriate mathematical methods, transposition and evaluation of more complex formulae to solve realistic engineering problems that require the use of at least two or more of these techniques, and demonstrate the ability to carry out chained calculations on a calculator.

For D1 learners should transpose and evaluate combined formulae. The problems should be set in a relevant and realistic context for learners' programme of study but must always require learners to apply the appropriate methods to reach a valid conclusion.

For D2 learners have to demonstrate competence in the correct evaluation of complex problems in one continuous calculation. It is essential that if this unit is offered for external moderation that a witness statement is provided to support the evidence.

Assignments could be written to include tasks that address intended different levels of criteria and should include the engineering applications as stated earlier and found within the content.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P3	Arithmetic and Graphical Methods	A written activity requiring learners to complete two tasks to satisfy each of the criteria.	A report containing written solutions to satisfy arithmetic methods showing clear evidence to check their answers are reasonable and graphical evidence from an engineering problem.
P2, D1, D2	Algebraic Methods	A written activity using actual engineering formulae to provide evidence that learners can transpose and evaluate them for differing values.	A report containing the solutions to the evaluation of differing standards of engineering formulae having had to apply transposition. Evidence of chained calculation needed for the distinction criteria.
P4, P5, M2, M3	Mensuration	A written activity requiring learners to determine areas and volumes.	A report containing written solutions to the calculation of areas and volumes.
P6	Trigonometry	A written activity requiring learners to carry out calculations relating to engineering problems using trigonometric methods.	A report containing the results of calculations carried out using trigonometric methods.

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

This unit forms part of the BTEC Engineering sector suite. The unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Applied Electrical and Mechanical Science for Technicians	Mathematics for Technicians
		Electrical and Electronic Principles
		Mechanical Principles and Applications

Essential resources

Learners will need access to electronic scientific calculators. Access to software packages to support the understanding of the concepts and principles and their application to science and engineering would be helpful to the learner.

Employer engagement and vocational contexts

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

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

Indicative reading for learners

Textbooks

Boyce A, Clarke S, Darbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Student Book* (Pearson, 2010) ISBN 9781846907234

Boyce A, Clarke S, Darbyshire A, Mantovani B and Weatherill B – *BTEC Level 2 First Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907258

Bird J – *Basic Engineering Mathematics* (Elsevier, 2005) ISBN 9780750665759

Stroud K – *Engineering Mathematics* (Industrial Press, 2008) ISBN 0831133279

Website

www.freestudy.co.uk – Engineering Council open learning tutorials

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information, judging its relevance and value.

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

Skill	When learners are …
Creative thinkers	trying out alternatives or new solutions to mathematical problems
Reflective learners	reviewing progress when solving problems during the learner's activities and acting on the outcomes to make corrections to understanding/solutions
Team workers	collaborating with others when working on investigative group work to achieve a valid solution
Self-managers	organising time and resources, prioritising actions.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine electrical and mechanical problems set within engineering contexts and situations
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant parameters and formulae to be applied to given electrical and mechanical situations
Select and apply a range of skills to find solutions	selecting and applying formulae to solve electrical mechanical problems in engineering
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to electrical and mechanical problems to evaluate their effectiveness and reality at each stage of the calculation
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and supervisors to establish an understanding of mathematical concepts and issues in engineering
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate mathematical data sources to solve engineering problems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	taking notes and solving engineering mathematical problems to communicate accurate solutions effectively.

Unit 4: Applied Electrical and Mechanical Science for Engineering

Unit code: A/600/0387

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit gives learners the opportunity to explore the scientific concepts and principles associated with electrical and mechanical engineering.

Unit introduction

This unit will give learners an opportunity to investigate many electrical and mechanical engineering units such as charge, current, voltage, resistance and power; mass, weight, force, density, velocity and acceleration. The definitions of these units will be explained and their mathematical interrelationships investigated. These mathematical relationships can be investigated experimentally and the learners will be able to experience how slight experimental error and other factors can cause differences between actual and expected values. A capable engineer is one who knows what level of error is acceptable in different given circumstances.

The unit will cover the parameters of direct electrical current and magnetic fields within the context of electrical and magnetic circuits. Learners will also examine the definitions and parameters of static and dynamic systems including statics, linear motion and the properties and behaviour of fluids.

Although the content lends itself to a theory-based delivery approach there is scope for experimentation and a practical approach to certain elements of the learning outcomes.

This unit provides the underpinning knowledge that will be used across other units within the qualification and for progression to further levels.

Learning outcomes

On completion of this unit a learner should:

1 Be able to define and apply concepts and principles relating to electrical science

2 Be able to define and apply concepts and principles relating to mechanical science.

Unit content

1 Be able to define and apply concepts and principles relating to electrical science

Definitions of parameters of direct current: electrical charge; electric current; electro-motive force; electrical resistance; electrical power

Definitions of parameters of magnetic fields: magnetic fields; magnetic flux and flux density

Direct current electrical circuits: circuit symbols; Ohm's Law; potential difference; current; resistance in series and parallel circuit networks; data for calculations

Magnetic circuits: force on a current-carrying conductor; construction, function and use of electro-magnetic coils eg relays, contactors, solenoids, sensors, motors, transformers; data for calculations

2 Be able to define and apply concepts and principles relating to mechanical science

Definitions of parameters of static and dynamic systems: mass; weight; force; moment of a force; density; relative density; displacement; velocity; acceleration; work; power

Statics: conditions for static equilibrium, parallelogram, triangle and polygon of forces; principle of moments; limiting coefficient of kinetic friction; frictional resistance to motion; data to determine resultants; equilibrants and reactions

Linear motion: displacement; velocity; acceleration; formulae for uniform acceleration and retardation; graphical representation of displacement against time and velocity against time; work done; power dissipated; data to determine acceleration/retardation

Properties and behaviour of fluids: absolute and gauge pressure; pressure at depth in a fluid; data to determine pressure

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	define parameters of direct current electricity and magnetic fields	**M1**	determine the force on a current carrying conductor situated in a magnetic field from given data	**D1**	explain the construction, function and use of an electro-magnetic coil
P2	determine total resistance, potential difference and current in series and parallel dc circuits from given data [IE3, IE4]	**M2**	describe the conditions required for the static equilibrium of a body.	**D2**	determine the work done and the power dissipated in moving a body of given mass along a horizontal surface at a uniform velocity, given the value of the coefficient of kinetic friction between the contact surfaces.
P3	define parameters of static and dynamic mechanical systems				
P4	determine the resultant and equilibrant of a system of concurrent coplanar forces from given data [IE3, IE4]				
P5	determine the uniform acceleration/retardation of a body from given data [IE3, IE4]				
P6	determine the pressure at depth in a fluid from given data. [IE3, IE4]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Where a single group contains learners from a number of engineering disciplines, such as plant and operations, mechanical, etc, it is important that delivery of the content is placed within an appropriate context to meet the individual needs of each learner.

There is no set order for the delivery of the two learning outcomes and tutors will each have their own preferences with regards to the best point to start. The order of delivery of the learning outcomes may well be determined by the make up of the group. That is, a group of electronics or maintenance learners may benefit from considering the first learning outcome – concepts and principles of electrical science, since they may see this as having immediate relevance. This could then be followed with the work on mechanical science, delivered as far as possible with a focus on its relevance to electronics or maintenance. Of course, this could be reversed for general engineering learners.

The unit lends itself to a range of tutor demonstrations and practical work and centres should strive to include as much hands on work for the learners as possible to bring the science alive. In most cases, expensive equipment is not required – for example building simple circuits on re-usable bread-boards, setting up a force board with pulleys to determine triangles and polygons of forces, arranging inclined planes for the determination of coefficient of friction between a range of materials.

When carrying out practical work with direct current circuits it is acceptable to use either real components and circuits or CAD simulation. It is recommended however, that the learner does have some contact and experience with real electronic components during the delivery of the unit.

Ultimately, the learning come down to the ability of the learner to gain a sufficient understanding of the concepts to enable them to solve, through calculation in most cases, relevant engineering problems. To this end, a large amount of the time available for delivery will be spent going through worked examples with the learners and then allowing the learner to tackle similar and varied problems.

The unit provides the underpinning knowledge for many other units in the qualification and should be delivered at an early stage in the programme of study. There is a strong correlation between this unit and *Unit 3: Mathematics for Engineering Technicians* and both units could be delivered in parallel.

Note that the use of ‘eg’ in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an ‘eg’ needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to the relevance of science to engineering, unit content, the scheme of work and assessment strategy • consider the definitions of common quantities and SI units. Group work: • explore and compare calculator types, review common functions and carry out calculator use exercises. Individual learner activity: • complete worksheet on common quantities and SI units.
Whole-class teaching: • explain the terminology used to describe the parameters of direct current and their associated symbols and units • tutor demonstration of an electrical circuit using components or computer simulation • develop practical circuits to show series and parallel connection of resistors • explain the formulae used for Ohms law and resistors in series and parallel followed by individual learner activity involving calculations using formulae • explain the terminology used to describe the parameters of magnetic fields and their associated symbols and units, current-carrying conductors and solenoids • tutor demonstration of magnetic fields and solenoids • define flux, flux density and state formula for calculation of force on a current carrying conductor in a magnetic field • tutor demonstration of the use of formula for the calculation of force on a current carrying conductor in a magnetic field and explain determination of direction of force. Individual learner activity: • exercises on solution of circuit problems involving force on a conductor. Whole-class teaching: • describe and discuss the principle of operation and practical applications of relays, contactors and solenoids, basic dc motors and transformers • tutor demonstration of the calculation of output emf for no load condition. Individual learner activity: • tutor-led revision exercises on dc circuits and force on a conductor.
Prepare for and carry out assignment 1 (P1, P2, M1, D1).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • consider mass, weight, concurrent and non-concurrent coplanar forces and the moment of a force and conditions required for static equilibrium • tutor demonstrate of the construction of parallelogram, triangle and polygon of forces. Individual learner activity: • exercises on graphical solution of concurrent coplanar force systems. Whole-class teaching: • explain the principle of moments and its applications with examples of calculations to determine simply supported beam reactions and solution of other simple non-concurrent coplanar force systems. Individual learner activity: • exercises on solution of non-concurrent coplanar force systems. Whole-class teaching: • explain and discuss Coulomb's laws for dry frictional resistance between surfaces in sliding contact, coefficient of kinetic friction and demonstrate calculation of frictional resistance to motion • practical activity to determine coefficient of friction • consider – density and relative density, common – units of pressure, absolute and gauge pressure, pressure at depth below the free surface of a liquid. Individual learner activity: • exercises on pressure calculation and measurement.
Prepare for and carry out assignment 2 (P6).
Whole-class teaching: • consider – displacement, velocity and acceleration, displacement-time and velocity-time graphs, formulae for motion with uniform acceleration • tutor demonstration of calculations to solve problems relating to linear motion from given data. Individual learner activity: • exercises on motion with uniform acceleration. Whole-class teaching: • consider Newton's law's of motion and inertia, develop formula for calculation of inertial resistance from Newton's 2nd law of motion, work and power • tutor demonstration of calculations using Newton's laws of motion and inertia. Individual learner activity: • exercises on motion with uniform acceleration involving work and power.
Prepare for and carry out assignment 3 (P3, P4, P5, M2, D2).
Feedback on assessment, unit evaluation and close.

Assessment

Evidence of achievement of the learning outcomes and Assessment and grading criteria may be obtained from well planned and supervised investigative assignments and/or through the responses to given engineering problems and questions that cover the requirements of the assessment criteria and related content.

It is expected that learners should demonstrate an acceptable range of accurate responses made in standard or engineers' form (eg 1.2×10^4 or 12×10^3). Solutions to problems should include a reasonable display of number skills demonstrated by the appropriate application and manipulation of formulae, suitable accuracy of calculations and, where applicable, statement of correct units.

Three assignments could be used for the assessment of this unit. The first might cover P1, P2, M1 and D1 and include questions that require learners to define parameters of direct current electricity and magnetic fields (P1) and solve direct current electrical circuit problems (P2). A task could also be set within this assignment to provide the learner with an opportunity to achieve M1 by the determination of the force on a current carrying conductor situated in a magnetic field. Finally, given a diagram of an electro-magnetic coil, the learner could achieve D1 by explaining its construction, function and use.

The second assignment could cover the criteria P3, P4, P5, M2, D2 – static and dynamic systems. The first task of the assignment could cover the basic definitions (P3) but these could also be integrated into the tasks associated with P4, P5 (and P6 related to assignment 3). For example, before the learner calculates the moments of a force they might be asked to define or state what is meant by a moment of a force. This approach has the potential of making the learner's definitions of the parameters more relevant and less disjointed. The design of the tasks for P4 and P5 should be such that they sufficiently cover the criteria and related content. Additional tasks or extensions to the tasks for P4 and P5 could then be suitably integrated into the assignment to enable the learner to the work towards the achievement of M2 and D2.

The third assignment, based around given data on a static fluid system, could be used enable the learner to demonstrate the determination of hydrostatic pressure at a depth in a fluid to achieve P6 and also the definitions of parameters required under P3 that are relevant to fluid systems – density and relative density.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Electricity and Magnetism	An activity requiring learners to complete four tasks that together define given parameters, determine calculations from given data and describe functions relating to current electricity and magnetic fields.	A report containing written responses on electricity and magnetism.
P3, P4, P5, M2, D2	Statics, Dynamics and Linear Motion	A written activity based on the parameters and solution of engineering problems relating to statics and linear motion.	A report containing written responses about static and dynamic system problems, determination of a system of coplanar forces plus calculations relating to uniform acceleration/retardation of a body.
P6	Fluid Pressure	A written activity requiring learners to carry out calculations relating to engineering problems associated with pressure in fluids.	A report containing the results of calculations to determine the properties and behaviour of a fluid.

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

This unit forms part of the BTEC Engineering sector suite. The unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Mathematics for Engineering Technicians	Mechanical Principles and Application
		Electrical and Electronic Principles

Essential resources

Learners will need access to engineering science laboratory facilities to enable practical experimentation and tutor demonstrations.

Employer engagement and vocational contexts

Delivery and assessment of this unit can be reinforced with company visits. Such visits can help learners understand how many of the concepts in electrical and mechanical engineering relate to industry. They would also enable learners to put the concepts into perspective, for example a visit to an electrical power station would enable learners to appreciate the potential scale of electro-magnetic equipment, engineering structures and the forces that these can be required carry.

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

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

Indicative reading for learners

Textbooks

Bird J O – *Science for Engineering* (Newnes, 2003) ISBN 0750657774

Bird J O – *Electrical and Electronic Principles and Technology* (Newnes, 2007) ISBN 0750685565

Bolton W – *Engineering Science* (Newnes, 2006) ISBN 0750680830

Hannah J and Hillier M J – *Applied Mechanics* (Longman, 1995) ISBN 0582256321

Tooley M – *BTEC First Engineering* (Newnes, 2006) ISBN 9780750680608

Website

www.howstuffworks.com

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	exploring issues and problems relating to electrical and mechanical engineering science analysing data and evaluating its relevance and value.

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

Skill	When learners are …
Reflective learners	reviewing progress when solving problems during the learner's activities and acting on the outcomes to make corrections to understanding/solutions
Self-managers	organising time and resources to carry out practical work relating to electrical and mechanical engineering science experiments and investigations
Creative thinkers	trying out alternatives or new solutions to electrical and mechanical engineering science problems
Team work	collaborating with others when working on practical and investigative group work to achieve a valid solution.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine electrical and mechanical problems set within engineering contexts and situations
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant parameters and formulae to be applied to given electrical and mechanical situations
Select and apply a range of skills to find solutions	selecting and applying formulae to solve electrical and mechanical science problems in engineering settings
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to electrical and mechanical problems to evaluate their effectiveness and reality at each stage of the calculation
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and supervisors to establish an understanding of electrical and mechanical engineering science concepts and issues
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate electrical and mechanical science information data sources to solve problems and carry out practical work
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	taking notes and solving electrical and mechanical science problems to communicate accurate solutions effectively.

Unit 5: Engineering Maintenance Procedures

Unit code: D/600/0388

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit gives learners the opportunity to explore the purpose, procedures and resources required to carry out maintenance activities on non-complex engineering systems.

Unit introduction

Engineering maintenance involves the service, repair and adjustment of engineering plant, equipment and machinery in order to ensure that it continues to perform its intended function. In recent years, maintenance needs have changed due to advances in manufacturing systems and increasing sophistication of industrial equipment and computer technology. It is therefore vital for modern manufacturing organisations to have effective maintenance planning and procedures in place to guarantee the reliable and safe operation of plant and equipment.

This unit introduces learners to the features of engineering systems that determine their reliability, safety and maintainability. The unit gives learners an understanding of the fundamentals of engineering system maintenance procedures and planning.

Learners will understand the causes and effects of equipment failure and know how planned maintenance can minimise or eliminate downtime due to failure. Learners will develop knowledge and understanding of engineering maintenance methods and procedures, and develop the skills needed to plan and carry out maintenance activities on engineering systems.

Learners will be expected to carry out maintenance procedures and planning activities on a non-complex engineering system and complete the necessary documentation before handing over and confirming that the system is now ready to run in a safe and operable condition.

Learning outcomes

On completion of this unit a learner should:

1 Know about engineering maintenance purposes, procedures and resources

2 Be able to plan and carry out a maintenance activity on a non-complex engineering system.

Unit content

1 Know about engineering maintenance purposes, procedures and resources

Causes and effects: causes of equipment failure eg age, wear, vibration, corrosion, fouling, environment, lack of maintenance; effects eg importance of downtime, increased cost, equipment/component life

Types of maintenance procedures: planned maintenance eg routine maintenance, preventative maintenance, condition monitoring, front-line maintenance and when/where they are used, servicing; unplanned maintenance eg breakdown, front-line maintenance and when/where they are used, repair, equipment failure, run to failure

Resources for maintenance operations: human (roles and responsibilities) eg managers, maintenance personnel, operators; tools, materials and equipment – for specific maintenance functions eg basic test instruments, hand tools, replacement parts, cleaning and lubricating materials

2 Be able to plan and carry out a maintenance activity on a non-complex engineering system

Maintenance activity: maintenance undertaken for specific parts of an engineering system eg pump, valve, compressor, heating, lighting, fluid power, manufacturing or test equipment

Identification of resources: availability of maintenance and production staff; appropriate documentation eg permit-to-work, maintenance check lists, production schedules, machine/process records, hand-over documents, equipment manuals; fault-finding aids; appropriate spares/materials/consumables; appropriate test equipment and tools

Maintenance planning: frequency of maintenance; reasons for selecting different frequency rates for specific maintenance eg on shift/daily/weekly/monthly/yearly routines; identification of planned repairs/ replacements; health and safety issues; environmental issues; estimation of costs

Maintenance documentation: information eg manufacturers' manuals, drawings charts and diagrams, planning sheets, instructions, schedules; recording eg maintenance logs, other records; hand-over documents; fault-finding aids

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe four different causes of engineering equipment failure	**M1**	explain the benefits and limitations of a planned maintenance activity	**D1**	evaluate maintenance documentation in terms of usefulness when used to plan and carry out a maintenance activity.
P2	describe the effect of each of the four failures	**M2**	justify the resources and methods used to carry out a given maintenance activity.		
P3	describe a planned type of maintenance procedure				
P4	describe an unplanned type of maintenance procedure				
P5	describe the resources needed for engineering maintenance operations				
P6	identify the resources required for a given maintenance activity [IE3]				
P7	use maintenance documentation to plan a given maintenance activity on an engineering system [SM3, EP4]				
P8	use documentation to carry out a maintenance activity. [EP4, SM2, RL3]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

Since most learners are unlikely to have had prior experience in this area of work, it is essential to have some formal introduction to the content. The unit can then be regarded as essentially investigative; the use of non-complex rigs would allow learners to carry out a practical investigation.

The approach will be determined best through an analysis of each learner's needs and, in particular, through consideration of the range of industries that centres are working with or preparing their learners for. Whichever approach is taken, the learner's experience should be sufficiently varied to provide them with knowledge and understanding of engineering system maintenance procedures and planning in most industrial settings.

This unit is a mix of theoretical and practical aspects and learners should have the opportunity to examine a range of mechanical, electrical and manufacturing systems. The unit is best delivered through a programme of lectures followed by some form of practical investigations or activities.

The unit provides an opportunity for learners to work individually or in groups when planning engineering system maintenance procedures.

The learning outcomes are ordered logically and it would be a reasonable approach to develop them sequentially throughout the unit. In this way, the learner will understand maintenance methods and procedures and then be able to carry out a maintenance planning activity.

Tutors should always ensure that each learner has the correct personal protective equipment and that systems are safe for inspection and operation. It is also important that learners work in a safe manner when using equipment or working on systems.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to the unit, delivery and assessment model, glossary of terms and terminology • introduction to engineering maintenance, its purpose, procedures and resources • outline applicable health and safety legislation, regulations and codes of practice and explain the need for maintenance and maintenance considerations. Individual learner activity: • investigate the maintenance operations in various organisations and the health and safety requirements and environmental considerations relating to maintenance in a given organisation/industry.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the causes of equipment failure and the effect of poor maintenance on downtime, costs, equipment/component life. Group activity: • identify the need for maintenance within particular organisations.
Whole-class teaching: • explain principles and procedures of planned and unplanned types of maintenance and examples of their application in industry. Individual learner activities: • identify types of maintenance in given situations • review of the factors affecting given maintenance type and evaluate types of maintenance.
Whole-class teaching: • explain the roles of personnel applicable to the maintenance process • explain the impact of using less well trained staff, in-house, contract, specialist • explain the tools materials and equipment requirements for maintenance functions also the cost implications of keeping spares and consumables. Industry visit: • to local company to see types of maintenance used.
Prepare for and carry out assignment 1 (P1, P2, P3, P4, P5 and M1).
Whole-class teaching: • introduction to planning and carrying out a maintenance activity • consider maintenance planning, documentation and discuss the possible environmental and health and safety issues. Individual learner activity: • identify and obtain maintenance planning documentation, produce written maintenance plans and carry out cost estimate for given task. Practical workshop activity: • tutor demonstration of a maintenance activity on a non-complex engineering system • learners plan and carry out maintenance activities on non-complex engineering systems.
Whole-class teaching: • explain maintenance resource requirements and examine further examples of maintenance information, documentation requirements, recording methods and charts. Practical workshop activity: • use of equipment manuals, fault-finding aids, selecting and using appropriate spares, materials, consumables, appropriate test equipment and tools.
Prepare for and carry out assignment 2 (P6, P7, P8, M2 and D1).
Feedback on assessment, unit evaluation and close.

Assessment

Learning outcome 1 and the associated criteria (P1, P2, P3, P4, P5 and M1) could be covered through an assignment that requires the learner to respond to preset questions. These questions may be based around a case study style scenario or test questions that have each been set within a relevant engineering context. In either case, it is most likely that controlled condition will be required to ensure the authenticity of the responses.

To achieve the merit grade M1, learners should be able to explain the benefits and limitations of a planned maintenance activity in terms of cause and effect, types of procedures and maintenance resources required (eg human, tools, materials and equipment).

Learning outcome 2 and its associated criteria (P6, P7, P8, M2 and D1) could be assessed using a practical assignment that requires the learners to identify the resources required for a given maintenance activity and use maintenance documentation to plan for and carry out a given maintenance activity on an engineering system. The engineering system should be a non-complex system eg pumps, valves, compressors, heating, lighting, fluid power and manufacturing or test equipment. Tutor observation will be necessary during the activity to capture the process evidence of maintenance documentation use and the safe use of correct procedures. The learners will also be required to produce a report that includes the identification of resources and all hand-over documentation and completed records.

To achieve the merit grade criterion M2, the learners will need to consider and justify the resources and methods used to carry out a given maintenance activity. This should be in terms of the correct choice of resources (expanding on P6) and ability to follow the recommended procedures for carrying out maintenance tasks (expanding on P7 and P8).

To achieve D1, learners are required to evaluate maintenance documentation in terms of usefulness when used to plan and carry out a maintenance activity. This should be in terms of the documentation's ability to assist them in their planning (eg frequency, replacement parts, health, safety and environmental issues) and when carrying out the maintenance activity (eg clarity of the information available to complete and record the outcomes of the tasks carried out).

An alternative approach to assessment could be to require the learners to build a portfolio of evidence for the unit as a whole as they carry out a range of investigations and operations in the workplace.

A further alternative method could be the use of an integrative assignment, which links this unit with other practical units in a programme of study. If this approach is adopted, the evidence for the specific learning outcomes and associated assessment and grading criteria will need to be clearly identified.

Whichever approach is used, the opportunity should always exist for merit and distinction grades to be achieved with relevant and sufficient evidence to justify the grade awarded.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4, P5 and M1	Maintenance Purposes, Procedures and Resources	In order to plan resource requirements, learners have been asked to produce a report detailing possible types of failure in engineering equipment, the types of possible maintenance and the related resources.	A written report containing a description of: • the different causes and effects of equipment failure. • planned and unplanned maintenance procedures • the benefits and limitations of a planned maintenance activity • the resources needed for engineering operations.
P6, P7, P8, M2 and D1	Plan and Carry out a Maintenance Activity	Learners have been asked by their line manager to carry out maintenance on a piece of non-complex equipment or engineering system.	A report for a given maintenance activity that includes an identification of resources required, the maintenance plan and relevant references to the documentation used. Tutor observation of the planning and implementation of the given maintenance activity. A report justifying the resources and methods used when carrying out the given maintenance activity. A report evaluating the maintenance documentation used.

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

This unit forms part of the BTEC Engineering sector suite. The unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Engineering Maintenance Procedures and Techniques
	Operation and Maintenance of Mechanical Systems and Components	
	Operation and Maintenance of Electrical Systems and Components	
	Operation and Maintenance of Electronic Systems and Components	
	Operation and Maintenance of Fluid Power Systems and Components	

The unit supports the SEMTA Level 2 National Occupational Standards in Maintenance and Installation in particular:

- Unit 4: Handing Over and Confirming Completion of Maintenance or Installation Activities.

The unit also has strong links with the Level 2 NVQ in Performing Engineering Operations, in particular:

- Unit 19: Maintaining Mechanical Devices and Systems
- Unit 21: Maintaining Fluid Power Equipment
- Unit 37: Maintaining Electrical Equipment/Systems
- Unit 38: Maintaining Electronic Equipment/Systems.

Essential resources

Access to a workshop environment and a wide range of equipment, systems, devices and components required to carry out engineering maintenance activities will be essential, together with relevant manufacturers' service manuals, data sheets, parts lists, diagrams and drawing. Relevant test instruments, tools and safety equipment will also be required as appropriate to the equipment, systems, devices and components used.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Learners will require access to workshops equipped with modern engineering systems and equipment and this could be achieved through links with local employers or in the learner's place of work. Alternatively, industry visits could be used to enable the learners to experience a range of different maintenance operations and industry settings.

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

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

Indicative reading for learners

Textbooks

Kibbe R – *Mechanical Systems for Industrial Maintenance* (Prentice Hall, 2001) ISBN 0130164909

Mobley K – *Maintenance Fundamentals, 2nd Edition* (Butterworth-Heinemann, 2004) ISBN 0750677988

Engineering data handbooks and manufacturers' specifications

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	exploring a given maintenance activity from different perspectives to identify the resources required
Self-managers	working towards a successful maintenance activity on an engineering system showing initiative, commitment and perseverance organising time and resources, prioritising actions when carrying out a maintenance activity o an engineering system
Effective participators	identify improvements when planning and carrying out a maintenance activity that would benefit themselves and others
Reflective learners	reviewing progress with the maintenance activity on an engineering system, acting on outcomes.

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

Skill	When learners are …
Team workers	collaborate with others when working in-groups to gather information on engineering maintenance and maintenance planning
Reflective learners	evaluate experiences during workshop activities to inform future progress with maintenance tasks.

Functional Skills – Level 2

Skill	When learners are …
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	selecting and using the sources of information required to carry out a maintenance activity independently
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking and listening to operators/supervisors when planning for and carrying out maintenance activities on engineering systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	comparing, selecting, reading and understanding resource material when preparing for a given maintenance activity
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing documents to describe causes of engineering equipment failure and explaining effect of failure writing documents to describe planned and unplanned maintenance procedures writing reports to document the maintenance procedures carried out on an engineering system.

Unit 6: Preparing and Controlling Engineering Manufacturing Operations

Unit code: H/600/0389

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit aims to give learners the skills needed to safely prepare and control a manufacturing operation using defined procedures.

Unit introduction

Whenever a manufacturing process is used, preparation and ongoing control are important to ensure the safety of those involved. The work area needs to be properly prepared before any manufacturing operation can begin and the correct documentation and procedures have to be followed.

Once manufacturing has started, the operation needs to be carefully monitored to ensure that the product is of the required quality and that production targets are met. This requires the proper analysis and use of a range of data so that the correct adjustments to the process can be made where necessary.

This unit will give learners a broad introduction to the skills needed when preparing and controlling a manufacturing operation in a particular set of circumstances.

Learners will prepare a work area and apply the fundamental principles of production control to safely enable manufacturing operations to start and continue. In doing so learners will also collect data in relation to a production method and deal with problems that the data identifies. They will also learn how to use relevant operating procedures.

Learning outcomes

On completion of this unit a learner should:

1 Be able to prepare a work area for a manufacturing operation according to defined procedures in a safe manner

2 Be able to control a manufacturing operation in a safe manner according to defined operating procedures.

Unit content

1 Be able to prepare a work area for a manufacturing operation according to defined procedures in a safe manner

Work area: prepare and maintain the area; accessibility for receipt and removal of materials; freedom from obstructions and hazards; correct equipment and material layout

Safe manner: health and safety and environmental regulations; safe working practices

Procedures: job instructions; equipment/tool operating instructions eg machinery, process plant, tools, material handling arrangements, equipment specific to the operation; reporting to appropriate person eg team leader, supervisor, maintenance personnel, quality control

Problems in preparation: areas where problems occur eg raw materials, documentation, tooling, equipment, work area

2 Be able to control a manufacturing operation in a safe manner according to defined operating procedures

Manufacturing operation: production method eg hand manufacturing operations, manually operated machine operations, fully automated machine operations, combined manufacturing operation

Data: collected on the condition of operation eg quality of finished product, dimensional accuracy, raw material use, consumable material use, machinery condition, equipment or tool condition, output/production targets

Control: dealing with problems; collecting and using data; making adjustments

Safe manner: health and safety and environmental regulations; safe working practices

Problems: eg trends, variation from specification, discrepancies

Adjustments: process effectiveness eg operational sequence, production time; process characteristics eg quality, accuracy; material utilisation eg in production, consumables; manufacturing programme changes; operational safety

Operating procedures: job instructions; equipment/tool operating instructions eg machinery, process plant, hand held and portable tools, material handling arrangements, equipment specific to the operation; making adjustments from data

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	prepare a work area in a safe manner	**M1**	describe how procedures promote a safe working environment	**D1**	explain the importance of keeping a well maintained work area
P2	prepare a work area following procedures, dealing with two different problems in preparation [SM3]	**M2**	describe how the collection of data can help control a manufacturing operation.	**D2**	explain the importance of keeping good control over a manufacturing operation.
P3	identify the condition of a manufacturing operation using data collected [IE4]				
P4	control a manufacturing operation in a safe manner by identifying a problem and making adjustments [SM3, EP4]				
P5	use operating procedures when controlling a manufacturing operation.				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

The unit lends itself to a practical approach when carrying out manufacturing operations. There are two main areas – setting up a work area ready for operation, and controlling the operation to ensure that the operation can continue. The learner needs a broad overview of the different responsibilities when preparing a work area before manufacturing commences. Learners are required to ensure the work area is safe to commence manufacture and that it complies with procedures. There will be job instructions that the learner should be competent to follow. The equipment or tool operating instructions will be dependent on the learner's individual circumstances when carrying out manufacturing operations. Learners should be aware of the whole range of standards and procedures that apply when preparing a work area, but they need to be able to follow at least two of those listed in the content. They should also be made aware of the data that can be collected from operations and what to do with that data once manufacturing has started.

The unit provides an opportunity for learning through practising the use of preparation and controlling procedures. Employed learners will be able to relate study to their own organisation and may be more motivated if they share their experience with others. Industrial visits will help underpin the breadth of knowledge and understanding required of company and operating procedures.

The two learning outcomes are ordered logically and it would be reasonable to develop them sequentially throughout the unit. In this way, the learner will begin to recognise the importance of preparing a work area correctly before manufacturing commences.

Formative assessment will play an important part in the general development of the learner but especially with their achievement of the higher-level abilities. The ability to review and evaluate is also required at distinction level and again formative work in the delivery phase will encourage learners to consider why it is important when using manufacturing operations to have a well-prepared work area and correct controlling procedures to follow.

It is appropriate that the teaching and learning strategies used to deliver the unit take into account the evidence needed for portfolio assessment.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and assessment • explain relevant aspects of health and safety legislation and discuss importance of maintaining work area • explain and discuss health and safety requirements (PPE, safe disposal of materials etc) • explain procedures for cleaning and storing tools and equipment. Practical workshop exercise: • preparing the work area.
Whole-class teaching: • explain the roles of maintenance and quality control personnel and procedures for reporting to appropriate person • identify and explain job instruction documents • identify and explain equipment/tool operating instructions • discuss consequences of failure to follow instructions • describe and discuss problems that might arise (with documentation, materials, work area etc).
Prepare for and carry out Assignment 1.
Whole-class teaching: • describe and discuss the range of production methods in relation to scales of production and different engineering activities • describe and discuss safe working practices associated with the range of production methods.
Industrial visit to local manufacturing company.
Whole-class teaching: • explain the purpose of process plans/specifications and the information that they contain • explain the use of engineering drawings • describe typical documentation and recording procedures • explain the procedures for checking the condition of machinery and tools • explain the purpose of production programmes/schedules and ways in which output is monitored and recorded.
Whole-class teaching: • describe procedures for reporting material faults, machine or equipment malfunction • describe typical quality control inspection and recording procedures • describe the tendency and reasons for a process to drift from specification
Whole-class teaching and practical demonstration: • describe procedures for setting up machinery and process plant in readiness for production • describe and demonstrate typical start-up, operating and shut-down procedures • describe and demonstrate typical material handling procedures and safe use of equipment.

Topic and suggested assignments/activities and/assessment
Whole-class teaching and practical demonstration: • describe and demonstrate the use of process monitoring techniques. • describe and demonstrate quality control procedures. • describe how changes to the manufacturing programme are typically accommodated.
Prepare for and carry out Assignment 2.
Review of unit.

Assessment

The assessment strategies used should be designed to suit the needs of learners and should be supported by the proper presentation of appropriate evidence. Assessment evidence is likely to be in the form of a portfolio built up from learners' practical work and investigations. Portfolios should not contain course notes, research etc, unless it is to become part of the required evidence and assessment. The assessment evidence needed for the pass criteria will need to be collected from practical work, and is likely to come from opportunities arising from work in other units (eg *Unit 14: Selecting and Using Secondary Machining Techniques to Remove Material*). If assessment is combined with work done in other units, care needs to be taken to ensure that evidence can be clearly linked to the criteria in this unit.

P1, P2, M1 and D1 relate to the first of the two learning outcomes. As such, they could be effectively assessed through a single practical assignment with a variety of tasks. Within the preparation task, centres will need to ensure that there are two problems for learners to deal with, eg with raw materials, documentation, tooling, equipment or with the work area.

The remaining criteria, P3, P4, P5, M2 and D2 relate to the second outcome and again can be assessed through a single practical assignment with a variety of tasks.

As already outlined, evidence could come from opportunities arising from work in other units. In both cases, the task would need to specify the practical requirements for the pass criteria and would need a range of procedures to follow when preparing the work area. A range of operating procedures is also required to ensure correct data can be collected and acted upon. For the higher criteria, tasks need to be developed that allow learners to describe and explain certain aspects of their work and evidence is therefore likely to be in the format of a written response. Good witness statements or observation records can support a learner's performance for the pass criteria. Other supplementary evidence such as annotated photographs of learners carrying out manufacturing operations and notes or records of the data collected with a record of the actions taken would be suitable.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1 and D1	Preparing the Work Area	A practical activity in which learners prepare their work area in a safe manner and following procedures, in readiness for an engineering or manufacturing activity, plus supporting written tasks.	A practical demonstration supported by witness statements/ observation records and annotated photographs. A report containing a written description of how procedures promote a safe working environment and an explanation of the importance of a well-maintained work area.
P3, P4, P5, M2	Controlling Manufacturing Operations	A practical activity in which learners control a manufacturing operation, using operating procedures, plus a written task.	A practical demonstration supported by witness statements/ observation records and annotated photographs. A written description of how the collection of data can help control manufacturing operations

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working safely and Effectively in Engineering	
	Interpreting and Using Engineering Information	
	Selecting and Using Secondary Machining Techniques to Remove Material	
	Production Planning for Engineering.	

This unit covers some of the knowledge and understanding associated with the Level 2 NVQ in Performing Manufacturing Operations, in particular:

- Unit 4: Preparing for Manufacturing Operations
- Unit 18: Controlling Manufacturing Operations.

Essential resources

To meet the needs of this unit it is essential that the centre has, or has access to, a range of manufacturing operations and work areas as specified in the unit content. Health and safety documentation should be made available to learners. If learners are not in employment, a range of company and operating procedures should be obtained and used to demonstrate current industrial practices.

Employer engagement and vocational contexts

The use of vocational contexts is essential for this unit and a range of company and operating procedures from local industry could be used. Visits to local companies will enable learners to see a range of manufacturing techniques being applied in an industrial context.

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

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

Indicative reading for learners

Textbook

Timings R L – *Basic Manufacturing* (Newnes, 2004) ISBN 0750659904

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	collecting, interpreting and using data to identify the condition of a manufacturing operation
Self managers	organising time and resources when controlling an manufacturing operation
Effective participators	identifying a problem in a manufacturing operation and making adjustments that will benefit themselves and others.

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

Skill	When learners are …
Reflective learners	reviewing progress during manufacturing operations and acting on the outcomes
Self-managers	organising time and resources, prioritising actions.

Functional Skills – Level 2

Skill	When learners are …
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	following job instructions and using equipment and tool operating instructions.

Unit 7: Electronic Devices and Communication Applications

Unit code: H/600/0392

QCF Level 2: BTEC First

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will provide learners with knowledge of electronic systems and components and the skills needed to construct and test a range of analogue and digital electronic circuits. Learners will also gain an understanding of electronic communication systems.

Unit introduction

Electronics drive the modern world and have given us pocket calculators, digital watches, electronically-controlled washing machines, microwave ovens and heart pacemakers. It has spawned the computer revolution, the internet, the global mobile phone network, and the Sony Playstation. Electronic systems are a major part of the design of F1 racing cars and the Hubble Space Telescope – indeed more engineer hours were spent creating the electronics of the new Airbus than were spent developing its airframe.

This unit is suitable for anyone who wishes to gain an understanding of the principles of electronics. The learning required for the unit is practically orientated with actual devices and the way they are used being considered. This encourages learners to develop their skills and knowledge in this field.

Learners will find out about the technology that underpins consumer electronics as well as the systems that keep industry and commerce running. The unit will develop learners' knowledge and understanding of topics embracing electrical, electronics and communications technology, thus enabling progression to further study in the areas of electronics and communications engineering.

The unit provides opportunities for learners to investigate practically the operation of devices and circuits along with learning the underpinning theory, hence attention must be paid to the relevant aspects of health and safety and safe working practices during practical activities.

Learning outcomes

On completion of this unit a learner should:

1 Know the types of signals and units of measurement used in electronic systems

2 Know the function of electronic components and devices

3 Be able to construct and test analogue and digital electronic circuits

4 Understand electronic communication systems and data transmission.

Unit content

1 Know the types of signals and units of measurement used in electronic systems

Signals: digital and analogue signals eg light intensity, temperature, voltage, frequency; DC and alternating signals eg sinusoidal, pulse, square/rectangular, triangular, sawtooth; waveform measurements eg amplitude, peak to peak, pulse duration, mark/space ratio, repetition rate, cycle, period time, frequency, phase; speech waveforms

Units of measurement: voltage (V, mV, μV, kV); current (A, mA, μA); frequency (Hz, kHz, MHz); bits per second (bps, kbps, Mbps)

2 Know the function of electronic components and devices

Components: physical forms and British Standard (BS) symbols; cells, batteries, power supplies, connectors; resistors, variable resistors, capacitors, inductors/chokes; diodes, transistors (bipolar and unipolar)

Devices: switches eg normally open (NO), normally closed (NC), change over (CO), single pole single throw (SPST), single pole double throw (SPDT), double pole double throw (DPDT), push button, rocker, toggle, rotary, microswitch, tilt, pressure; transducers eg light dependant resistor (LDR), photodiode, thermistor, thermocouple, microphone, strain gauge; indicators and output devices eg lamp, LED, buzzer, speaker, relay, motor, solenoid, heater; operational amplifiers eg inverting and non-inverting amplifiers, comparators; timers and multivibrators eg astable, bistable and monostable; two input logic gates eg AND, OR, NOT, NAND, NOR, XOR

3 Be able to construct and test analogue and digital electronic circuits

Simple passive circuits: combinations of series and parallel resistor components eg potential divider circuits; series and parallel combinations of two capacitors; time-delay effect of capacitor eg time constant $T = CR$, charge and energy storing

Analogue circuits: diode as a one-way device eg use of diode for device protection, circuits comprising diode-resistor combinations, turn on voltage, zener diode stabiliser; bipolar and unipolar transistor circuits eg transistor operation as an amplifier and as a switch; linear integrated circuit/operational amplifier eg acting in inverting or non-inverting mode or as a comparator, 555 timer circuits in astable and monostable mode

Digital circuits: simple combinational logic circuits and truth tables eg 74 Series and/or CMOS 4000B series integrated circuits implementation, or teaching laboratory modules, D type and T type flip flop circuits, cascaded flip flops and effect on input waveform, counting pulses

Construction: protoboard; veroboard; PCB

Testing: test equipment eg multimeter, logic probe, oscilloscope, signal and pulse generators

4 Understand electronic communication systems and data transmission

Electronic communication systems: transmitter sub-systems eg audio source, radio carrier for radio transmission or light emitting diode for optical communication; channel/link eg copper wire twisted or untwisted and shielded or un-shielded, co-axial cable, radiowave carrier, optical fibre; receiver eg radio or photodiode/phototransistor; the requirement for repeaters and regenerators for communication over longer distances

Data transmission: representation of digital signals and data eg digital logic levels, binary numbers, coding methods, binary, BCD, ASCII, audio tones; protocols eg handshaking, flow control, error checking; simplex, half and full duplex working

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the types of signals produced by electronic devices including the correct use of units of measurement	**M1**	explain the operation of an analogue electronic circuit and a digital electronic circuit	**D1**	justify the choice of components and devices to ensure correct functionality of an electronic circuit
P2	describe the function of electronic components and devices	**M2**	explain the function of repeaters and regenerators for communication over longer distances and how they are used.	**D2**	identify and describe the advantages of two given electronic communication systems.
P3	identify BS symbols and the physical forms of given electronic components and devices				
P4	construct a passive circuit using at least two different methods of construction [IE1, SM3]				
P5	construct and test the operation of an analogue electronic circuit [IE1, SM3]				
P6	construct and test the operation of a digital electronic circuit [IE1, SM3]				
P7	explain how electronic communication is achieved [IE4]				
P8	explain how electronic communication systems can be used to successfully transfer data. [IE4]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Delivery of this unit should be based on a combination of well-planned practical laboratory work, supported by related theory. Learners should study the fundamental principles of electronic components and devices and have the opportunity to apply these to a wide range of circuits and applications.

This unit complements *Unit 13: Operation and Maintenance of Electronic Systems and Components* and *Unit 19: Electronic Circuit Construction* and the delivery of all three units could be enhanced by integrating their content.

This unit is designed to develop learners' underpinning knowledge and skills in the field of electronic components and devices and their applications. All four learning outcomes involve a large amount of practical investigative work. Learning outcomes 2 and 3 have the most practical content whilst learning outcome 1 provides the supporting knowledge of signals and units of measurement used in electronic systems. Learning outcome 4 covers the requirements for electronic communication systems and data transfer.

To support learning outcome 1 tutors should provide support in the form of demonstrations, guided discussion, case studies and presentations on the type of signals produced by electronic components and devices. Tutors should offer opportunities for learners to become familiar with the units of measurement used in electronic systems.

For learning outcome 2 learners should be introduced to the physical, diagrammatical representation and applications of a variety of passive and active electronic components.

When delivering the content for learning outcome 3 tutors should introduce learners to the various techniques employed for the construction of passive and active electronic circuits. Learners should be instructed on the correct operation and performance of the range of hand tools and test equipment that will be encountered.

Delivery of learning outcome 4 should ensure that learners are introduced to, and become familiar with, the function and operation of all parts of an electronic communication system including transmitter sub-systems, channel/link and receiver. Learners will also need to have an understanding of the way data is transmitted electronically.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and methods of assessment • explain digital, analogue, DC and alternating signals • explain waveform measurements and speech waveforms • explain and demonstrate use of units of measurement for voltage, current, frequency and bits per second.
Prepare for and carry out assignment 1 (P1).
Whole-class teaching: • introduce and explain the function and use of different types of components • explain and demonstrate the use of British Standards • explain the function and use of electronic devices. Practical learner activity: • learners investigate physical function of a range of passive and active electronic components and devices and their diagrammatical representation.
Prepare for and carry out assignment 2 (P2 and P3).
Whole-class teaching: • explain combinations of series and parallel resistor components, combinations of two capacitors and time-delay effect of capacitor in passive circuits • explain use of diode as a one-way device, and bipolar and unipolar transistor circuits. Describe purpose and function of linear integrated circuit • explain function of simple combinational logic circuits and truth tables • demonstrate electronic circuit construction and testing techniques. Practical learner activity: • practise use of protoboard, veroboard and PCBs for analogue and digital circuit construction • practise use of correct equipment for testing of electronic circuits.
Prepare for and carry out assignment 3 (P4, P5 P6, and M1 and D1).
Whole-class teaching: • explain the function and operation of transmitter sub-systems, channel/link and receivers • explain the use of repeaters/regenerators for long distance communications • explain and demonstrate representation of digital signals and data. Explain the use of protocols • explain the operation of different duplex communication systems. Employer visit: • visit to local employer to view electronic communication systems in industrial setting.
Prepare for and carry out assignment 4 (P7, P8, M2 and D2).
Unit evaluation, feedback and close.

Assessment

Learners' summative assessment for this unit will need to be on an individual basis. However, group work and the sharing of tools and equipment is acceptable for the practical sessions and should be encouraged as it can often add to the learners' experience and aid the acquisition of knowledge. Evidence of learning outcomes can be collected from well-planned practical and written assignments that provide the opportunity to produce and test a wide range of electronic circuits.

The content of this unit has been designed to complement that of *Unit 13: Operation and Maintenance of Electronic Systems and Components* and *Unit 19: Electronic Circuit Construction*. It is recommended that tutors bear this in mind where possible when planning the assessment of all three units. It should therefore prove possible for learners to develop evidence to satisfy more than one grading criteria and across units when attempting assignments – thus reducing the risk of over assessment.

Some of the assessment for this unit will naturally take place through tutor observation and questioning. To support this assessment approach the learner should provide supporting evidence, for example the use of a logbook that is maintained by the learner in order to record the series of practical experiments, construction activities and tests carried out. The log could contain a description of the task undertaken, the instructions provided (annotated to record progress or difficulties), a list of tools, components and equipment provided and their condition and relevant annotated photographs. Such supporting activity evidence would then validate the tutor or witness observation/oral questioning records and vice versa. The use of witness testimonies to confirm that the learner has met the relevant assessment criteria should be encouraged.

The assessment grid shows that there are links across the criteria, from pass to merit to distinction. Tutors should make these links apparent when planning assessment tasks so that learners can develop their evidence in order to satisfy more than one grading criteria when attempting set assignments.

A series of four assignments could be used for assessment. The first assignment could use written tests where learners describe the types of signals and the units required when quoting or measuring voltage, current, frequency and bits per second (P1). A second assignment could again involve written tasks to describe functions and identify symbols and forms of given components and devices (P2 and P3).

The knowledge shown for criterion P2 will be required in a third assignment that could be set as a practical task involving the construction and testing of the different circuits (P4, P5 and P6). On completion of these practical tasks, learners could be given further written tasks to explain the operation of the circuits (M1) and to justify the choice of components and devices in a given circuit (D1).

The fourth assignment could involve two written tasks, to explain how electronic communication is achieved (P7) and how communication systems successfully transfer data (P8). Further tasks could ask the learner to explain the function of repeaters and regenerators for communication over longer distances and how they are used (M2) and to identify and describe the advantages of different models of communication systems (D2).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Electronic Signals and Units	Learners produce an information poster for new apprentices outlining the different types of signal and the use of units of measurement.	A written assignment requiring descriptions of digital, analogue, DC and alternating signals, waveform measurements and speech waveforms and the units used to measure voltage, current, frequency and bits per second.
P2 and P3	Electronic Devices and Components	Learners write a short report identifying and describing electronic devices and components.	A written assignment with tasks requiring learners to describe functions and identify symbols and forms of given components and devices.
P4, P5, P6 and M1 and D1	Constructing and Testing Electronic Circuits	Learners need to construct and test a series of circuits to meet customer requirements.	A practical assignment requiring learners to construct and test different circuits.
P7, P8, M2 and D2	Electronic Communication Systems	Learners produce a report to explain electronic communication.	A written assignment with two tasks requiring learners to explain how electronic communication is achieved and how communication systems successfully transfer data.

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

This unit forms part of the BTEC Engineering sector suite. The unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Operation an Maintenance of Electronic Systems and Components	Electronic Design and Manufacture
	Electronic Circuit Construction	

This unit can contribute towards the underpinning knowledge requirements of Unit 33: Wiring and Testing Electrical Equipment and Circuits and Unit 36: Assembling and Testing Electronic Circuits from the Level 2 NVQ in Performing Engineering Operations.

Essential resources

Delivery should be based in a fully-equipped electronics laboratory to provide equipment for a range of construction and testing techniques. Test equipment, including oscilloscopes, signal generators, pulse generators, low voltage power supplies and multimeters should be provided.

Access to a computer suite for obtaining information from the internet and to use related computer aided drafting software should also be available.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Industrial visits can help enabling learners to see the There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

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

Indicative reading for learners

Textbooks

Bird J O – *Electrical and Electronic Principles and Technology* (Newnes, 2007) ISBN 0750685565

Frenzel L – *Principles of Electronic Communication Systems* (McGraw-Hill, 2007) ISBN 0071108106

Sinclair I – *Electronic and Electrical Servicing* (Butterworth-Heinemann, 2007) ISBN 0750669888

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information, judging its relevance when researching electronic communication systems identifying questions to answer and problems to resolve when testing the operation of analogue and digital circuits
Self-managers	organising time and resources when constructing and testing a range of analogue and digital circuits.

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

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Team workers	collaborating with others in small teams when carrying out practical activities.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Select and apply a range of skills to find solutions	using numerical data arising from practical work and investigations
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching electronic signals, components and devices and the use of electronic communication systems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing and explaining the function and operation of electronic devices and communication systems.

Unit 8: Selecting Engineering Materials

Unit code: A/600/0396

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit will give learners an understanding of common engineering materials and their properties and will enable them to select appropriate materials for different engineering applications.

Unit introduction

Engineering technicians need to be able to identify the materials that are specified on engineering drawings, production plans and servicing schedules. Some materials such as copper and lead have a distinctive appearance but others are not so easy to tell apart. This is particularly true of the different grades of steel, brass and aluminium alloys. Very often, an engineering technician has to select raw materials in the form of wire, bars, sheet metal and plate from stores and also components such as rivets, nuts and bolts. It is essential to select the correct material if a product or a replaced component is to be fit for its intended purpose.

This unit will give learners an understanding of a range of common materials encountered in engineering, their properties, uses and availability.

Learners will be expected to identify a range of ferrous, non-ferrous and non-metallic materials and know about the form in which they are obtained. Learners will also need to understand the properties that make individual materials suitable for particular tasks. Learners will need to know about the way in which materials are colour coded when stored and other material identification standards used such as the British and European Standard classifications. With this knowledge, and using information, abbreviations and symbols supplied on engineering drawings, learners will then be able to select the correct form and size of the material specified for a particular application.

Learning outcomes

On completion of this unit a learner should:

1 Understand the properties of common engineering materials

2 Know how engineering materials are identified.

Unit content

1 Understand the properties of common engineering materials

Properties: mechanical eg tensile strength, hardness, toughness/brittleness, malleability/ductility; electromagnetic eg electrical conductivity, ferromagnetism; chemical and durability eg resistance to corrosion, solvents, environmental degradation, wear

Common engineering materials: ferrous material eg cast iron, low and high carbon steel, stainless steel; non-ferrous material eg aluminium, brass, bronze, copper, lead; organic materials eg hard and soft woods, wood composites; thermoplastics eg PVC, nylon, PTFE, polythene, Perspex; thermosetting polymer eg Bakelite, Formica, melamine, Kevlar epoxy resin, polyester resin, reinforcing material (glass fibres, carbon fibres, wood flour); smart materials eg piezoelectric materials, shape memory alloys, magneto-rheostatic fluids, electro-rheostatic fluids

2 Know how engineering materials are identified

Symbols and abbreviations: symbols and abbreviations for material selection eg bright drawn mild steel bar, copper-coated circuit board, solid diameters, pipe/tube diameters, wire gauges; documentation eg engineering drawings and related specifications

Form of supply: form eg bar stock, sheet materials, pipe/tube, wire, rolled steel sections, castings, forgings, mouldings, extrusions, powders and fluids; surface finish eg bright drawn, cold drawn, plated, painted, plastic coated; size eg diameter(s), thickness, gauge; identification coding eg International Organisation for Standardisation (ISO) and British Standards Institution (BSI) materials coding systems, suppliers and organisation's colour codes

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:		To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:	
P1	describe the properties that are used to define the behaviour of common engineering materials	**M1**	explain the choice of material for a given engineering component based on the material's properties	**D1**	establish that a material has the required properties for a given application.
P2	review the properties of a given ferrous metal and a given non-ferrous metal [IE1, CT2]	**M2**	select an appropriate form of supply for a given material requirement.		
P3	review the properties of a given organic material, a given thermoplastic, a given thermosetting polymer and a given smart material [IE1, CT2]				
P4	identify symbols and abbreviations used on given engineering documentation [IE4]				
P5	identify the forms of supply available for a given engineering material. [IE1, IE4]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using lectures, tutor-led demonstrations and material tests. Since most learners are unlikely to have had prior instruction on the properties, uses and selection of materials it is essential that some formal introduction to the unit content is given. The unit could then be delivered with an investigative emphasis. Learners should have the opportunity to handle a wide range of materials and recognise them in the workshop environment. Informal and improvised materials testing techniques can be devised to confirm the properties of materials, for example weight/density, appearance (colour/hue, texture), accompanied by an element of formal testing (hardness, impact, tensile tests) where facilities are available.

It will be of value to give a historical setting to the introduction and use of particular engineering materials. Learners should be given an appreciation of developments leading from the small range of materials available in ancient times to the wide range available today. They might be made aware of how the spread of industry, demands of warfare and the advent of space travel have brought about advances in materials technology. Information on the properties and forms of supply of engineering materials should be made accessible. A range of engineering drawings, specifications and documentation should be available for material identification and selection exercises. Access to databases and the internet would be an advantage.

The unit can be delivered in a particular engineering context. However it would be advantageous to choose an approach that draws on examples and applications from different areas of engineering. The delivery approach used will best be determined through an analysis of the learners' needs and in particular through consideration of the range of industries for which centres are preparing them.

The two learning outcomes are ordered logically and it is reasonable to develop them sequentially. To begin with it will be necessary to define the properties used to characterise the range of materials. Having done this, the materials can be described and classified in terms of their properties, typical applications, forms of supply and identification.

Analytical skills are required at merit and distinction level and formative work during delivery will encourage learners to relate material properties and form of supply to a wide range of applications. Industry links could be particularly valuable in this respect by providing materials, components and applications that relate to local organisations/employers.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content • define mechanical properties, electromagnetic properties and properties of durability and resistance to chemical attack • describe and discuss typical components and applications where knowledge of these properties is essential to good design.
Whole-class teaching: • describe composition, appearance and properties of the range of ferrous materials. Discuss applications, view and handle specimen components • describe composition, appearance and properties of the range of non-ferrous materials. Discuss applications, view and handle specimen components • describe composition, appearance and properties of the range of polymer materials. Discuss applications, view and handle specimen components • describe composition, appearance and properties of the range of organic and smart materials. Discuss applications, view and handle specimens. Individual or small-group activity: • carry out investigation involving visual and tactile recognition of materials and informal property tests.
Preparing for and carrying out assignment 1 (P1, P2 and M1).
Whole-class teaching: • explain abbreviations used for items on engineering drawings and documents. Individual or small-group activity: • interpret material specifications on given drawings and documents. Whole-class teaching: • describe and discuss surface finishes resulting from cold and hot forming processes • describe and discuss paints commonly used for surface protection • describe and discuss plating techniques commonly used for surface protection. Individual or small-group activity: • carry out investigation involving visual and tactile recognition of the range of surface finish and surface protection. Whole-class teaching: • describe commonly available range of barstock, pipe, tube, wire and extruded sections • describe commonly available range of rolled sheet, plate and structural sections • describe procurement of castings, forgings and mouldings. Individual or small-group activity: • carry out investigation to identify the suppliers and costs of given materials.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • describe and discuss ISO and BSI identification codes for common engineering materials • describe and discuss typical in-house colour coding systems used for barstock and other materials • describe and discuss typical in-house systems used by engineering firms to identify and locate materials in stock. Individual or small-group activity: • carry out exercise to identify material types and properties from coded information.
Preparing for and carrying out assignment 2 (P3, P4, P5, M2 and D1).

Assessment

Evidence of achievement of the learning outcomes and Assessment and grading criteria may be obtained from well-planned investigative assignments or reports of workshop activities. Alternatively, it may be accumulated by learners building a portfolio from investigations and observations in the workplace or through realistic exercises and tests. In either case the opportunity should exist for merit and distinction grades to be achieved with relevant and sufficient evidence to justify the grade awarded. It is anticipated that integrative assignments might be used to link this unit with others in the programme. If this approach is adopted, the evidence for the specific learning outcomes and associated assessment and Assessment and grading criteria will need to be clearly identified separately.

Assuming that the unit is delivered in the same order as the learning outcomes, the criterion P1 could be met through a short, written task in which learners are required to define a given mechanical property, a given electromagnetic property and a given chemical/durable property from the range. It may be more appropriate however, to link it with the criteria P2, P3 and M1 in an assignment that asks the learner to define behavioural properties and then to describe the properties of given materials combined with the reasons for choosing one of them in a given application.

Criterion P4 could be met in isolation by means of an identification exercise in which learners are presented with an engineering drawing or document and asked to identify the materials specified as abbreviations or symbols. Alternatively, it might be linked with P5, M2 and D1 in an assignment that requires the learner to identify material specifications from given drawings or documents, identify the available forms of supply and select the most appropriate for the specification. The properties of the specified material might then be evaluated (D1) to confirm that it is suitable for the given application. This could be achieved by reference to a material database, BS/ISO specifications, suppliers' catalogues and websites.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1	Properties of Engineering Materials	Learners need to assess behavioural properties of engineering materials. Also to explain the properties of given materials and the reasons for choosing one of them in a given application.	A report containing written responses to the set tasks.
P4, P5, M2, D1	Identifying Engineering Materials	Learners to identify material specifications from given documents, identify available forms of supply and select the most appropriate for the specification. Also to evaluate selection of the material for the given application.	A report containing written responses to the set tasks.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Properties and Applications of Engineering Materials
	Interpreting and Using Engineering Information	
	Application of Welding Processes	
	Casting and Moulding Engineering Components	

Essential resources

A range of ferrous and non-ferrous metals in their different forms of supply should be made available for identification and demonstration purposes. A variety of finished components which illustrate the application of particular materials should also be provided.

In addition to standard workshop tools and equipment used for informal testing, engineering drawings, parts lists and service manuals should be available to assist in the identification of materials.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Learning outcome 2 particularly lends itself to investigating the selection and use of materials in the real world of engineering production and company visits will enhance delivery of this part of the unit.

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

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

Indicative reading for learners

Textbooks

Askeland D – *Science and Engineering of Materials* (Cengage Publishing, 2006) ISBN 0495244422

Sullivan M and Shackleford J – *Introduction to Materials Science for Engineers* (Prentice Hall, 2004) ISBN 0131276190

Tooley M – *BTEC First Engineering* (Newnes, 2006) ISBN 0750680601

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying symbols and abbreviations used on given engineering documentation identifying the forms of supply available for a given engineering material
Creative thinkers	asking questions when reviewing the properties of engineering materials to extend their thinking.

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

Skill	When learners are …
Reflective learners	explaining the properties that are used to define the behaviour of common engineering materials describing the properties of a given engineering material
Team workers	participating in small groups to carry out exercises in material identification and forms of supply
Self-managers	preparing for and carrying out set assignments
Effective participators	discussing issues relating to the properties and applications of engineering materials.

Functional Skills – Level 2

Skill	When learners are …
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	identifying forms of supply available for engineering materials
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the properties that are used to define the behaviour of common engineering materials describing the properties of given engineering material.

Unit 9: Engineering Assembly Methods and Techniques

Unit code: L/600/0404

QCF Level 2: BTEC First

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit aims to give learners the skills and knowledge needed to carry out a range of relevant assembly methods and techniques on engineering equipment.

Unit introduction

Many engineering activities rely on the correct arrangement of components and assemblies to carry out specific functions. This unit aims to give learners the skills and knowledge needed to carry out a range of relevant assembly methods and techniques on engineering equipment. For example the assembly/sub-assembly and fitting of mechanical, electrical/electronic, fluid power and pipework components or systems in accordance with approved procedures.

Learners will use a range of assembly tools and equipment and check that they are in a safe and usable condition. When assembling components the learner will be required to work to given procedures and check that they have the appropriate information and tools to carry out the task set. Having followed the assembly instructions the learner will be expected to ensure that the components are correctly orientated, positioned and aligned. They will also need to check that moving parts have the correct working clearances, that all fasteners are tightened, that wiring or piping is correctly laid and that the assembly functions as per the specification.

The unit can be applied within a specific area such as fluid power equipment, but it is more likely that a range of disciplines will be covered in any one assembly task. For example, the fitting of a fluid pump may well require mechanical, electrical and pipework skills and knowledge. Learners will need to have a basic understanding of the components being assembled, their functions and expected operating parameters.

Safe working practices and good housekeeping will be a recurrent theme throughout the unit. The learner will be expected to demonstrate an understanding of the responsibility they have for their own safety and that of others in the workplace.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use tools, equipment and measuring instruments safely

2 Be able to assemble components to engineering equipment.

Unit content

1 Be able to use tools, equipment and measuring instruments safely

Tools, equipment and measuring instruments: hand tools eg hacksaws, files, spanners, wrenches, sockets, screwdrivers, crimping tools; power tools eg drills, air tools, soldering irons; equipment eg for lifting and moving, jigs, fixtures, supports, wiring looms; measuring instruments eg rule, tape measures, micrometers, gauges, multimeters

Fit for service: appropriate to assembly task eg following the guidance of drawings, job instructions, assembly procedures; health and safety considerations eg safe working methods, relevant regulations and guidelines, use of control of substances hazardous to health (COSHH) sheets, risk assessment, personal protective equipment and clothing; safe and serviceable condition; permitted operating range eg torque, safe working load, voltage/current range

Quality checks: completeness; alignment; positional accuracy; component security; damage or foreign objects; specific component checks eg pipework (correct direction and flow, component quality such as pipes free from ripple, creases), electrical/electronic (correct inputs/outputs, electrical continuity), fluid power (dimensions, function, leak and pressure testing, electrical continuity, pipework free from ripple and creases), sub-assemblies (function, dimensions, freedom of movement, orientation, operating/working clearances, bearing end float)

Engineering equipment: any relevant assembly or sub-assembly with a range of components eg mechanical, electrical/electronic, pipework, fluid power equipment

2 Be able to assemble components to engineering equipment

Connect/fit components: this may be for pipework, electrical or electronic, or fluid power, eg:

- pipework: control components eg valves, taps, regulators; storage devices eg tanks and reservoirs; monitoring equipment eg sensors, meters, gauges; fluid distribution equipment eg motors, pumps; use of steel, copper, plastic pipes and flexible hoses; joining methods eg compression joints, brazing/soldering/cementing/bonding; connectors eg straight, reduction, elbows, flanges
- electrical or electronic: components eg conduit, trunking or tray type cable enclosures, plugs and sockets, sensors, motors, transformers, relays, solenoids, switches, electronic modular units, instrumentation units; techniques eg routing cables and wires, mounting/securing components, cable fixings and fasteners, terminating and joining cables/wires using screwed/clamped/soldered/crimped connections; use of cable protection devices eg sleeving or grommets
- fluid power: components eg motors, pumps, compressors, intensifiers, filters, lubricators, separation units, reservoirs, accumulators, sensors, meters, gauges and indicators; pipework and connection devices eg manifolds, couplings, laying pipework/cables/wires; control components eg valves, actuators/cylinders, regulators

Assembly methods and techniques: fitting eg filing, scraping, lapping, polishing, blue bedding of components, shimming and packing, use of expansion/contraction methods; securing eg fasteners, threaded devices, bolt locking methods, riveting, soldering/brazing, sealants and adhesives; use of tools eg drilling, reaming, soldering irons, press tools; quality checks eg setting working clearances, torque setting, alignment, balancing; use of assembly aids and equipment eg work-holding devices, jigs and fixtures, supports, lifting and moving equipment, rollers or wedges; working within specified time frames eg estimating time to complete task, working to set times, carrying out time and motion studies; maintaining safe working environment eg appropriate and approved assembly techniques used at all times, work-area housekeeping, awareness of potential risks and hazards

Assembly task: this may be either sub-assemblies or assemblies eg single components, component kits, fastener kits, casings, panels, support frameworks

Quality and accuracy: national standards eg British Standards (BS) and/or International Organisation for Standardisation (ISO); design standards eg customer standards and requirements, company standards and procedures; specified instructions eg specific system requirements, operational manuals, manufacturer's instructions; co-ordinating with others eg supervisors/line managers, customer feedback, inspection/ quality control teams

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 check that given tools, equipment and measuring instruments are fit for service [IE1]	**M1** explain the action to be taken with defective or inappropriate tools, equipment and measuring instruments	**D1** evaluate the assembly methods and techniques used to carry out an assembly task and make a proposal for improvement.
P2 use tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment [SM2, SM4]	**M2** correct any assembly problems that occur and that are within their control.	
P3 connect/fit components to engineering equipment		
P4 use given tools and relevant assembly methods and techniques to carry out an assembly task safely [SM4, RL3]		
P5 check the compliance of an assembly for quality and accuracy.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

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

The two learning outcomes logically follow one another and it would make sense to deliver them sequentially. In this way, learners will begin to recognise a range of specific tools and their function and limits related to specific tasks, components and assemblies. This will also help retain a practical approach rather than spending too much time on theory. For example, a short introduction to a component, the function of the component within the larger assembly, the tools necessary to carry out the assembly task and their limits, together with any safety considerations, followed by practise. Once learners have the necessary knowledge and skills to work with a sufficient range of tools the other aspects can then be introduced. This will include working to instructions, quality checking own/others' work, and checking compliance with given standards and specifications.

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

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and method of assessment • explain workshop layout and health and safety requirements relevant to assembly processes • explain importance of using PPE and guards • explain and discuss COSHH regulations • view a range of hand-tools, equipment and measuring instruments, explaining their safe use and storage • explain importance or working to job instructions and assembly drawings.
Whole-class teaching and practical workshop exercise: • introduce and explain the requirements of inspection • carry out inspection on selected systems and components.
Whole-class teaching and practical workshop exercise: • explain importance of working to set times • introduce and explain the requirements of assembly, fitting and joining exercises • tutor demonstration/group practical of assembly, fitting and joining techniques.
Individual learner activities: • carry out risk assessment of practical activities and prepare for, and carry out assembly, fitting and joining exercises, including component removal/refitting, equipment strip and rebuild. Prepare for and carry out assignment 1 (P1, P3, P4, M2, D1).
Whole-class teaching: • explain the importance of quality checks • tutor demonstration of correct and safe procedures for carrying out quality checks. Individual learner activities: • prepare for, and carry out quality checking exercises.
Whole-class teaching: • explain specific system quality requirements • explain importance of customer feedback and co-ordinating with line managers and quality control teams. Group activity: • discuss impact of quality and accuracy on production or maintenance of final product.
Individual learner activity: • investigate and carry out quality checks during and on completion of assembly tasks • prepare for and carry out assignment 2 (P1, P2, P5, M1).
Unit review, feedback and evaluation.

Assessment

A large proportion of the assessment for this unit will occur naturally through tutor observation and oral questioning. To support the high level of process evidence, centres will also need to consider what additional product evidence (that so often surrounds a process) could be used. For example, the use of a logbook record of the assembly task(s) carried out. The log could contain a description of the task undertaken, the instructions provided (annotated to record progress or difficulties), a list of tools provided and their condition, written tool/equipment defect reports and relevant photographs that have been annotated to explain procedures/difficulties. Such supporting product evidence would then validate the tutor or witness observation/oral questioning records and vice versa.

For summative assessment it is unlikely that group work would be appropriate unless very large assemblies were available. To achieve the unit each learner must provide individual evidence of achievement for all the learning outcomes and as such all the pass criteria.

To achieve a pass grade, all the pass criteria must be met. It can be seen from the grading grid that there are three main tasks to be carried out – using tools, equipment and measuring instruments (P2), connecting/fitting components (P3) and carrying out an assembly task safely (P4).

These three main tasks are supported by the two other 'checking' criteria – P1 and P5. This may mean that these two criteria (P1 and P5) are visited more than once depending upon the approach taken.

All the criteria can be covered through one single assignment, based around a carefully selected assembly task that enables learners to demonstrate all the necessary skills and knowledge. However two or more assignments would be suitable, and centres should determine the range of assessment opportunities. Having done so, to then decide when they (the assessor) are confident that the learner would be able to demonstrate the criteria in any future context and indicate to the learner what has been achieved and what needs further evidence.

Learners will need to be given an assembly task to carry out that involves connecting/fitting, and the appropriate tools, equipment and measuring instruments. Learners will need to check that the tools and equipment are appropriate to the assembly task including health and safety considerations, and that they are in a safe and serviceable condition. They should also be given an opportunity to explain the action to be taken with any tools, equipment or measuring instruments that are defective or inappropriate (M1). Centres may need to arrange such situations for the purpose of this criterion, by issuing learners with some defective or inappropriate tools in the tool kit provided for the task(s). If it did happen naturally then, of course, this evidence can be captured for the individual learner's summative assessment records but this should not be left to chance.

Similarly, when carrying out the assembly task, situations where assembly problems occur may need to be arranged, in order that learners can achieve M2. For example, the learner could be provided with incorrect parts such as bolts that are too short, but which they are able to requisition the correct replacements from the workshop stores under their own authority.

Once learners have carried out the assembly task, they will need to check the compliance of the assembly for quality and accuracy. The quality and accuracy requirements should also be provided by the tutor. To achieve a distinction grade, the learner must also be able to evaluate assembly methods and techniques used to carry out an assembly task and make a proposal for improvement. There is a direct link between the criteria P4 and D1, and centres may choose to make this opportunity explicit in the task/assignment brief that is used with the learner.

It is important that the criteria that include 'tools, equipment and measuring instruments' (P1, P2, M1) are not fragmented. It is expected that the task(s) chosen for summative assessment will require learners to use all three (ie tools, equipment and measuring instruments).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P3, P4, M2, D1	Using Assembly Methods and Techniques	An activity requiring learners to carry out a given assembly task, including connecting/fitting components, using given tools, equipment and measuring instruments. Learners will need to check that tools to be used are fit for service.	Practical task evidenced through completion of a logbook and tutor observation.
P1, P2, P5, M1	Carrying out Quality Checks	An activity requiring learners to carry out quality checks on engineering assemblies. Learners will need to check that tools to be used are fit for service.	Practical task evidenced through completion of a logbook and tutor observation.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	
	Operation and Maintenance of Mechanical Systems and Components	
	Operation and Maintenance of Electrical Systems and Components	
	Operation and Maintenance of Electronic Systems and Components	
	Operation and Maintenance of Fluid Power Systems and Components	

This unit has links with and supports the Level 2 SEMTA National Occupational Standards in Mechanical Manufacturing Engineering:

- Unit 27: Producing Mechanical Sub-Assemblies/Assemblies
- Unit 28: Assembling Fluid Power Components to Mechanical Equipment
- Unit 29: Assembling Electrical or Electronic Components to Mechanical Equipment
- Unit 30: Assembling Pipework Components to Mechanical Equipment.

Essential resources

To deliver this unit centres will need to have, or at least have access to, a range of components and assemblies to enable learners to carry out the practical aspects of the unit as defined by the content and grading criteria. Centres will also need a range of suitable tools, equipment and measuring instruments to support the cohort size undertaking the units.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the work can be set in the context of learners' work placements or be based on case studies.

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

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

Indicative reading for learners

Textbook

Tooley M – *BTEC First Engineering* (Newnes, 2006) ISBN 0750680601

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying problems to resolve when checking the suitability of tools and equipment
Reflective learners	reviewing progress when carrying out an assembly task and acting on the outcomes
Self-managers	anticipating, taking and managing risks to ensure an assembly task is carried out safely.

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

Skill	When learners are …
Creative thinkers	trying out alternative or new solutions when carrying out an assembly task and following ideas through
Reflective learners	reviewing progress to identify assembly problems and acting on the outcomes to correct them.

Functional Skills – Level 2

Skill	When learners are …
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading and interpreting procedures, national and design standards and specified instructions.

Unit 10: Using Computer Aided Drawing Techniques in Engineering

Unit code: L/600/0399

QCF Level 2: BTEC First

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners the opportunity to use computer aided drawing (CAD) techniques in an engineering context.

Unit introduction

CAD is used extensively throughout the engineering industry as a means of communicating drawing data to required standards. Two and three-dimensional representations of components can be drawn and modified allowing the sharing of data from designer to customer. CAD data can be shared with CNC machines and Computer Aided Manufacturing (CAM) software, which may then assist in improving productivity, flexibility and quality of the final product. In addition 3D CAD models can be realised using rapid prototyping techniques quickly and at low cost.

The unit will provide learners with an introduction to CAD and enable them to produce engineering drawings to given industry standards. The unit will provide the necessary foundation to study CAD at a higher level. There are several units at Level 3 which are a natural progression from this Level 2 unit.

To achieve this unit the learner will be expected to produce engineering drawings using the standard conventions of orthographic and isometric projection and electrical/electronic, pneumatic or hydraulic circuit diagrams. In addition learners will be able to access drawings to modify previously created drawings and circuits.

Learners will also be expected to understand and apply the basic procedures of starting up and closing down a CAD system and the storage, retrieval, modification and printing/plotting of drawings.

Learning outcomes

On completion of this unit a learner should:

1 Be able to start up and close down hardware and software in order to perform CAD activities

2 Be able to produce CAD drawings

3 Be able to modify engineering drawings using CAD commands

4 Be able to store and retrieve engineering drawings for printing/plotting.

Unit content

1 Be able to start up and close down hardware and software in order to perform CAD activities

Start up: system configuration eg digitiser, printer/plotter; power up and execute software in correct order; set up the environment eg paper size, units, layers, colours, toolbars; produce standard layout including a border, title block and logo

Close down: exit, close down and switch-off system in the approved manner

2 Be able to produce CAD drawings

CAD drawings: 1st or 3rd angle orthographic projections of components and assemblies; isometric projections of components; circuit diagram types eg pneumatic, hydraulic, electrical, electronic; use of standards eg BS8888, BS3939, BS2917

Drawing commands: co-ordinates eg absolute, relative and polar entry systems; features eg types of line, grids, snaps, circle, text, hatching, dimensioning; viewing eg zoom-in, zoom-out, previous and pan

3 Be able to modify engineering drawings using CAD commands

Modify drawings: orthographic projections of components and assemblies; isometric projections of components; circuit diagrams

Commands: eg array/pattern, copy/duplicate, move, rotate/revolve, erase, stretch, trim, scale, chamfer and fillet, change layers/levels, colours and types of line

4 Be able to store and retrieve engineering drawings for printing/plotting

Storage: set up computer-based directories, folders and files for storing drawings; store drawings

Retrieval: retrieve drawings for editing and printing; set-up and print/plot drawings in a range of sizes

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	start up a CAD system, produce and save a standard drawing template and close down CAD hardware and software in the approved manner	**M1**	identify and describe four methods used to overcome problems when starting up and closing down CAD hardware and software	**D1**	justify the use of CAD for the production of a range of drawing types
P2	produce a CAD drawing using an orthographic projection method	**M2**	describe the drawing commands used across the range of drawing types	**D2**	demonstrate an ability to produce detailed and accurate drawings independently and within agreed timescales.
P3	produce a CAD drawing using an isometric projection method [IE1, CT1, CT5]	**M3**	describe the methods used to create relevant folder and file names and maintain directories to aid efficient recovery of data.		
P4	produce a circuit diagram using CAD [IE1, CT1, CT5]				
P5	use CAD commands to modify a given orthographic and isometric drawing [IE1, CT1, CT5]				
P6	use CAD commands to modify two different given circuit diagram types [IE1, CT1, CT5]				
P7	set up an electronic folder for the storage and retrieval of information				
P8	store, retrieve and print/plot seven CAD-generated or modified drawings. [IE1, CT1, CT5]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit is best suited to a practical delivery approach. Since most learners are unlikely to have had experience in this area of work, it is essential that some formal introduction to the unit content is given.

Although learners are likely to be relatively proficient in the use of a computer system, the differences between software that they may be familiar with and CAD packages should be emphasised. Similarly an introduction to engineering drawing presentation and exercises on how drawings are constructed would be beneficial.

Learners should be given the opportunity to familiarise themselves with the fundamental drawing and editing commands, initially through a series of basic activities that will develop and build on these CAD skills. As learners acquire competence with the range of skills required then the complexity of the drawings tackled could be increased. It is not necessary for this formative work to be presented as assessment evidence. These formative activities will enable the tutor to provide practical support and guidance for the learner and enable them to gain a view of the learner's progress and potential.

The use of pre-printed activity sheets will allow learners to develop skills and knowledge at an appropriate pace and enable the tutor to focus on those learners who are less familiar with the system.

At key points in the learners' development the assignments can be introduced. For example, learners should be able to follow the conventions of constructing CAD drawings using orthographic projection and demonstrate this before the first assignment is introduced.

Learners will require an introduction to isometric drawing and need to gain some familiarity with developing this type of drawing before the second assignment is undertaken.

Similarly, proficiency in the development of circuit diagrams would be expected before undertaking assignment 3. Although CAD software can be used to construct circuit diagrams other proprietary software and/or circuit symbols may be used to develop this element as appropriate.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to CAD system • exercise on using the operating system to identify and activate CAD software. Tutor demonstration/individual practical activities: • introduction to system configuration and setting up the drawing environment including the use of relevant toolbars and menus • exiting and closing down the CAD system. Whole-class teaching: • use of appropriate standards used in creating drawings eg BS 8888, BS 3939, BS 2917.
Whole-class teaching: • alignment and presentation of views in 1st and 3rd angle projection systems and the use of standard drawing layouts including a border, title block and logo Individual learner activities: • exercises developing CAD skills and using relevant use of navigation commands eg absolute, relative and polar entry systems • exercises developing CAD skills and using relevant use of drawing commands eg types of line, grids, snaps, circle, text, hatching, dimensioning • exercises to produce, store, retrieve and modify CAD-generated drawings.
Tutor demonstration/individual practical activities: • printing/plotting drawings using appropriate scale and paper size in order to produce hard copies of CAD-generated drawings of components and assemblies in 1st/3rd angle orthographic projection • using editing and modification commands eg array, copy, move, rotate, erase, stretch, trim, scale, chamfer and fillet, change layers, colours and line types.
Preparation for and carry out assignment 1 (P1, P2, P7, P8 and D2 (part – 1st drawing).
Individual learner activities: • exercises on using isometric tools and techniques to produce CAD-generated drawings • exercises on using scale and paper size in order to produce hard copies of isometric drawings.
Preparation for and carry out assignment 2 (P3, P5, M1, M3 and D2 (Part – 2nd drawing).
Individual learner activities: • exercises on using appropriate tools and techniques to produce CAD-generated drawings of components, symbols and associated hardware used in circuit diagrams eg hydraulic, electronic, electrical, pneumatic • exercises on using text annotation to correctly label circuit components • exercises on the use of appropriate scale and paper size in order to produce hard copies of circuit diagrams.
Prepare for and carry out assignment 3 (P4, P6, M2, D1 and D2 (Part – 3rd drawing).
Unit review, feedback and evaluation.

Assessment

Evidence may be collected from a planned series of competence based practical drawing activities. The assessment will, most likely, be based on the product of these activities and the tutor's observations/oral questioning of the learner during the process of producing the drawings. If so, it is important that a careful assessment record of this process evidence is maintained in addition to the portfolio of drawings used for final assessment. Witness statements will be a good way of collecting the process-type evidence required by the assessment criteria. Screen dumps are also very useful to show structure of folders, commands used and time taken.

It may be appropriate to devise three assignments. Assignment 1 will involve producing an orthographic drawing (P2) and should include the starting up and closing down of a CAD system (P1), the storing, retrieving and printing/plotting of CAD drawings (P8), and the setting up of an electronic folder for storage and retrieval purposes (P7). The use of witness statements and screen dumps can be used to demonstrate competence in these elements and the ability to produce detailed/accurate drawings within agreed timescales (part of D2).

Assignment 2 will involve producing an isometric drawing (P3) and modifying given orthographic and isometric drawings (P5). In addition a written description of the methods used to overcome problems when starting-up and closing-down CAD hardware and software (M1) and to create relevant folder and file names and maintain directories to aid efficient recovery of data (M3) is needed. It would also address the second drawing required by D2.

The third assignment will involve producing a circuit diagram (P4) and modifying two given circuit diagrams of different types (P6). The different circuit diagrams could be an electronic, electrical, hydraulic or pneumatic circuit and will depend on the learner's particular interests and chosen area of work. A written response should also be used to describe the range of drawing used across the range of drawing types (M2) and to justify the use of CAD for the production of a range of drawing types (D1). Again, witness statements and screen dumps can be used as evidence of competence for these elements and to demonstrate the ability to produce detailed/accurate drawings within agreed timescales (part of D2).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P7, P8 and D2 (In part – 1st drawing)	CAD Drawing Using an Orthographic Projection Method	Learners produce a CAD drawing using orthographic projection from a given diagram/component.	A practical activity. Evidence is likely to be in the form of an electronic file containing a CAD drawing showing appropriate use of orthographic projection techniques together with a plotted/printed hard copy. Witness statements demonstrating time taken and competence in setting up/closing down CAD hardware/software and setting up and using electronic folders for storage/retrieval of CAD drawings. Screen dumps can be used to show folder structure etc.
P3, P5, M1, M3 and D2 (In part – 2nd drawing)	CAD Drawing Using an Isometric Projection Method and Modifying Given Orthographic and Isometric Drawings	An activity requiring learners to produce a written report describing methods used to overcome problems when starting up and closing down CAD hardware and software. In addition the report should describe methods used to create files, folders and directories to aid efficient recovery of data. This report should be accompanied by a CAD drawing using isometric projection from a given diagram/component. In addition learners should modify given isometric and orthographic drawings.	A report containing written responses about methods used to overcome problems when starting up and closing down CAD hardware and software. The report should also contain written responses about methods used to create files, folders and directories to aid efficient recovery of data. In addition electronic files and hard copies of a CAD drawing created using isometric projection and modified CAD drawings using isometric and orthographic techniques. Screen dumps can be used to show an annotated range of commands used and time taken.

Criteria covered	Assignment title	Scenario	Assessment method
P4, P6, M2, D1 and D2 (In part – 3rd drawing)	Producing a Circuit Diagram Using CAD and Modifying Two Given Circuit Diagrams	An activity requiring learners to produce a circuit diagram and modify two circuit diagrams using CAD techniques including a description of the range of drawing commands used in producing different drawing types and a justification of the use of CAD for producing these drawings.	A report containing written responses about the range of drawing commands used in producing different drawing types and a justification of the use of CAD for producing these drawings. In addition electronic files and hard copies of a circuit diagram created and two diagrams that have been modified. Screen dumps can be used to show an annotated range of commands used and time taken.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Interpreting and Using Engineering Information	Computer Aided Drafting in Engineering

Achievement of the learning outcomes of this unit will contribute skills, knowledge and understanding towards the Level 2 NVQ in Performing Engineering Operations, particularly:

- Unit 3: Using and Communicating Technical Information
- Unit 4: Producing Mechanical Engineering Drawings Using a CAD System
- Unit 32: Producing Electrical or Electronic Engineering Drawings Using a CAD System
- Unit 61: Producing CAD Models (Drawings) Using a CAD System
- Unit 63: Using Computer Software Packages to Assist with Engineering Activities.

Essential resources

Centres will need to have access to a suitably equipped computing room with printing/plotting facilities. Software requirements for this unit may be considered at an introductory level, for which there are suitable inexpensive packages available. However centres need to consider the use of packages appropriate for further levels of study and that they produce output that is to appropriate British Standards. A range of computer packages may be used in addition to a conventional CAD package particularly where the production of circuit diagrams is concerned.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the work can be set using real engineering drawings and drawings from local employers or gathered during work placements should be referenced. Company visits will allow the learners to observe the use of CAD generated drawings in manufacture, inspection, CAD/CAM etc.

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

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

Indicative reading for learners

Textbooks

Ambrosius L – *AutoCAD 2009 and AutoCAD LT 2009 All-in-one Desk Reference for Dummies, 2nd Edition* (John Wiley and Sons, 2008) ISBN 0470243783

Cheng R – *Using Pro/Desktop 8* (Delmar Learning, 2004) ISBN 1401860249

Conforti F – *Inside Microstation XM* (Delmar Learning, 2005) ISBN 1401814816

Simmons C and Maguire D – *Manual of Engineering Drawing to British and International Standards* (Newnes, 2004) ISBN 0750651202

Yarwood A – *Introduction to AutoCAD 2009: 2D and 3D Design* (Newnes, 2008) ISBN 0750689838

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirer	identifying questions to answer and problems to resolve when preparing to produce a range of CAD drawings
Creative thinkers	generating ideas and exploring possibilities when producing CAD drawings.

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

Skill	When learners are …
Reflective learners	reviewing the progress made against individual tasks and assignments.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using a CAD system to create a variety of drawings for use in different contexts
Manage information storage to enable efficient retrieval	creating a file/folder system for the storage and retrieval of CAD drawings
ICT – Develop, present and communicate information	
Present information in ways that are fit for purpose and audience	plotting/printing a variety of CAD drawings
Evaluate the selection and use of ICT tools and facilities used to present information	justifying the use of a CAD system for the production of engineering drawings.

Unit 11: Operation and Maintenance of Mechanical Systems and Components

Unit code: A/600/0401

QCF Level 2: BTEC First

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will develop learners' knowledge of the function, operation and maintenance of a variety of mechanical systems and system components.

Unit introduction

Mechanical engineering equipment, systems, processes and service operations all need to be maintained to ensure continued serviceability and fitness for purpose. This unit has been designed to ensure that learners' have the knowledge and skills necessary to undertake such maintenance in a safe and efficient manner.

Learners will gain knowledge of the safety precautions required for personal protection, the protection of others and the safe handling of the equipment and systems they will find in a mechanical engineering environment.

Learners will be introduced to the function and operation of a variety of mechanical systems and system components, and will be expected to carry out maintenance on these systems and components. In particular, learners will carry out activities that develop their skills and knowledge in fault-finding, routine maintenance, dismantling and assembly of a variety of mechanical systems.

Learners will be expected to obtain all necessary information, documentation, tools and equipment, prior to carrying out any given maintenance activity. They will also need to demonstrate that they can select, follow and correctly interpret maintenance procedures, safe working practices and health and safety requirements when carrying out routine maintenance activities.

Learning outcomes

On completion of this unit a learner should:

1. Know about the workplace hazards and health and safety requirements associated with mechanical maintenance operations
2. Know the operation of mechanical systems
3. Understand the selection, function and operation of mechanical system components
4. Be able to fault-find and carry out routine maintenance activities on mechanical components and systems.

Unit content

1 Know about the workplace hazards and health and safety requirements associated with mechanical maintenance operations

Workplace hazards: eg flammable substances, pressurised systems, hot surfaces, electrical equipment, unfenced machinery, toxic substances and fumes, falling objects, liquid spillage, untidy work area, badly maintained tools and equipment

Health and safety requirements: personal safety eg appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators; personal health eg appropriate use of barrier creams, personal cleanliness, consumption of food, prompt attention to injuries; procedures eg response to alarms, use of safety equipment, reporting of accidents, reporting of hazardous items of plant or equipment; safe working practices eg permit to work, use of danger tags, warning notices, safety barriers, cones and tapes, isolation of equipment, proof marking, recording of maintenance operations

2 Know the operation of mechanical systems

Mechanical systems: block diagram representation, operation of systems eg:

- ◊ power transmission systems (such as belt drives, chain drives, gearboxes, transmission shafts)
- ◊ lifting and handling systems (such as cranes, hoists, jacks, roller and belt conveyers, robot arms, mechanical weighing equipment)
- ◊ rotary equipment (such as pumps, compressors, mixers, portable power tools, pillar drills, centre lathes)
- ◊ control systems (such as mechanical governors, valves, pressure switches, thermostats)

3 Understand the selection, function and operation of mechanical system components

Mechanical components: eg:

- ◊ bearings (such as plain journal and thrust bearings, ball bearings, roller bearings, tapered roller bearings, needle bearings, typical faults, grading and coding systems, use of maker's catalogue/database for selecting replacements)
- ◊ seals and gaskets (such as circular oil seals, glands, gaskets, shims, hoses, jointing compounds, typical faults, use of maker's catalogue or database for selecting replacements)
- ◊ lubricating devices (such as grease nipples and cups, capillary action lubricators, gravity feed and forced feed lubricators)
- ◊ fastenings (such as metric bolt and screw types, locking devices, studs, self-tapping screws, rivets)
- ◊ other components (such as springs, couplings, levers, pulleys, chains, sprockets, gears, cams, shafts, structural components, guards)

4 Be able to fault-find and carry out routine maintenance activities on mechanical components and systems

Faults, aids, techniques and documentation: faults eg intermittent operation, partial failure/out-of-specification output, complete breakdowns; aids eg functional charts, diagrams, trouble shooting charts, dial test indicators, torque measuring devices, flow meters, alignment devices, self-diagnostic equipment, pressure/force indicators, component data sheets, software-based records and data; techniques eg six point (collect the evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system), half split, input/output, unit substitution, emergent sequence, visual examination, unit substitution; documentation eg operation and maintenance manuals, fault/repair reports, final test handover procedures

Dismantling and assembly: aids eg use of manufacturers' service manuals, parts lists and drawings, approved working procedures, spare parts catalogues, maintenance manuals; systems eg power transmission, rotary equipment, lifting and handling

Component removal/fit and replacement: components eg fasteners, seals, gaskets, bearings, transmission components; use of appropriate tools, equipment and documentation eg taps, dies, easy-outs, drills, torque wrenches, circlip pliers, jointing compounds, spanners, replacement parts, approved working procedures and spare parts catalogues

Routine maintenance activities and documentation: inspection, checks and tests eg leak detection, wear, chafing, fouling, security of attachment, overheat, corrosion, lubrication, replenishments, adjustments, replacements, repair; reports and documentation eg BS, ISO and/or BSEN standards, scheduled maintenance report, corrective maintenance report, other company-specific report, job cards, maintenance log, recording of condition, use of maintenance manuals and parts catalogues

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the workplace hazards and safe working practices relevant to a given mechanical maintenance operation	**M1**	carry out a risk assessment for a mechanical work area and report on findings	**D1**	analyse a given mechanical system for ease of maintenance
P2	describe with the aid of block diagrams, the operation of a given mechanical system	**M2**	describe the relationship between component faults and the malfunction of a given mechanical system	**D2**	compare and contrast two fault-finding techniques when carrying out maintenance work on a mechanical system.
P3	use manufacturers' databases or parts catalogues to select four mechanical system components [IE4]	**M3**	explain the reasons for following correct procedures and carrying out post rectification tests when undertaking corrective maintenance on mechanical systems		
P4	explain the function and operation of six mechanical system components	**M4**	detail the benefits of carrying out routine maintenance on a mechanical component or system.		
P5	use four fault-finding aids/ techniques to identify the problem in a mechanical system and report findings [IE1]				
P6	use the appropriate aids and tools to dismantle and reassemble a mechanical system, replace any identified faulty components and test the system for serviceability [SM3]				

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P7 carry out a routine maintenance operation on a mechanical component or system, using the correct documentation and record actions. [SM3]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit can be delivered as a stand-alone package or integrated with other units in the qualification such as those outlined below.

This unit is essentially practical and learners should have the opportunity to dismantle, examine and reassemble a range of mechanical components and systems. Ideally the learning outcomes should be achieved through investigation and participation in practical activities. Thus the unit is best delivered through a programme of lectures, demonstrations and practical work.

The approach used will be determined through an analysis of learners' needs and through consideration of the range of industries that the centre is working with or preparing its learners for. Whichever approach is taken should provide learners with the underpinning knowledge and skills required to repair, replace and generally maintain mechanical components and systems in most industrial settings.

Learners must be made aware of, and have access to, relevant UK health and safety legislation and know the importance of the use of risk assessment appropriate to the maintenance techniques they are using. Tutors should always ensure that each learner has the correct personal protective equipment and that the system is safe for operation. It is also important that learners work in a safe manner when using equipment or working on mechanical systems.

The unit provides an opportunity for learners to work in teams or groups when diagnosing component or system faults. The delivery of this unit should focus on learners developing diagnostic and practical skills together with an understanding of mechanical components and systems maintenance.

The four learning outcomes are ordered logically and it would be reasonable to deliver them sequentially throughout the unit.

All the learning outcomes should be delivered using a practical approach rather than spending too much time in theory lessons. For example, a short introduction to a component (or range of components), the function of the component within the larger system, the tools necessary to carry out the maintenance task together with any safety considerations, followed by practise. Learners need a broad overview of the different mechanical components and systems to enable correct selection and application of maintenance, fault-finding and testing techniques.

Learning outcome 4 has a high reliance on understanding developed from the other three learning outcomes. As such, teaching and learning needs to focus on the development of this knowledge so that it may be applied to learning outcome 4. The use of demonstrations to introduce fault-finding, dismantling and assembly techniques, would be a beneficial method of delivery for the learner, prior to them carrying out their practise practical activities and assessments.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, overview of activities and assessment methods, issue of scheme of work/ assessment plan • introduction to types of mechanical systems and components. Identify hazards associated with the mechanical workplace/workshop environment. Practical exercise: • learners identify potential hazards in the workshop/workplace and how the risk from these hazards has been minimised using good practice.
Whole-class teaching/workshop demonstration and practise: • health and safety requirements for a mechanical workshop environment –personal safety, personal health, procedures, safe working practices. Individual learner exercise: • using safety documents and physical walk round, learners to familiarise themselves with centre workshop/ workplace local safety rules, placards and procedures.
Preparation for and carrying out assignment 1 (P1, P2, M1)
Workshop teaching and demonstration: • demonstration and explanation of appropriate system function and operation, using actual mechanical system. Explanation of associated operational and isolation safety of the particular system • demonstration and explanation of mechanical components and consumables eg bearings, seals, gaskets, lubricating devices, fasteners and mechanical hardware • demonstrate use of associated manuals, parts catalogues and manufacturers databases, used for information on component selection, function and where appropriate, operation • using actual mechanical system, demonstrate and explain the function and basic operation of major components. Learner exercise: • write in their own words, the function and operation of the system demonstrated and the associated safety precautions to be observed, before, during and after operation • produce block diagram of the system and its major components, with written description of the function and basic operation of these components within the system.
Practical workshop activities: • given the appropriate maintenance and parts manuals/database, together with a range of mechanical components/consumables learners identify components, state their function, detail common faults and where appropriate describe their operation.

Topic and suggested assignments/activities and/assessment
Prepare for and carrying out assignment 2 (P3, P4, P5)
Workshop/workplace whole-class teaching and demonstration: • fault-finding theory, related safety and use of aids and instruments • application of fault-finding theory to relevant system/s • system dismantling, assembly and functional testing techniques, related safety precautions and use of manufacturers and other maintenance documentation • system component removal and fit/replacement and system functional test. Practical learner exercises: • fault-finding using a range of aids, instruments, techniques and appropriate maintenance documentation/ manuals • system dismantling, assembly and test • system component removal/fit and/or replacement of identified faulty components and post assembly functional testing.
Industrial visit to regional mechanical maintenance company. Learners to complete a pre-designed questionnaire relating to workplace safety, fault-finding and associated maintenance activities.
Preparation for and carrying out assignment 3 (P6, P7, M2, M3, D1, D2).
Workshop teaching and demonstration: • routine maintenance theory, benefits and activities (such as fastener/rivet replacement, bearing replacement/ re-grease, minor repairs, system and component lubrication, replenishments, examination and adjustments), completion of maintenance documentation, and related safety issues. Practical learner exercises: • undertake a range of routine maintenance activities, following best safe practice and completing maintenance documents.
Preparation for and carrying out assignment 4 (P8, M4).
Unit review.

Assessment

Assessment evidence can be collected from well-planned investigative assignments or reports of practical workshop activities. It may be accumulated by learners building a portfolio from their investigations, maintenance activities in the workplace or a tutor-led series of assignments, maintenance exercises and tests.

Evidence of achievement for learning outcome 1 could come from a written assignment, requiring learners to describe the hazards and health and safety requirements related to a mechanical maintenance activity. In order to identify and recognise the significance of workplace hazards and meet M1, learners will need to have an additional task added to this assignment that requires them to undertake a physical investigation/risk assessment of their own workshop or workplace environment and produce a written report on their findings.

Learning outcomes 2 and 3 are linked, so might best be assessed using one combined assessment instrument. A written assignment (completed in a workshop environment) could be used, where learners provide evidence for P2 by sketching a block diagram of a required system, showing the interconnection of its major components. A parts catalogue or access to a suitable database would be needed so that learners' can select four mechanical system components (P3). In order to satisfy P4 learners will need to describe the function and operation of six mechanical components. These should be selected by the tutor based on the specialist needs of the learner.

Learning outcome 4 is best assessed through one or more investigative practical activities carried out in a mechanical workshop environment or at the learner's workplace. A multi-stage practical/theoretical assignment could be set to cover the related criteria (P5, P6, M2, M3, D1, D2), where learners are first required to identify the problem/fault on a given mechanical system using four fault-finding aids/techniques and report their findings. Evidence is likely to come from the learner's report and the results of observation at the time the activity takes place. For P6, learners need to dismantle the system, replace the component/part identified as causing the problem, reassemble the system and carry out a simple test to ascertain serviceability. Assessment evidence can be obtained from the results of tutor observations and by determining whether or not the learner returns the system to a serviceable condition.

In order to meet M2, learners need to investigate and identify the relationship between system component faults and malfunctions, such as intermittent operation, partial failure or complete breakdown. The investigation can look at either the system used for P5 and P6 or another system. A further theoretical task may be set, as part of the overall assignment in order to provide an opportunity to meet M3. This task could be timed to take place at or near the same time as the functional testing of the system carried out for P6.

During or after the fault-finding exercise carried out for P5, learners will need to compare and contrast two fault-finding techniques and provide a suitable written response to their findings (D2). In order to meet D1 the learner will need to analyse the system being worked on or another suitable system in order to assess that particular system for ease of maintenance and produce a short written report, as evidence of achievement.

Learners are required to undertake and successfully complete a routine maintenance activity in order to meet the criteria for P7. A further written task could be incorporated into this assignment in order to meet M4, with learners detailing the benefits of carrying out routine maintenance on mechanical systems, may be used as evidence. The learner's ability to use the correct documentation and accurately record their actions, as well as perform the practical aspects of the given maintenance should be taken into account. This final assignment should be focused on the learner's particular field of mechanical maintenance and the routine maintenance activities applicable to their mechanical systems.

The learner's knowledge of and compliance with all related safety issues, also needs to be assessed during the time that all the above practical assignment activities are being carried out.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Workplace Hazards and Health and Safety in Mechanical Maintenance	Learners carry out an investigation and risk assessment of hazards in their own working environment.	Written response about workplace hazards and health and safety and a written report on a risk assessment, identifying and commenting on findings.
P2, P3, P4	Mechanical Systems and Components	A written activity requiring learners to respond to set tasks, given appropriate components and maintenance documentation.	Written response to set tasks.

Criteria covered	Assignment title	Scenario	Assessment method
P5, P6, M2, M3, D1, D2	System Fault-finding, Dismantling/assembly and Testing	A multi-stage practical and theoretical activity, requiring learners to fault-find, assemble/dismantle and test a mechanical system and to provide a written response to theoretical tasks.	Evidence provided by written results of tutor observations on learners practical activities and learners' written response to results of investigative theoretical tasks.
P7, M4	Routine Maintenance	A practical and part theoretical activity requiring learners to carry out a routine maintenance operation on a mechanical component or system using appropriate documentation.	Evidence provided by written results of viva-voice and tutor observations together with learners' response to written tasks.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Engineering Maintenance Procedures and Techniques
	Operation and Maintenance of Electrical Systems and Components	
	Operation and Maintenance of Electronic Systems and Components	
	Operation and Maintenance of Fluid Power Systems and Components	

The unit has been mapped against the Level 2 SEMTA National Occupational Standards and current NVQs. Achievement of the learning outcomes of this unit will contribute skills and knowledge towards the Level 2 NVQ in Engineering Maintenance and Installation, particularly:

- Unit 4: Handing Over and Confirming Completion of Maintenance or Installation Activities
- Unit 5: Carrying out Fault Location on Mechanical Equipment
- Unit 6: Carrying out Maintenance Activities on Mechanical Equipment
- Unit 7: Restoring Mechanical Components to Usable Condition by Repair
- Unit 8: Carrying out Scheduled Maintenance Activities Mechanical Equipment.

The unit also contributes skills and knowledge to the current SEMTA Level 2 NVQ in Performing Engineering Operations, Unit 19: Maintaining Mechanical Devices and Systems.

Essential resources

Learners will require access to a mechanical engineering workshop equipped with the relevant tools and equipment needed to carry out a range of mechanical maintenance activities. As a minimum learners should have access to:

- a wide range of industry standard, mechanical systems and their associated components and consumables
- appropriate fault-finding instruments, safety equipment and tools
- manufacturers' data books and specifications
- maintenance manuals, parts catalogues and/or databases, flow charts and system diagrams
- British/International Standards, health and safety publications and local workshop safety documentation and procedures.

Employer engagement and vocational contexts

Delivery and assessment of this unit should be set within a vocational context, especially for learning outcome 4. Visits to the learner's workplace or other local mechanical maintenance companies will help foster employer cooperation and set the focus for practical maintenance activities.

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

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

Indicative reading for learners

Textbooks

Knotek R and Stenerson J – *Mechanical Principles and Systems for Industrial Maintenance* (Prentice Hall, 2005) ISBN 9780130494177

Salmon D and Powdrill P – *Mechanical Engineering Level 2 NVQ Performing Engineering Operations* (Newnes, 2002) ISBN 0750654066

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information in manufacturers' databases, evaluating its relevance and value identifying questions to answer and problems to resolve when using a variety of fault-finding techniques to identify the problem
Self-managers	organising time and resources when dismantling, inspecting and reassembling a mechanical system.

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

Skill	When learners are …
Independent enquirers	carrying out routine maintenance operations on mechanical components and systems, that have been identified by inspection and recording actions analysing a given mechanical system for ease of maintenance
Creative thinkers	analysing a given mechanical system for ease of maintenance
Effective participators	carrying out a risk assessment investigation of a mechanical work area and reporting their findings.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Manage information storage to enable efficient retrieval	using manufacturers' databases and/or parts catalogues to identify and select mechanical components
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing the work place hazards and health and safety requirements relevant to given mechanical maintenance activities
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating the function and operation of mechanical systems and components
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the work place hazards and health and safety requirements relevant to given mechanical maintenance activities.

Unit 12: Operation and Maintenance of Electrical Systems and Components

Unit code: F/600/0402

QCF Level 2: BTEC First

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will develop learners' knowledge of the function, operation and maintenance of a variety of electronic systems and system components.

Unit introduction

Electrical engineering equipment, systems, processes and service operations, all need to be maintained to ensure continued serviceability and fitness for purpose. This unit has been designed to ensure that learners' have the knowledge and skills necessary to undertake such maintenance in a safe and efficient manner.

Learners will gain knowledge of the safety precautions required for personal protection, the protection of others and the safe handling of the equipment and systems they will find in an electrical engineering environment.

Learners will be introduced to the function and operation of a variety of electrical systems and system components and will be expected to carry out maintenance on them. In particular, learners will carry out activities that develop their skills and knowledge in fault-finding, routine maintenance, dismantling and assembly of a variety of electrical systems.

Learners will be expected to obtain all necessary information, documentation, tools and equipment, prior to carrying out any given maintenance activity. They will also need to demonstrate that they can select, follow and correctly interpret maintenance procedures, safe working practices, and health and safety requirements when carrying out routine maintenance activities.

Learning outcomes

On completion of this unit a learner should:

1 Know the workplace hazards and health and safety requirements associated with electrical maintenance operations

2 Know the operation of electrical systems and circuits

3 Understand the selection, function and operation of electrical system components

4 Be able to fault-find and carry out routine maintenance activities on electrical components and systems.

Unit content

1 Know the workplace hazards and health and safety requirements associated with electrical maintenance operations

Workplace hazards: eg flammable substances, pressurised systems, hot surfaces, electrical equipment, electrostatic hazards, unfenced machinery, toxic substances and fumes, falling objects, liquid spillage, untidy work area, badly maintained tools and equipment

Health and safety requirements: personal safety eg appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators, electrical testing safety; personal health eg appropriate use of barrier creams, personal cleanliness, consumption of food, prompt attention to injuries; procedures eg treatment for electric shock, response to alarms, use of safety equipment, reporting of accidents, reporting of hazardous items of plant or equipment; safe working practices eg permit to work, use of danger tags, warning notices, safety barriers, cones and tapes, isolation of equipment, proof marking, recording of maintenance operations

2 Know the operation of electrical systems and circuits

Electrical systems: block diagram representation; equipment eg switchgear and distribution panels, electrical plant, wiring enclosures, portable appliances, motors and starters, luminaries, control systems, small fans, pumps, compressors, alarm and safety systems

Electrical circuits: wiring diagram representation; circuit eg single phase power, single phase lighting, three phase power, direct current power

3 Understand the selection, function and operation of electrical system components

System components: electrical supply eg cables and connectors, batteries, transformers, rectifiers, contactors; circuit components eg capacitors, circuit boards, switches, solenoids, thermistors, thermocouples; devices eg overload protection device, inverter and servo controllers, relays, sensors, encoders, resolvers, locking and retaining devices, lighting fixtures; use of maker's catalogue or database for selecting replacements

4 Be able to fault-find and carry out routine maintenance activities on electrical components and systems

Faults, aids, techniques and documentation: faults eg intermittent operation, partial failure/out-of-specification output, complete breakdowns; aids eg functional charts, diagrams, trouble shooting charts, instruments (such as multimeter, insulation resistance tester, light meter, portable appliance tester, earth loop impedance tester), component data sheets, software-based records and data; techniques eg six point (collect the evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system), half split, input/output, unit substitution, emergent sequence, visual examination, unit substitution; documentation eg operation and maintenance manuals, fault/repair reports, final test handover procedures

Dismantling and assembly: aids eg use of manufacturers' service manuals, parts lists and drawings, approved working procedures, spare parts catalogues, maintenance manuals; systems/equipment eg switchgear/distribution panels, electrical plant, wiring enclosures, portable appliances, motors and starters, luminaries, control systems, fans, pumps, compressors, alarm and safety systems

Component/equipment removal and replacement: components eg damaged wires and cables, electrical units/components, termination and connection, soldering and de-soldering; use of appropriate tools, equipment and documentation eg solder, soldering irons, crimping pliers, hand tools, replacement parts, approved working procedures and spare parts catalogues

Routine maintenance activities and documentation: inspection, checks and tests eg as wear, chafing, fouling, security of attachment, missing or loose fittings, adjustments, replacements; reports and documentation eg BS, ISO and/or BSEN standards, scheduled maintenance report, corrective maintenance report, other company-specific report, job cards, maintenance log, recording of condition, use of maintenance manuals and parts catalogues

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the workplace hazards and health and safety requirements relevant to a given electrical maintenance activity	**M1**	carry out a risk assessment for an electrical work area and report on findings	**D1**	analyse a given electrical system for ease of maintenance
P2	describe with the aid of block diagrams, the operation of a given electrical system	**M2**	describe the relationship between component faults and the malfunction of a given piece of electrical equipment or system	**D2**	compare and contrast two fault-finding techniques when carrying out maintenance work on an electrical system.
P3	describe with the aid of diagrams the operation of a given electrical circuit	**M3**	explain the reasons for following correct procedures and carrying out post rectification tests/checks when undertaking corrective maintenance on electrical systems		
P4	use manufacturers' data bases or parts catalogues to select four electrical equipment or system components [IE4]	**M4**	detail the benefits of carrying out routine maintenance on an electrical component, equipment or system.		
P5	explain the function and operation of six electrical system components				
P6	use four fault-finding aids/ techniques to identify the problem in an electrical system and report findings [IE1]				
P7	use the appropriate aids and tools to dismantle and reassemble an electrical system, replace any identified faulty components and check the system for serviceability [SM3]				

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P8 carry out routine maintenance activities on an electrical component or system, using the correct documentation, and record actions. [SM3]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit can be delivered as a stand-alone package or integrated with other units in the qualification such as those outlined below.

This unit is essentially practical and learners should have the opportunity to dismantle, examine and reassemble a range of electrical components, equipment and systems. Ideally the learning outcomes should be achieved through investigation and participation in practical activities. Thus the unit is best delivered through a programme of lectures, demonstrations and practical work.

The approach used will be determined through an analysis of learners' needs and through consideration of the range of industries that the centre is working with or preparing their learners for. Whichever approach is taken should provide learners with the underpinning knowledge and skills required to repair, replace and generally maintain electrical components, equipment and systems in most industrial settings.

Learners must be made aware of, and have access to, relevant UK health and safety legislation and know the importance of the use of risk assessment appropriate to the maintenance techniques they are using. Tutors should always ensure that each learner has the correct personal protective equipment and that the system is safe for operation. It is also important that learners work in a safe manner when using equipment or working on electrical circuits and systems.

The unit provides an opportunity for learners to work in teams or groups when diagnosing component or system faults. The delivery of this unit should focus on learners developing diagnostic and practical skills together with an understanding of electrical components, equipment and systems maintenance.

The four learning outcomes are ordered logically and it would be reasonable to deliver them sequentially throughout the unit.

All the learning outcomes can be delivered using a practical approach rather than spending too much time in theory lessons. For example, a short introduction to a component (or range of components), the function of the component within the larger equipment or system, the tools necessary to carry out the maintenance task together with any safety considerations, followed by practise. Learners need a broad overview of the different electrical components and systems to enable correct selection and application of maintenance, fault-finding and testing techniques.

Learning outcome 4 has a high reliance on understanding developed from the other three learning outcomes. As such, teaching and learning needs also to focus on the development of this knowledge in order that it may be applied to learning outcome 4. The use of demonstrations to introduce fault-finding, dismantling and assembly techniques, would be a beneficial method of delivery for the learner, prior to them carrying out their practise practical activities and assessments.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, overview of activities and assessment methods, issue of scheme of work/ assessment plan • introduction to different types of electrical systems, equipment and components. Identify hazards associated with the workplace/workshop environment. Practical exercise: • learners identify potential hazards in the workshop/workplace and how the risk from these hazards has been minimised using good practice.
Whole-class teaching/workshop demonstration and practise: • health and safety requirements for an electrical workshop environment – personal safety, personal health, procedures, safe working practices. Individual learner exercise: • using safety documents and physical walk round, learners to familiarise themselves with centre workshop/ workplace local safety rules, placards and procedures.
Preparation for and carrying out assignment 1 (P1, M1).
Workshop teaching and demonstration: • describe the different electrical systems and circuits. Workshop demonstration and explanation of appropriate system operation, using live system. Explanation of associated operational and isolation safety of the particular system • explain the operation of electrical system components (electrical supply, circuit components, devices) • demonstrate the use of associated manuals, parts catalogues and manufacturers' databases, used for information on component/device selection, function and where appropriate, operation. Learner exercises: • investigate and describe the function and operation of the system demonstrated and the safety precautions to be observed before, during and after operation. Read simple wiring diagram of a given electrical power or lighting circuit and describe the operation of the components, within the circuit • produce block diagram of the system and its major components, with written description of the operation of the components within the system.
Practical workshop activities: • given the appropriate maintenance and parts manuals/database, together with a range of electric system components/devices, learners identify components/devices, state their function, detail common faults and where appropriate describe their operation.
Preparation for and carrying out assignment 2 (P2, P3, P4, P5).

Topic and suggested assignments/activities and/assessment
Workshop/workplace whole-class teaching and practical demonstration: • explain fault-finding theory, related safety and use of aids and instruments • application of fault-finding theory to relevant systems/circuits • system/equipment dismantling, assembly and functional check/test techniques, related safety precautions and use of manufacturers' and other maintenance documentation • system component removal and fit/replacement and system functional test. Practical learner exercises: • fault-finding using a range of aids, instruments, techniques and appropriate maintenance documentation/ manuals • equipment dismantling, assembly and testing • removal/fit and/or replacement of identified faulty components and post assembly functional checking/testing.
Industrial visit: • visit regional electrical maintenance or electrical component assembly/testing company. Learner exercise: • completion of a pre-designed questionnaire relating to workplace safety, fault-finding and associated electrical maintenance activities.
Preparation for and carrying out assignment 3 (P6, P7, M2, M3, D1, D2).
Workshop teaching and demonstration: • routine maintenance theory, benefits and activities, completion of maintenance documentation, related safety issues. Practical learner exercises: • undertake a range of routine maintenance activities, following best safe practice and completing maintenance documents.
Preparation for and carrying out assignment 4 (P8, M4).

Assessment

Evidence of achieving the learning outcomes may be collected from well-planned investigative assignments or reports of practical workshop activities. It may be accumulated by learners building a portfolio from their investigations, maintenance activities in the workplace or by a tutor-led series of assignments, realistic maintenance exercises and tests.

Evidence of achievement for learning outcome 1 could come from a written assignment, requiring learners to describe the hazards and safe working practices related to an electrical maintenance activity. In order to identify and recognise the significance of workplace hazards and meet M1, learners will need to have an additional task added to this assignment that requires them to undertake a physical investigation/risk assessment of their own workshop or workplace environment and produce a written report on their findings.

Learning outcomes 2 and 3 are linked, so might best be assessed using one combined assessment instrument. A written assignment (completed in a workshop environment) could be used, where learners provide evidence for P2 by sketching a block diagram of a required system, showing the interconnection of its major components. Then for P3, learners use a given simple circuit diagram and again describe its operation. A parts catalogue or access to a suitable database would be needed in order that learners' can select four electrical system components (P4). In order to satisfy P5 learners will need to describe the function and operation of six electrical system components/devices. These should be selected by tutors based on the specialist needs of the learner.

Learning outcome 4 is best assessed through one or more investigative practical-based activities carried out in an electrical workshop environment or at the learner's workplace. A multi-stage practical/theoretical assignment could be set to cover the related criteria (P6, P7, M2, M3, D1, D2), where learners are first required to identify the problem/fault on a given electrical system using four fault-finding aids/techniques and report their findings. Evidence is likely to come from the learner's report and the results of observation at the time the activity takes place. For P7, learners need to dismantle the system, replace the component/part identified as causing the problem, reassemble the system and carry out a simple test/check to ascertain serviceability. Assessment evidence can be obtained from the results of tutor observations and by determining whether or not the learner returns the system to a serviceable condition.

In order to meet M2, learners need to investigate and identify the relationship between system component faults and malfunctions, such as intermittent operation, partial failure or complete breakdown. The investigation can either look at the system used for P6 and P7 or another system. A further theoretical task may be set, as part of the overall assignment in order to provide the learner with the opportunity to meet M3. This task could be timed to take place at or near the same time as the functional testing of the system carried out for P7.

During or after the fault-finding exercise carried out to meet P6, learners will need to compare and contrast two fault-finding techniques and provide a suitable written response to their findings (D2). In order to meet D1 the learner will need to analyse the system being worked on or another suitable system in order to assess that particular system for ease of maintenance and produce a short written report as evidence.

Learners are required to undertake and successfully complete a routine maintenance activity in order to meet the P8. A further written task could be incorporated into this assignment in order to meet M4, with learners detailing the benefits of carrying out routine maintenance on electrical systems, may be used as evidence. The learner's ability to use the correct documentation and accurately record their actions, as well as perform the practical aspects of the given maintenance, should be taken into account when tutor observation evidence, is obtained. This final assignment should be focused on the learner's particular field of electrical maintenance and the routine maintenance activities applicable to their electrical systems, circuits or equipment.

The learner's knowledge of and compliance with all related safety issues, also needs to be assessed during the time that all the above practical assignment activities are being carried out.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Workplace Hazards and Health and Safety in Electrical Maintenance	Learners carry out an investigation and risk assessment of hazards in their own working environment.	Written responses about workplace hazards and health and safety and a written report on a risk assessment investigation, identifying and commenting on findings.
P2, P3, P4, P5	Electrical Systems, Circuits and Components	A written activity requiring learners to respond to set tasks, given appropriate components and maintenance documentation.	Written response, to set written tasks.
P6, P7, M2, M3, D1, D2	System Fault-finding, Dismantling/assembly and Testing	A multi-stage practical and theoretical activity, requiring learners to fault-find, assemble/ dismantle and test an electrical system and to provide a written response to theoretical tasks.	Evidence provided by written results of tutor observations on learners' practical activities and learners written response to results of investigative theoretical tasks.
P8, M4	Routine Maintenance	A practical and part theoretical activity requiring learners to carry out a routine maintenance operation on an electrical component, equipment, circuit or system using appropriate documentation.	Evidence provided by written results of viva-voice and tutor observations together with the learner's response to written tasks.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Engineering Maintenance Procedures and Techniques
	Operation and Maintenance of Mechanical Systems and Components	
	Operation and Maintenance of Electronic Systems and Components	
	Operation and Maintenance of Fluid Power Systems and Components	

The unit has been mapped against the Level 2 SEMTA National Occupational Standards and current NVQs. Achievement of the learning outcomes of this unit will contribute skills and knowledge towards several of the units from the Level 2 NVQ in Engineering Maintenance and Installation, particularly:

- Unit 4: Handing Over and Confirming Completion of Maintenance or Installation Activities
- Unit 9: Carrying out Fault Location on Electrical Equipment and Circuits
- Unit 10: Carrying out Maintenance Activities on Electrical Equipment
- Unit 11: Carrying out Modifications or Rewiring Electrical Circuits
- Unit 12: Carrying out Scheduled Maintenance Tasks on Electrical Equipment.

The unit also contributes skills and knowledge to the current SEMTA Level 2 NVQ in Performing Engineering Operations, Unit 37: Maintaining Electrical Equipment/Systems.

Essential resources

Learners will require access to an electrical engineering workshop and relevant tools and equipment. In particular learners should have access to:

- a wide range of industry standard, electrical circuits, equipment and systems and their associated components and consumables
- appropriate fault-finding instruments, safety equipment and tools
- manufacturers' data books and specifications
- maintenance manuals, parts catalogues and/or databases, flow charts, electrical circuit and system diagrams
- British/International Standards, health and safety publications and local workshop safety documentation and procedures.

Employer engagement and vocational contexts

Delivery and assessment of this unit should be set within a vocational context, especially for learning outcome 4. Visits to the learner's workplace or other local mechanical maintenance companies will help foster employer cooperation and set the focus for practical maintenance activities.

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

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

Indicative reading for learners

Textbooks

Adams J – *Electrical Safety: A Guide to the Causes and Prevention of Electrical Hazards* (Institution of Electrical Engineers, 1994) ISBN 085296806X

Gates E – *Introduction to Electronics* (Delmar, 2006) ISBN 140188900X

Health and Safety Executive – *Essentials of Health and Safety at Work* (HSE, 2006) ISBN 0717661792

Sinclair I and Lewis G – *Electronic and Electrical Servicing* (Newnes, 2002) ISBN 0750654236

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information in manufacturers' databases, evaluating its relevance and value identifying questions to answer and problems to resolve when using a variety of fault-finding techniques to identify the problem
Self-managers	organising time and resources when dismantling, inspecting and reassembling a electrical system.

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

Skill	When learners are …
Independent enquirers	using the appropriate instruments, aids and tools to dismantle, inspect and reassemble, an electrical equipment or system replace identified faulty components/devices and test the system for serviceability, following safety and servicing procedures
Creative thinkers	analysing a given electrical equipment or system for ease of maintenance
Effective participators	carrying out a risk assessment investigation of an electrical work area and reporting their findings.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Manage information storage to enable efficient retrieval	using manufacturers data bases and/or parts catalogues to identify and select electrical components/devices
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing the work place hazards and health and safety requirements relevant to given electrical maintenance activities
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating the function and operation of electrical systems and components
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the work place hazards and health and safety requirements relevant to given electrical maintenance activities.

Unit 13: Operation and Maintenance of Electronic Systems and Components

Unit code: J/600/0403

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will develop learners' knowledge of the function, operation and maintenance of a variety of electronic systems and system components.

Unit introduction

Electronic engineering equipment, circuits, systems, processes and services, all need to be maintained to ensure there continued serviceability and fitness for purpose this unit has been designed to ensure that learners' possess the necessary knowledge and skills to undertake such maintenance in a safe and efficient manner.

In this unit learners will be provided with an intimate knowledge of the safety precautions required for personnel protection, the protection of others and the safe handling of the equipment and systems they will find in an electronic engineering environment.

Learners will be introduced to the function and operation of a variety of electronic systems, circuits and their associated components, where they will be expected to apply this knowledge to the maintenance of these electronic systems, circuits and components. In particular, learners will carry out activities that develop their skills and knowledge in fault-finding, routine maintenance, dismantling and assembly of, for example; motors, motor control circuits, control systems, transmitters, receivers and electro-optical systems and the electronic components/devices associated with these systems and circuits.

Learners will be expected to obtain all necessary information, documentation, tools and equipment, prior to carrying out any given maintenance activity. They will also need to demonstrate that they can select, follow and correctly interpret; maintenance procedures, safe working practices, health and safety requirements and fault location methods, when undertaking corrective and routine maintenance activities.

Learning outcomes

On completion of this unit a learner should:

1 Know the workplace hazards and health and safety requirements associated with electronic maintenance operations

2 Know the operation of electronic systems and circuits

3 Understand the selection, function and operation of electronic system components

4 Be able to fault-find and carry out routine maintenance activities on electronic systems and components.

Unit content

1 Know the workplace hazards and health and safety requirements associated with electronic maintenance operations

Workplace hazards: eg flammable substances, pressurised systems, hot surfaces, electronic equipment, electrostatic hazards, unfenced machinery, toxic substances and fumes, falling objects, liquid spillage, untidy work area, badly maintained tools and equipment

Health and safety requirements: personal safety eg appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators, electronic testing safety; personal health eg appropriate use of barrier creams, personal cleanliness, consumption of food, prompt attention to injuries; procedures eg treatment for electric shock, response to alarms, use of safety equipment, reporting of accidents, reporting of hazardous items of plant or equipment; safe working practices eg permit to work, use of danger tags, warning notices, safety barriers, cones and tapes, isolation of equipment, proof marking, recording of maintenance operations

2 Know the operation of electronic systems and circuits

Electronic systems: block diagram representation; systems/equipment eg power supplies, motor control systems, transmitters, transceivers, receivers, analogue signal processing, digital signal processing, aerial systems, transmission lines, display systems, electro-optical systems, cryptographic systems data network systems

Electronic circuits: wiring and schematic diagram representation; circuits eg sensor/actuator, digital, signal processing, alarms and protection, Analogue to Digital Converter (ADC) and Digital to Analogue (DAC), hybrid

3 Understand the selection, function and operation of electronic system components

System components: electrical supply eg cables and connectors, batteries, transformers, rectifiers, contactors; circuit components eg capacitors, fixed resistors, variable resistors, thermistors, transistors, diodes; devices eg overload protection device, integrated circuits, heat sinks, inverter and servo controllers, decoders, sensors, encoders, resolvers; use of maker's catalogue or database for selecting replacements

4 Be able to fault-find and carry out routine maintenance activities on electronic systems and components

Faults, aids, techniques and documentation: faults eg intermittent operation, partial failure/out-of-specification output, complete breakdowns; aids eg functional charts, wiring diagrams, schematic diagrams, trouble shooting charts, instruments (such as multimeter, signal generator, oscilloscope, logic probe, signal tracer, light meter, continuity tester), component data sheets, software-based records and data; techniques eg six point (collect the evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system), half split, input/output, unit substitution, emergent sequence, visual examination, unit substitution; documentation eg operation and maintenance manuals, fault/repair reports, final test handover procedures

Dismantling and assembly: aids eg use of manufacturers' service manuals, parts lists and drawings, approved working procedures, spare parts catalogues, maintenance manuals; systems/equipment eg sensor/actuator, alarm/protection, transmission, data network, ADC/DAC circuits, circuit boards, motor control circuits

Component/equipment removal and replacement: eg wiring and cables, terminations/connections, servo controllers, sensors, integrated circuits, protection devices, inverters, use of appropriate tools, equipment and documentation eg solder, soldering irons, crimping pliers, hand tools, replacement parts, approved working procedures and spare parts catalogues

Routine maintenance activities and documentation: inspection, checks and tests eg wear, chafing, fouling, security of attachment, missing or loose fittings, adjustments, performance, continuity, input/output, replacements; reports and documentation eg BS, ISO and/or BSEN standards, scheduled maintenance report, corrective maintenance report, other company-specific report, job cards, maintenance log, recording of condition, use of maintenance manuals and parts catalogues

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the workplace hazards and heath and safety requirements relevant to specific electronic maintenance activities	**M1**	carry out a risk assessment for an electronic work area and report on findings	**D1**	analyse a given electronic system for ease of maintenance
P2	describe with the aid of block diagrams, the operation of a given electronic system	**M2**	describe the relationship between component faults and the malfunction of a given piece of electronic equipment or system	**D2**	compare and contrast two fault-finding techniques when carrying out maintenance work on an electronic system.
P3	describe with the aid of diagrams the operation of a given electronic circuit	**M3**	explain the reasons for following correct procedures and carrying out post rectification tests/checks when undertaking corrective maintenance on electronic systems		
P4	use manufacturers' databases or parts catalogues to select four electronic system components [IE4]	**M4**	detail the benefits of carrying out routine maintenance on an electronic component, equipment or system.		
P5	explain the function and operation of six electronic system components				
P6	use four fault-finding aids/ techniques to identify the problem and report findings [IE1]				
P7	use the appropriate aids and tools to dismantle and reassemble an electronic system, replace any identified faulty components and check the system for serviceability [SM3]				

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P8 carry routine maintenance on an electronic component, equipment or system, using the correct documentation, and record actions. [SM3]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit can be delivered as a stand-alone package or integrated with other units in the qualification such as those outlined below.

This unit is essentially practical and learners should have the opportunity to dismantle, examine and reassemble a range of electronic components, equipment and systems. Ideally the learning outcomes should be achieved through investigation and participation in practical activities. Thus the unit is best delivered through a programme of lectures, demonstrations and practical work.

The approach used will be determined through an analysis of learners' needs and through consideration of the range of industries that the centre is working with or preparing their learners for. Whichever approach is taken should provide learners with the underpinning knowledge and skills required to repair, replace and generally maintain electronic components, equipment and systems in most industrial settings.

Learners must be made aware of, and have access to, relevant UK health and safety legislation and know the importance of the use of risk assessment appropriate to the maintenance techniques they are using. Tutors should always ensure that each learner has the correct personal protective equipment and that the system is safe for operation. It is also important that learners work in a safe manner when using equipment or working on electronic circuits and systems.

The unit provides an opportunity for learners to work in teams or groups when diagnosing component or system faults. The delivery of this unit should focus on learners developing diagnostic and practical skills together with an understanding of electronic components, equipment and systems maintenance.

The four learning outcomes are ordered logically and it would be reasonable to deliver them sequentially throughout the unit.

All the learning outcomes should be delivered using a practical approach rather than spending too much time in theory lessons. For example, a short introduction to a component (or range of components), the function of the component within the larger equipment, circuit or system, the tools needed to carry out the maintenance task together with any safety considerations, followed by practise. Learners need a broad overview of the different electronic components and systems to enable correct selection and application of maintenance, fault-finding and testing techniques.

Learning outcome 4 has a high reliance on understanding developed from the other three learning outcomes. As such, teaching and learning needs to focus on the development of this knowledge in order that it may be applied to learning outcome 4. The use of demonstrations to introduce fault-finding, dismantling and assembly techniques, would be a beneficial method of delivery for the learner, prior to them carrying out their practise practical activities and assessments.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, overview of activities and assessment methods, issue of scheme of work/ assessment plan • ensure learners have correct personal safety equipment for their working environment • introduction to the types of systems, equipment and components found in an electronic maintenance, working environment. Identify hazards associated with the workshop environment. Visit to centre workshop/learners workplace: • learners (under supervision) to carry out an exercise to identify potential hazards and to identify how the risk from these hazards has been minimised, using good health and safety practice. Practical exercise: • learners identify potential hazards in the workshop/workplace and how the risk from these hazards has been minimised using good practice.
Whole-class teaching/workshop demonstration and practise: • health and safety requirements for an electronic workshop environment – personal safety, personal health, procedures, safe working practices. Individual learner exercise: • using safety documents and physical walk round, learners to familiarise themselves with centre workshop/ workplace local safety rules, placards and procedures.
Preparation for and carry out assignment 1 (P1, P2, M1).
Whole-class workshop teaching: • function and operation of electronic system components and devices. • demonstrate use of associated manuals, parts catalogues and manufacturers databases, used for information on component/device selection, function and where appropriate, operation. Learner exercise: • given the appropriate maintenance and parts manuals/database, together with a range of electronic system components/devices, learners identify components/devices, state their function, detail common faults and where appropriate describe their operation.
Prepare for and carry out assignment 2 (P3, P4, P5, P6)Workshop teaching and demonstration: • describe the different electronic systems and circuits; electronic circuits and symbols • explain appropriate system function and operation, using live system/circuit set-up. Explanation of associated operational and isolation safety of the particular system • workshop teaching at an electronic system/equipment – system major components function and basic operation given.

Topic and suggested assignments/activities and/assessment
Learner exercise: • write down in their own words, the function and operation of the system demonstrated and the associated safety precautions to be observed, before during and after operation. Read simple wiring diagram of a given electronic signal processing, sensor/actuator or alarm/protection circuit and describe the purpose of the components, within the circuit • produce block diagram of the system and its major components, with written description of the function and basic operation of these components within the system.
Whole-class teaching: • fault-finding theory, related safety and use of aids and instruments. Workshop teaching and demonstration: • demonstration of application of fault-finding theory to relevant systems/circuits • system/equipment dismantling, assembly and functional check/test techniques, related safety precautions and use of manufacturers and other maintenance documentation • system/circuit component removal and fit/replacement and system/circuit functional test. Practical learner exercises: • fault-finding using a range of aids, instruments, techniques and appropriate maintenance documentation/manuals • system/equipment dismantling, assembly and test • given system/circuit component removal/fit and/or replacement of identified faulty components and post assembly functional checking/testing.
Industrial visit: • visit to regional electronic maintenance or electronic component assembly/testing company. Learner exercise: • completion of a pre-designed questionnaire relating to workplace safety, fault-finding and associated electronic maintenance activities.
Preparation for and carry out assignment 3 (P7, P8, M2, M3, D1, D2).
Workshop teaching and demonstration: • routine maintenance theory, benefits and activities eg inspection/checks of electronic wiring, cabling, fixtures, fittings, terminations, soldered joints, (such as wear, chaffing, fouling, security of attachment, mechanical damage, fire damage), adjustments, component/equipment/system tests for correct operation, completion of maintenance documentation, and related safety issues. Practical learner exercises: • undertake a range of routine maintenance activities, following best safe practice and completing maintenance documents.
Preparation for and carry out assignment 4 (P9, M4).

Assessment

Assessment evidence can be collected from well-planned investigative assignments or reports of practical workshop activities. It may be accumulated by learners building a portfolio from their investigations, maintenance activities in the workplace or by a tutor-led series of assignments, realistic maintenance exercises and tests.

Evidence of achievement for learning outcome 1 could come from a written assignment, requiring learners to describe the hazards and health and safety requirements related to an electronic maintenance activity. In order to identify and recognise the significance of workplace hazards and meet M1, learners will need to have an additional task added to this assignment that requires them to undertake a physical investigation/risk assessment of their own workshop or workplace environment and produce a written report on their findings.

Learning outcomes 2 and 3 are linked, so might best be assessed using one combined assessment instrument. A written assignment (completed in a workshop environment) could be used, where learners provide evidence for P2 by sketching a block diagram of a required system, showing the interconnection of its major components. Then for P3, learners use a given simple circuit diagram and again describe its operation. A parts catalogue or access to a suitable database would be needed in order that learners' can select four electronic system components (P4). In order to satisfy P5 learners will need to describe the function and operation of six electronic system components/devices. These should be selected by tutors based on the specialist needs of the learner.

Learning outcome 4 is best assessed through one or more investigative practical-based activities carried out in an electronic workshop environment or at the learner's workplace. A multi-stage practical/theoretical assignment could be set to cover the related criteria (P6, P7, M2, M3, D1, D2), where learners are first required to identify the problem/fault on a given electronic system using four fault-finding aids/techniques and report their findings. Evidence is likely to come from the learner's report and the results of observation at the time the activity takes place. For P7, learners need to dismantle the system, replace the component/part identified as causing the problem, reassemble the system and carry out a simple test/check to ascertain serviceability. Assessment evidence can be obtained from the results of tutor observations and by determining whether or not the learner returns the system to a serviceable condition.

In order to meet M2, learners need to investigate and identify the relationship between system component faults and malfunctions, such as intermittent operation, partial failure or complete breakdown. The investigation can either look at the system used for P6 and P7 or another system. A further theoretical task may be set, as part of the overall assignment in order to provide the learner with the opportunity to meet M3. This task could be timed to take place at or near the same time as the functional testing of the system carried out for P7.

During or after the fault-finding exercise carried out to meet P6, learners will need to compare and contrast two fault-finding techniques and provide a suitable written response to their findings (D2). In order to meet D1 the learner will need to analyse the system being work-on or another suitable system in order to assess that particular system for ease of maintenance and produce a short written report, as evidence of achievement.

Learners are required to undertake and successfully complete a routine maintenance activity in order to meet the criteria for (P8). A further written task could be incorporated into this practical assignment in order to address the requirements of (M4), where the learners written response to the need and benefits of carrying out routine maintenance on mechanical systems, may be used as evidence. The learner's ability to use the correct documentation and accurately record their actions, as well as perform the practical aspects of the given maintenance, should be taken into account when tutor observation evidence, is obtained. This final assignment should be focused on the learner's particular field of electronic maintenance and the routine maintenance activities applicable to their electronic systems, circuits or equipment.

The learner's knowledge of and compliance with all related safety issues, also needs to be assessed during the time that all the above practical assignment activities are being carried out.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Workplace Hazards and Health and Safety in Electronic Maintenance	Learners carry out an investigation and risk assessment of hazards in their own working environment.	Written responses about workplace hazards and health and safety and a written report on a risk assessment investigation, identifying and commenting on findings.
P2, P3, P4, P5	Electronic Systems, Circuits and Components	A written activity requiring learners to respond to set tasks, given appropriate components and maintenance documentation.	Written response, to set written task.
P6, P7, M2, M3, D1, D2	System Fault-finding, Dismantling/assembly and Testing	A multi-stage practical and theoretical activity, requiring learners to fault-find, assemble/ dismantle and test an electron system and to provide a written response to theoretical tasks.	Evidence provided by written results of tutor observations on learners practical activities and learners written response to results of investigative theoretical tasks.
P8, M4	Routine Maintenance	A practical and part theoretical activity requiring learners to carry out a routine maintenance operation on an electronic component, equipment, circuit or system using appropriate documentation.	Evidence provided by tutor observations together with the learner's response to written tasks.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Engineering Maintenance Procedures and Techniques
	Operation and Maintenance of Mechanical Systems and Components	
	Operation and Maintenance of Electrical Systems and Components	
	Operation and Maintenance of Fluid Power Systems and Components	

The unit has been mapped against the Level 2 SEMTA National Occupational Standards and current NVQs. Achievement of the learning outcomes of this unit will contribute skills and knowledge towards several of the Level 2 NVQ units in Engineering Maintenance and Installation, particularly:

- Unit 4: Handing Over and Confirming Completion of Maintenance or Installation Activities
- Unit 13: Carrying Out Fault Location on Electronic Equipment and Circuits
- Unit 14: Carrying out Tests on Electronic Equipment and Circuits
- Unit 15: Carrying out Repairs to Electronic Equipment.

The unit also contributes towards the skills and knowledge of the SEMTA Level 2 NVQ in Performing Engineering Operations, Unit 38: Maintaining Electronic Equipment/Systems.

Essential resources

Learners will require access to an electronic engineering workshop relevant tools, instruments and equipment. In particular learners should have access to:

- A wide range of industry standard, electronic circuits, equipment, rigs and systems and their associated components and consumables.
- Appropriate fault-finding instruments, safety equipment and tools.
- Manufacturers' data books and specifications.
- Maintenance manuals, parts catalogues and/or databases, flow charts, electronic circuit and system diagrams.
- British/International Standards, health and safety publications and local workshop safety documentation and procedures.

Employer engagement and vocational contexts

Delivery and assessment of this unit should be set within a vocational context, especially for learning outcome 4. Visits to the learner's workplace or other local mechanical maintenance companies will help foster employer cooperation and set the focus for practical maintenance activities.

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

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

Indicative reading for learners

Textbooks

Gates E – *Introduction to Electronics* (Delmar, 2000) ISBN 0766816982

Health and Safety Executive – *Essentials of Health and Safety at Work, 4th Edition* (HSE, 2006) ISBN 0717661792

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Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information in manufacturers' databases, evaluating its relevance and value identifying questions to answer and problems to resolve when using a variety of fault-finding techniques to identify the problem
Self-managers	organising time and resources when dismantling, inspecting and reassembling a electronic system.

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

Skill	When learners are …
Independent enquirers	use appropriate instruments, aids and tools to dismantle, inspect and reassemble an electronic system or equipment replacing identified faulty components/devices and checking the system for serviceability, following all safety and servicing procedures
Creative thinkers	analysing a given electronic equipment or system for ease of maintenance
Effective participators	carrying out a risk assessment investigation of an electronic work area and reporting their findings.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Manage information storage to enable efficient retrieval	using manufacturers' databases and/or parts catalogues to identify and select electronic components/devices
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing the work place hazards and health and safety requirements relevant to given electronic maintenance activities
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating the function and operation of electronic systems and components
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the work place hazards and health and safety requirements relevant to given electronic maintenance activities.

Unit 14: Selecting and Using Secondary Machining Techniques to Remove Material

Unit code: D/600/0410

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners the opportunity to explore, select and use appropriate secondary machining techniques to remove material.

Unit introduction

This unit will provide learners with a detailed understanding of the manufacturing processes mainly associated with generating and forming shapes through machining techniques. The unit introduces the learner to secondary machining techniques, focussing on the traditional techniques of turning, milling, drilling and grinding, primarily giving a deeper understanding of the practical processes involved.

Learners will develop skills and understanding in selecting, investigating and using secondary manufacturing techniques involving shaping with loss of volume. They will manufacture a component using an appropriate machining technique, during this process they will perform checks for accuracy and demonstrate the fundamental and safety requirements of these techniques.

In this unit learners will develop knowledge of how work-holding devices are used, to allow manufacturing processes to be carried out safely and efficiently. In addition the unit will provide an understanding of the range and types of tools used in manufacturing processes.

Learning outcomes

On completion of this unit a learner should:

1 Know how a range of secondary machining techniques is used

2 Know how work-holding devices and tools are used

3 Be able to use a secondary machining technique safely and accurately to make a workpiece

4 Know about aspects of health and safety relative to secondary machining techniques.

Unit content

1 Know how a range of secondary machining techniques is used

Secondary machining techniques: a range of secondary machining techniques eg:

- ◊ turning: generation of shapes; forming of shapes eg centre lathe, capstan, turret, automatic
- ◊ milling: generation of shapes; forming of shapes, up-cut, down-cut eg horizontal, vertical
- ◊ drilling: eg pedestal, bench, radial
- ◊ grinding: eg surface, cylindrical, centreless, profile grinding; thread grinding

2 Know how work-holding devices and tools are used

Work-holding devices: work-holding devices for secondary machining techniques eg:

- ◊ for turning: eg chucks with hard jaws, chucks with soft jaws, collet chucks, drive plate and centres, fixtures, faceplates, magnetic or pneumatic devices, fixed steadies or travelling steadies, four jaw chucks, power chucks
- ◊ for milling: eg clamping direct to machine table, pneumatic or magnetic table, machine vice, angle plate, vee block and clamps, fixtures, chucks, indexing head/device, rotary table
- ◊ for drilling: eg clamping direct to machine table, machine vice, angle plate, vee block and clamps, fixtures
- ◊ for grinding: eg chucks, collets, centres, face plate, machine vices, power chucks, clamps, angle plates, vee blocks, works rests, control stops, fixtures, injector mechanisms, magnetic blocks, pots

Tools: materials eg solid high speed steel, brazed tungsten carbide, indexible tips, composite wheels; tools for specific secondary machining techniques eg:

- ◊ for turning: eg turning tools, facing tools, form tools, parting off tools, thread chaser, single point threading, boring bars, recessing tools, centre drills, twist/core drills, solid reamers, expanding reamers, taps, dies, knurling tool
- ◊ for milling: eg face mills, slab mills/cylindrical cutters, side and face cutters, slotting cutters, slitting saws, profile cutters, twist drills, boring tools, end mills, slot drills
- ◊ for drilling: eg drill bit, flat bottomed drill, counterboring tool, countersinking tool, centre drill, spot facing tool, reamer, tap
- ◊ for grinding: eg soft wheel, hard wheel, cup, flaring cup, straight sided wheel, recessed wheel, double recessed wheel, dish, saucer, disc, segmented

3 Be able to use a secondary machining technique safely and accurately to make a workpiece

Machining parameters: position of workpiece; position of tools in relationship to workpiece; cutting fluid flow rate; machine guards/safety mechanisms; parameters for different secondary machining techniques eg:

- ◊ for turning: eg threading/profile/taper mechanisms, workpiece revolutions per minute, linear feed rate, depth of cut for roughing and finishing
- ◊ for milling: eg linear/table feed rate, milling cutter revs per minute, depth of cut for roughing and finishing
- ◊ for drilling: eg tooling revs per minute, linear feed rate, swarf clearance
- ◊ for grinding: eg linear/table feed rate, depth of cut for roughing and finishing, cross feed, dressing of wheels

Features of the workpiece: producing features eg:

- ◊ for turning: eg flat faces, parallel diameters, stepped diameters, tapered diameters, drilled holes, bored holes, reamed holes, profile forms, internal threads, external threads, eccentric features, parting off, chamfers, knurls or special finishes, grooves, undercuts
- ◊ for milling: eg flat faces, square faces, parallel faces, angular faces, steps/shoulders, open ended slots, enclosed slots, recesses, tee slots, drilled holes, bored holes, profile forms, serrations, indexed or rotated forms, special forms
- ◊ for drilling: eg blind holes, through holes, flat bottomed holes, counterbored holes, countersinking, spot facing, reaming, tapping
- ◊ for grinding: eg flat faces, vertical faces, parallel faces, faces square to each other, shoulders and faces, slots, parallel diameters, tapered diameters, counterbores, tapered bores, parallel bores, profiles forms, other thread forms, vee form threads, right hand threads, single start threads, multi-start threads, internal threads, external threads, angular faces

Checks for accuracy: components to be free from burrs and sharp edges; use of appropriate tools and instruments; checks relevant to specific secondary machining techniques eg:

- ◊ for turning: eg components to be free from false tool cuts, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6μm (63 μin), reamed or bored holes within H8, screw threads BS medium fit, angles within +/- 1.0 degree
- ◊ for milling: eg components to be free from false tool cuts, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6μm (63 μin), flatness and squareness within 0.125 mm per 25 mm (0.005 inch per inch), angles within +/- 1.0 degree
- ◊ for drilling: eg components to be free from false tool cuts, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface texture 1.6μm (63 μin), reamed holes within H8, screw threads BS medium fit
- ◊ for grinding: eg tolerance to BS EN 22768-1 or BS 4500, surface texture 0.2μm(8μin), angles within +/- 0.5 degree, free from false grind cuts

4 Know about aspects of health and safety relative to secondary machining techniques

Health and safety: UK health and safety legislation; European directives; reducing risks eg risk assessment, avoidance of dangerous conditions

Working safely: moving parts; machine guards; handling cutting fluids; insecure components; emergency stop; machine isolation; wearing appropriate protective clothing and equipment; clean and tidy work area; safe working relevant to specific secondary machining techniques eg:

◊ for turning: eg handling turning tools, airborne particles, tool breakage, swarf disposal

◊ for milling: eg handling milling cutters, cutter breakage, swarf disposal, backlash in machine slides

◊ for drilling: eg handling drills, taps and reamers, tool breakage, swarf disposal

◊ for grinding: eg handling grinding wheels, sparks/airborne particles, bursting wheels

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe how three different secondary machining techniques are used	**M1**	explain why it is important to carry out checks for accuracy of features on components during and after manufacture	**D1**	justify the choice of a secondary machining technique for a given workpiece
P2	describe the appropriate use of three different work-holding devices for these different techniques	**M2**	explain the importance of using the correct tooling and having machine parameters set correctly when machining a workpiece.	**D2**	compare and contrast three secondary machining techniques for accuracy and safety of operation.
P3	describe the appropriate use of three different tools for these different techniques				
P4	monitor and adjust the machining parameters to machine a given workpiece correctly and safely and to produce features as defined by the workpiece [RL3]				
P5	machine a given workpiece safely and carry out necessary checks for accuracy [SM3, SM4]				
P6	describe methods of reducing risk for the secondary machining technique used.				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit develops the knowledge and skills required for several material removal techniques and as such should be delivered mainly through practical work. Work-based learners are likely to have a defined technique or range of techniques they are using or being trained to use in their workplace. The unit context should allow these techniques to be used during delivery. Whilst only one learning outcome is associated with the machining of a product the assessment throughout relies on evidence generated by this activity.

Each learner should be allowed to study in detail at least one of the techniques listed to allow safe use in the workshop. However they will need to have an understanding of at least two more techniques. For work-based learners these techniques may well be determined by their chosen skill route.

Learners will need to be able to describe how these techniques are used. Tutors should ensure that learners are aware of the design of the machine tool and how shapes can be either generated or formed when using secondary machining techniques.

A range of work-holding devices and tools should be introduced in practical sessions ensuring that learners think about the importance of their use.

The main part of this unit involves the learner using a secondary technique when operating a machine safely. Care needs to be taken to ensure that all learners work safely and in a safe environment. Workshop briefings and formative tests may be required to establish that this is the case. Learners should also be taught how to monitor progress during machining and how to make adjustments to the technique. To check the accuracy of workpieces subjected to material removal tutors should ensure that learners are familiar with appropriate tools and instruments, for example micrometers, texture gauges etc.

Learners must be made aware of, and have access to, relevant UK health and safety legislation. They need to know the importance of the use of risk assessments appropriate to the techniques they are using. Tutors should always ensure that each learner has the correct protective clothing and has the machine correctly guarded before operation.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to engineering workshop • class exercise on identifying different machine tools • health and safety briefing, legislation and assessment of risk • class exercise on risk assessments. Practical workshop activity: • identify safety devices and equipment.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the principles of turning, milling, drilling and grinding. Workshop activity: • identifying individual component parts and features of machines and safety precautions.
Workshop activities: • identify key features of a range of components • use of measurement tools, techniques and gauges to determine appropriate levels of accuracy.
Preparation for and carrying out assignment 1 (P1 and M1).
Small-group activities: • demonstration of the use of work holding devices for different manufacturing techniques. Individual learner exercise: • use of work holding devices.
Small-group activities: • workshop demonstration of the use of different tools • demonstration of the use of different tools for different applications.
Preparation for and carrying out assignment 2 (P2 and P3).
Workshop activity: • workshop demonstration on the use of a manufacturing technique and the use of guards/safety devices, lubricants etc.
Workshop activity: • closely supervised small-group machining activity.
Individual learner exercise: • using appropriate techniques to manufacture a component to a given standard.
Preparation for and carrying out assignment 3 (P4, P5, P6, M2, D1 and D2).
Review of unit delivery and assessment.

Assessment

This unit requires a variety of different evidence to be gathered to support assessment. Some will be in the form of written responses, gathered through asking learners to describe techniques, use of work-holding devices and tools and suggesting health and safety aspects. Others will be in the form of process-type evidence, when witness statements or observation records will be required to capture monitoring and adjusting parameters when machining a workpiece safely.

To achieve a merit grade, learners will need to demonstrate that during machining of a given workpiece they should be able to identify the features of the workpiece and explain the importance of monitoring those features during and after machining. Learners should be able to explain the importance of using correct tooling and issues relating to incorrect setting of machine parameters. The evidence required for these criteria is likely to be in the form of a written response to tasks set for the learner after a range of practical exercises.

To achieve D1, learners will need to demonstrate evaluative skills in justifying a choice of one of the techniques when given a workpiece to machine. This technique is likely to be one from their chosen skill route. Further underpinning knowledge is required for this level of performance, as learners need to compare and contrast three techniques for both accuracy and safety (D2). Judgements need to be made about whether the techniques succeed or whether they are unlikely to meet the needs and features of the workpiece. Some comparison could include coupling similar techniques such as comparing turning with grinding and drilling or comparing milling with grinding and drilling.

As P1 and M1 are closely linked these could be assessed through a written task that asks learners to describe the techniques and explain the importance of features that require monitoring during machining. Pass criteria P2 and P3 could be achieved by learners attempting a written task that explores the use of work-holding devices and tools. This might best be attempted when and after learners are familiar with their chosen specialist secondary machining technique. The other three pass criteria (P4, P5, P6) and the second merit criteria (M2) rely on practical activities in the workshop, in addition reflecting on methods of reducing risk and the importance of applying the correct procedures when machining a workpiece. Both distinction criteria; D1 and D2, also rely on this reflection of workshop activities. Therefore, centres may wish to design an assignment with a range of tasks to cover this practical work and give learners opportunities for reflection through written responses.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Machining Techniques	An activity requiring learners to investigate three different secondary machining techniques and the importance of carrying out checks for accuracy during and after manufacture.	A report containing written responses about three different secondary machining techniques and the importance of carrying out checks for accuracy during and after manufacture.
P2, P3	Work Holding Devices and Tooling	An activity requiring learners to produce a written report describing three different work holding devices and tooling requirements.	A report containing written responses describing the use of work holding devices and tools.

Criteria covered	Assignment title	Scenario	Assessment method
P4, P5, P6, M2, D1, D2	Using Secondary Machining Techniques Safely	An activity requiring learners to machine a given workpiece using a secondary machining technique and reflecting on the accuracy, health and safety, use of tooling and method used.	A practical demonstration supported by witness statements/ observation records and annotated photographs. A report evaluating the suitability of the chosen secondary machining techniques with reference to two others in terms of accuracy and safety. The report should also contain written responses suggesting and describing methods of reducing risk and explaining the importance of using the correct tooling and machine settings during manufacture.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Engineering Secondary and Finishing Techniques and Processes
	Interpreting and Using Engineering Information	Computer Aided Manufacturing
	Part Programming CNC Machines	

The unit has been mapped against the SEMTA National Occupational Standards and current NVQs at Level 2. Achievement of the learning outcomes of this unit will contribute skills, knowledge and understanding towards the following units in the Level 2 NVQ in Performing Engineering Operations:

- Unit 1: Working Safely in an Engineering Environment
- Unit 2: Working Efficiently and Effectively in Engineering
- Unit 11: Preparing and Using Lathes for Turning Operations
- Unit 12: Preparing and Using Milling Machines
- Unit 13: Preparing and Using Grinding Machines.

The unit can also contribute towards the knowledge requirements of the Level 2 NVQ in Mechanical Manufacturing, particularly:

- Unit 4: Operating Capstan or Turret Lathes
- Unit 5: Operating Centre Lathes
- Unit 6: Operating Single Spindle Automatic Turning Machines
- Unit 7: Operating Multi-Spindle Automatic Turning Machines
- Unit 8: Operating Milling Machines
- Unit 9: Operating Single and Multi-Spindle Drilling Machines
- Unit 10: Operating Grinding Machines.

Essential resources

To meet the needs of this unit it is essential that the centre has or has access to some if not all of the range of machines as specified in the content. All auxiliary equipment such as that listed under work-holding devices should also be made available for those techniques. Centres should have a range of tools suitable to measure the accuracy of the workpieces to be machined.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Much of the work can be generated from real engineering drawings and drawings from local employers. Company visits will allow learners to observe secondary machining techniques in an industrial context.

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

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

Indicative reading for learners

Textbooks

Meyers A and Slattery J – *Basic Machining Reference Handbook* (International Press Inc, 2001) ISBN 0831131209

Timings R L – *Basic Manufacturing* (Newnes, 2004) ISBN 0750659904

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Reflective learners	monitoring machining parameters, reviewing progress and acting on the outcomes
Self-managers	organising time and resources and anticipating and managing risks when machining a workpiece.

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

Skill	When learners are …
Self-managers	monitoring and adjusting machining parameters to machine a given workpiece correctly and safely.

Functional Skills – Level 2

Skill	When learners are …
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching the use of different secondary machining techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing three different secondary machining techniques and the importance of carrying out checks for accuracy during and after manufacture describing the use of work holding devices and tools evaluating secondary machining techniques describing methods of reducing risk and explaining the importance of using the correct tooling and machine settings during manufacture.

Unit 15: Part Programming CNC Machines

Unit code: H/600/0411

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners the skills required to plan, part program and use computer numerical control (CNC) machines for product manufacture.

Unit introduction

Computer numerical control is used extensively throughout the engineering industry as a means of producing precisely controlled movements. Its main application in engineering/manufacturing is in the production of components using machine tools for material removal. For example, CNC turning and milling centres, grinding machines, electronic discharge machining (EDM) – die sinking/wire cutting and fabrication are just some examples of these types of machine tools.

In addition to the manufacturing processes, CNC is used to aid the quality control process by providing the movement of probes (for in-line inspection) and on co-ordinate measuring machines (CMM). CNC has revolutionised the engineering/manufacturing environment in many ways and in particular, it has helped to improve productivity, speed of design, flexibility and quality.

This unit will provide learners with a firm introduction to CNC part programming. It will enable them to plan for the manufacture, using a CNC machine, of a product from its design specification. This will include the selection of an appropriate CNC machine tool, the materials and cutting tools required together with relevant cutting speeds and feeds. Learners will write part programs for safe use on a CNC machine. They will also learn how to load, store, retrieve, transfer and run part programs on CNC machines, complying with all relevant health and safety precautions. Finally, learners will gain experience of proof reading CNC programs and checking products for conformity including verification and dry running before final execution of the program.

Learning outcomes

On completion of this unit a learner should:

1 Be able to write a plan for a CNC machine from a product specification

2 Be able to write a part program for safe use on a CNC machine

3 Be able to run part programs on a CNC machine, complying with all relevant health and safety precautions

4 Be able to carry out a proofreading procedure for a CNC program and check conformity to specification.

Unit content

1 Be able to write a plan for a CNC machine from a product specification

Product specification: CNC machine required; materials required; cutting tools; speeds and feeds; product tolerances

Planning: suitable machining methods to be used; suitable sequences of machining operations; avoidance of wasted tool/cutter movements and tool changes

CNC machines: eg turning centres, milling machines, machining centres, fabrication machines, electrical discharge machining (EDM – die and wire machines), grinding

2 Be able to write a part program for safe use on a CNC machine

Part programs: reference (datum) points; co-ordinates eg absolute, incremental; machine axes; enter positional information using both absolute and incremental systems of measurement; cutter path change points; tool change positions; tool lengths; tool offsets and radius compensation; codes for preparatory and miscellaneous functions

Safe use: safe working practices; guards/screens; personal protective equipment; identification of hazards

3 Be able to run part programs on a CNC machine, complying with all relevant health and safety precautions

Load, store, retrieve, transfer: manual data input (MDI); down loading; storing and retrieving programs eg tapes, disks or CDs; down loading via computer interface; program edit facilities

Run part programs on CNC machines: eg dry run, single block run, program run

Safety precautions: safe working practices; guards/screens; personal protective equipment; identification of hazards

4 Be able to carry out a proofreading procedure for a CNC program and check conformity to specification

Proofreading: eg simulation/graphing software; single block program run; dry run; over-ride controls; adjustments for tool or probe compensation

Conformity to specification: features eg unilateral and bilateral tolerances, direct measurement; equipment eg rulers, callipers, micrometers, slip gauges

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	use a product specification to produce a plan for a CNC machine [SM3]	**M1**	describe the safety precautions used when operating CNC machines	**D1**	justify the part program used to operate the CNC machine
P2	write a part program for safe use on a CNC machine [CT1]	**M2**	describe the methods used to store, retrieve, transfer, load and run a CNC program	**D2**	compare two different methods of proofreading used to check a given part program.
P3	load, store, retrieve and transfer a CNC program	**M3**	explain the proofreading methods used to check a program conforms to specification.		
P4	run a part program to operate a CNC machine safely [SM4]				
P5	use proofreading methods to check a program [IE3]				
P6	use equipment to check conformity.				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

The unit would be best delivered using a practical approach and centres should ensure that they have suitable resources or access to industrial workshops with CNC facilities.

The learning outcomes are logically ordered to lead learners through the planning phase of CNC machining operations, writing a part program, loading and running a part program in a safe manner and, finally, proving that the program meets its product specification.

The four learning outcomes could be developed step-by-step throughout the unit as each stage is introduced. In this way, learners will begin to recognise the importance of planning a sequence of events before machining takes place and then following the incremental stages leading to the effective and safe running of a part program on a CNC machine. Wherever possible learners should gain hands-on experience with more than one type of CNC machine and a range of product specifications.

The identification of health and safety and safe working practices should be an integral part of the delivery, including the writing of risk assessments for each machining task. These should be reviewed and approved by the tutor before the learners access and use machinery.

It should be noted that, although practical competence is assessed entirely at the pass level, learners will be more motivated and will gain a better understanding and knowledge of CNC part programming if the entire unit is delivered in an integrative way. This will help develop the theoretical understanding required for the merit and distinction criteria as practical tasks are undertaken, and will encourage learners to think analytically and reflectively.

Formative assessment and feedback should be used throughout the delivery of the unit as this will play an important part in the general development of learners. In particular, encouragement to reflect on each task and experience will help learners to achieve the higher-level skills required by the merit and distinction criteria.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, assessment strategy and method of working • introduction to product specifications, including consideration of materials to be machined, cutting tools required, speeds and feeds of cutting processes and product tolerances. Group work: • examination of a range of product specifications to extract relevant information. Whole-class teaching: • examination of CNC machine types (eg turning, milling, EDM, etc) and their applications. Group work: • match CNC machines to required machining methods for given product specifications.
Whole-class teaching: • tutor demonstration of how to prepare a plan for the use of a CNC machine to manufacture a given product from its specification including machining methods to be used, sequence of operations and avoidance of wasted tool/cutter movements and tool changes. Group work: • preparing a plan for the manufacture of a product, using a CNC machines, from the product specification. Group presentation: • present plans for given CNC machines and products. Invite feedback from the group and discuss possible enhancements to the plan.
Whole-class teaching: • examine datum points, co-ordinate systems and relationship with machine axes. Group work: • setting datum and co-ordinates for a given product. Whole-class teaching: • tutor demonstration of writing a part program for a given product and CNC machine. Examination of safety issues associated with machining processes. Group work: • writing a part program for the manufacture of a product from a CNC machining plan.
Group presentations: • present part program including identified risks. Invite feedback from the group and discuss possible enhancements to the program.
Prepare for and carry out assignment 1 (P1, P2).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • tutor demonstration of how to safely load and store a part program. Group work: • writing, loading and storing part programs.
Whole-class teaching: • tutor demonstration of how to safely retrieve and transfer a part program. Group work: • retrieving and transferring part programs.
Whole-class teaching: • tutor demonstration of how to safely run a part program on a CNC machine. Group work: • summative activities to write, load, store and run part programs on CNC machines.
Prepare for and carry out assignment 2 (P3, P4, M1, M2 and D1).
Whole-class teaching: • introduction to proofreading a CNC part program and checking for conformity to specification • discussion and tutor demonstrations of proofreading and conformity check techniques. Group work: • exercises with pre-prepared part programs to proofread, run on CNC machines and adjust so that output conforms fully to specification.
Prepare for and carry out assignment 3 – covering P5, P6, M3 and D2.
Feedback on all assessment tasks, guidance on remedial action if necessary. Unit evaluation and close.

Assessment

Evidence of learners' achievement of the learning outcomes and related criteria could be collected from three assignments. These assignments should require learners to prepare reports of their activities in the workshop with CNC machines and related equipment, and where necessary collect the evidence in the form of a portfolio. Due to the practical nature of the unit, tutor observation and possibly oral questioning will play an important part in the final assessment of the learners' achievement. This direct evidence of process skills should be planned, documented and recorded appropriately.

It may be possible to use integrative assignments that link this unit with other units in a programme of study. If integration is used then the evidence used to demonstrate achievement of this unit's criteria will need to be clearly identified.

The first of the three assignments, covering P1 and P2, will require learners to use a given product specification to identify and plan for the type of CNC machine required, the materials being cut and the cutting tools and their speeds and feeds. Learners must also consider the importance and relevance of the defined product tolerances. Having completed their plan the learners should then use this information to help them write a part program for safe use on the identified CNC machine. The evidence, which is likely to be in the form of a report, must clearly show the stages of the planning and preparation of the part program. The report must also identify any relevant safety issues (for example safe working practices, guard/screens, personal protective equipment (PPE) required and potential hazards).

The second assignment, covering P3, P4, M1, M2 and D1, will need to be a series of practical activities that enable learners to load, store, retrieve, transfer and run a part program to operate a CNC machine safely. The evidence is likely to be in the form of a portfolio of evidence of each stage as it is carried out. The nature of the evidence will be different for each product and type of CNC machine but must cover all relevant aspects of the related unit content. Tutor observation will play an important part in the assessment of this assignment and the portfolio should contain the completed records of this method of assessment. Photographic records may also be helpful to capture the steps and processes carried out by the learner (for example machine layout and set-ups, tooling, safety equipment used, etc). Such photographic evidence must be suitably annotated by the learner to indicate its relevance with respect to unit content/criteria and verified by the tutor (eg comments added, signed and dated as a true record). The higher-level criteria (M1, M2 and D1) will require a written response and this should be included in the portfolio of evidence. It is important that these written responses relate to the work carried out for the pass criteria to ensure relevance for learners is maintained.

The last assignment, covering P5, P6, M3 and D2, could be developed to use proofreading methods to check a part program and equipment to check the conformity of a product manufactured using the program. Again, the evidence for this assignment is likely to be in the form of a portfolio. Tutor observation and other methods, as suggested for assignment 2, are likely to be applicable to this assignment. Written responses will be required for M3 and D2 and should relate to the work undertaken for P5.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2	Planning CNC Machining Operations	A practical activity requiring learners to use a product specification to plan for and write a part program.	A report containing the product specification used, the plan for the safe use of a CNC machine to manufacture the product and the written part program required to achieve this.
P3, P4, M1, M2, D1	Running a Part Program to Operate a CNC Machine	A practical activity requiring learners to load, store, retrieve, transfer and run a part program safely.	A portfolio of evidence including: • the part program used • tutor observation records of practical tasks • printout records • photographic records of processes • descriptions/justification of CNC methods used.
P5, P6, M3, D2	Proofing and Conformity Checks for Part Programs	A practical activity requiring learners to proofread and check outputs for conformity with specification.	A portfolio of evidence including: • annotated and amended part program • records of test runs • records of equipment used and results of tests • tutor observation records • written explanation/comparison of proofreading methods.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Applications of Computer Numerical Control in Engineering
	Interpreting and Using Engineering Information	Computer Aided Manufacturing
	Selecting and Using Secondary Machining Techniques to Remove Material	

The unit has close links with the Level 2 NVQ in Performing Engineering Operations, Unit 14: Preparing and Proving CNC Machine Tool Programs.

The unit also covers some of the knowledge and understanding associated with the following units from the Level 2 NVQ in Mechanical Manufacturing Engineering:

- Unit 19: Operating CNC Turning Machines
- Unit 20: Operating CNC Milling Machines
- Unit 21: Operating CNC Grinding Machines
- Unit 26: Operating CNC Machining Centres.

Essential resources

Whilst many centres will have CNC machines (these may be lathes, mills etc), it is important that learners have access (for assessment) to at least one type of CNC machine identified in the content. Centres do not need to cover all the machine types. Where resources are not directly available, it may be possible to engage local industry, colleges or universities to support the delivery of this unit.

Access to relevant software will be needed to design, transfer, prove and run a part program on the intended machine type. Proof reading needs to be carried out using simulation/graphing software together with dry run facilities for the program. Planning templates would also be useful for learners to follow when preparing their part programs. A full range of tooling and work-holding devices should also be available.

Employer engagement and vocational contexts

It is essential that this unit is delivered and assessed in a vocational context. Much of the work can be set within the context of products manufactured by or used in the learners' workplace, or based upon case studies that relate to local industries. Centres are unlikely to have access to a wide range of CNC machines and so it would be beneficial to make use of local industries which use CNC machines in their manufacturing operations. This could provide learners with a greater appreciation of the scope for CNC in manufacturing and could be achieved through work experience or industry visits. Failing this, centres could encourage visiting lecturers from local industries that make use of CNC in their manufacturing processes.

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

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

Indicative reading for learners

Textbooks

Evans K – *Programming of CNC Machines* (Industrial Press, 2007) ISBN 100831133163

Jha B – *CNC Programming Made Easy* (Vikas Publishing, 2004) ISBN 8125911804

Smid A – *CNC Programming Handbook* (Industrial Press, 2003) ISBN 0831131586

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	exploring a part program from different perspectives to carry out proofreading
Creative thinkers	generating ideas and exploring programming possibilities when writing a part program
Self-managers	organising time and resources to produce a plan for a CNC machine and prioritising actions to be taken when preparing the part program anticipating, taking and managing the risks associated with the use of a CNC machine safely.

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

Skill	When learners are …
Creative thinkers	questioning their own and others' assumptions during group work to plan, write and run a part program
Reflective learners	reviewing progress following group presentations of own work and acting upon the outcome of feedback
Team workers	collaborating with others during group work when planning for and programming a CNC machine.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Manage information storage to enable efficient retrieval	managing the storage, retrieval and downloading of part programs
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	manually inputting data to create the part program
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting and reading texts to establish the required information from a product specification and relevant reference texts (eg engineering data books on material properties, speeds and feeds) to plan for the use of a CNC machine
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing a plan to inform and communicate the processes identified as being required to create the part program for safe use on a CNC machine.

Unit 16: Application of Welding Processes

Unit code: K/600/0412

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners the knowledge and skills they need to safely carry out a range of welding techniques and to test welded joints for defects and irregularities.

Unit introduction

Welding is frequently used in manufacturing engineering to ensure that permanent, high-quality joints are made between metal **parts or components**. This unit gives learners with little or no previous welding experience the opportunity to gain knowledge and understanding of the processes used throughout industry. This applies to a diverse number of engineering industries including those involving sheet metal, structural steel fabrication and motor vehicle bodies.

Learners will develop knowledge of the importance starting with the preparation of their work area, ensuring that health and safety legislation and safe working practices are understood and adhered to at all times. Learners will select appropriate welding equipment and check that it is in a safe and usable condition before welding. This is particularly important as learners will be working with electric currents or combustible gas mixtures.

Learners will be expected to interpret written, graphical and verbal instructions while carrying out practical tasks. They will become competent in using a fusion welding process through tutor-led demonstrations and supervised practise.

Continuous assessment should be carried out to ensure that learners' skill levels are improved to meet the required standard. To measure their competence, learners will test their welded joints with reference to European quality standards, ensuring that they are able to produce acceptable welds as well as recognise them. This will be reinforced with the use of destructive and non-destructive tests.

Learning outcomes

On completion of this unit a learner should:

1 Know about health and safety legislation and safe working practices when welding

2 Be able to prepare for work in a welding environment

3 Be able to produce joints to welding standards

4 Be able to perform destructive and non-destructive tests on welded joints.

Unit content

1 Know about health and safety legislation and safe working practices when welding

Legislation: aspects relevant to welding eg Health and Safety at Work Act, Fire Precautions Act, Control of Substances Hazardous to Health (COSHH), Provision and Use of Work Equipment Regulations (PUWER), Health and Safety (First Aid) Regulations, Manual Handling Operations Regulations

Safe working practices: fire prevention; accident prevention and reporting; risk assessment; fuses; circuit breakers; earthing of equipment; manual handling eg materials, safe handling of gas cylinders; checking conditions eg gas leaks, voltage and amperage, leads; personal protective equipment (PPE); ventilation and extraction; closing down equipment safely; storing equipment; safe disposal of waste materials; emergency procedures eg within the learning environment, workplace; common hazards associated with welding eg fumes, burns, radiation, electric shock

2 Be able to prepare for work in a welding environment

Tools and equipment: equipment availability eg cables, hoses, torches/electrode holders, gas pressure regulators, flow meters; assembling welding equipment eg cables, weld return clamps, electrode holders, gas supplies, safety devices; setting and adjusting welding conditions eg gas pressures/flow rates, voltage, amperage; connecting the weld return lead

Information sources: safety instructions; job instructions; engineering drawings; quality control documentation eg weld procedure specification, record/reporting sheet

Welding: processes eg oxy-acetylene, manual metal arc (MMA), metal inert gas (MIG), metal active gas (MAG), cored wire, tungsten inert gas (TIG), plasma-arc

Consumables: storage of consumables; consumables appropriate for welding processes eg:

- ◊ for MMA: eg rutile, basic, nickel alloy, cellulosic, stainless steel, other electrodes
- ◊ for MIG, MAG and cored wire: eg two wire types from different groups, two different shielding gases where applicable
- ◊ for TIG, plasma-arc: eg one size of electrode, two types of filler wire from different material groups
- ◊ for gas welding: oxygen; acetylene; filler wire eg two different sizes, two different material groups

3 Be able to produce joints to welding standards

Safety: fire prevention; accident prevention and reporting; risk assessment; manual handling; checking conditions eg gas leaks, voltage and amperage, leads; personal protective equipment (PPE); ventilation and extraction; closing down equipment safely

Welding positions: to British Standard (BS) EN 287 eg flat (PA), horizontal vertical (PB), horizontal (PC), vertical upwards (PF), vertical downwards (PG); welding technique eg torch and filler angles for various positions

Joints: producing joints using welding processes eg:

◊ for MMA, MIG, MAG and cored wire: a fillet and a butt weld

◊ for TIG, plasma-arc and gas welding: a butt weld and either a fillet weld or an autogenous weld (without filler wire)

Material: types eg carbon steel, stainless steel, aluminium; forms eg plate, section, pipe/tube, sheet metal less than 3mm thick

Quality standard: minimum weld quality equivalent to the level given in the relevant European/ International Standard eg BS EN ISO 5817 and BS EN ISO 10042; meeting the required dimensional accuracy within the specification

4 Be able to perform destructive and non-destructive tests on welded joints

Weld testing: safety when using test equipment and chemicals; visual inspection for defects and irregularities; non-destructive eg visual, dye penetrant, fluorescent particle, magnetic particle; destructive eg macroscopic examination, nick break (fracture) tests, bend tests; non-thermal specimen removal processes eg hand saws, power saws, abrasive discs; specimen preparation processes eg removing slag, spatter and surface irregularities, cleaning, degreasing, polishing, making saw cuts in welds to be fracture tested; typical defects; consequences of defects; recording and reporting of weld defects

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	outline the health and safety legislation and safe working practices used in a welding environment	**M1**	describe common hazards that may occur in a welding environment	**D1**	analyse the cause of weld defects, suggest a remedy for three defects that can be found in a welded joint
P2	select the tools, equipment and information needed when materials are to be joined by welding [SM3]	**M2**	identify by visual examination the features that affect the quality of two welded joints	**D2**	evaluate the advantages and disadvantages of using a destructive or non-destructive test on a welded joint.
P3	prepare a list of consumables which are needed for a welding process	**M3**	explain the procedure used during a destructive or non-destructive test.		
P4	produce two joints safely and to a required quality standard using different welding positions [SM3]				
P5	produce two joints safely and to a required quality standard using different types of joint [SM3]				
P6	perform two destructive and two non-destructive tests and record the test outcomes. [IE1, SM3]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using tutor-led demonstrations followed by practical tasks, during which learners can gain experience of working with appropriate tools and equipment. Underpinning knowledge could be delivered using practical demonstrations supported by classroom based sessions focusing on specific theoretical aspects of the processes used.

Tutors must ensure that learners understand the hazards and safe working practices associated with welding equipment before they are allowed to use the process. Learners should be introduced to the process using a series of graded, formative tasks to enable them to demonstrate their competence before attempting the summative tasks.

Learners should be encouraged to evaluate their performance through formative tasks using a combination of tutor and self/peer assessment. Learners should be provided with appropriate feedback, both formative and summative, to further encourage their development. The early introduction of weld testing in the workshop will encourage discussion and self assessment, enabling learners to improve weld quality by making adjustments to process parameters.

The learning outcomes are ordered to enable learners to develop an understanding of the fundamental stages involved in the production of welded joints, irrespective of the process used. Job instructions should be written in a logical format, that will lead learners to consider all aspects of the task from safety, selection of tools, equipment and materials, process set-up and operation, through to production and testing of the welded joint.

Summative tasks will assess learners' competence in the use of the welding process and technique and their ability to control process parameters to produce welds that meet a specified quality standard.

Work-based learners should be encouraged to relate to the processes and techniques used at their place of work and also the wider perspective of welding processes used in industry. Centres should relate tasks to the needs of local industries to prepare learners not currently employed with the appropriate skills and knowledge necessary to enter employment.

Note that the use of 'eg' in the unit content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to welding producing permanent joints • specific processes applicable to welding • health and safety related to welding and safe working practices.
Prepare for and carry out assignment 1 (P1, M1).
Whole-class teaching: • sources of information required and used when welding • selection of welding processes • theory of welding practice • tools and equipment required and used during welding.
Workshop practical session: • process selection • introduction to welding equipment used • preparation for use, shutdown procedures and storage of equipment.
Prepare for and carry out assignment 2 (P2, P3).
Whole-class teaching: • welding theory; techniques, joints, materials, positions • weld quality standards • visual inspection of welds and common defects and irregularities.
Workshop demonstrations followed by individual learner practice: • safety in welding workshops • welding basics – process specific • techniques in welding different joints • techniques in welding different materials • techniques in welding different positions • weld quality and visual inspection.
Prepare for and carry out assignment 3 (P4, M2, D1).
Whole-class teaching: • weld testing theory, visual, destructive and non-destructive • test standards • test procedures • methods of reporting.

Topic and suggested assignments/activities and/assessment
Workshop practical followed by individual learner practice: • preparation of joints for testing • testing of welded joints • reporting results of weld tests.
Prepare for and carry out assignment 4 (P5, P6, M3, D2).

Assessment

Achievement of the pass criteria will require evidence of the production of welded joints in a workshop environment and responses to questions, either oral, written or a combination of both. Observations carried out during practical sessions should evidence the learners understanding of health and safety legislation and safe working practices; however a written description would produce best evidence against this criteria (P1). In the event of a breach of health and safety or approved safe working practices, the assessment should be terminated.

Assessment and grading criteria P2 and P3 must be completed satisfactorily before proceeding with criteria P4 and P5. It is expected that observation will capture learners' performance when using these welding processes. On completion of the welded joints, it is recommended that learners carry out the mandatory visual inspection of the weld during P4 and P5. The outcome from these welding processes should compare with the quality standard required. The requirement for P6 can be achieved during or after the practical activities and could be listed as a separate task.

In order to document evidence of practical tasks, centres may wish to consider the use of a logbook or portfolio to record the processes and techniques used. The inclusion of photographic evidence, drawings and a written description of each stage of the task would enable learners to demonstrate their competence with regard to the tools and equipment. Health and safety legislation and working practices relative to the task should be included in each description, as well as references to the safe operation of specific tools and equipment.

To achieve a merit grade, learners will need to be able to identify common hazards that they must guard against when working in a welding environment (M1). Demonstration of this is best achieved through a written task. Visual inspection of welds will be used to identify the visual quality of a welded joint. Learners should be encouraged to recognise and note visual defects and vary their welding parameters and technique to improve the weld quality eg access, materials, type of joint, technique and process settings (M2) The learners knowledge of weld testing methods will be delivered and consolidated during practical sessions; however, learners should be given the opportunity to research the subject using written and information technology sources. The evidence for explaining the procedure for destructive and non-destructive tests (M3) will most likely be in the form of written answers to a focused task set by the tutor.

To achieve a distinction grade, learners will need to be able to understand the causes of weld defects, and the principles and applications of a range of weld testing techniques. D1 requires the learner to analyse the cause of weld defects. This follows on from the use of welding positions in P4 and the learners assessing the welds they have produced in M2. The evidence for D1 and D2 could include responses to oral questioning; however, at this level written answers to questions or tasks would be a more appropriate method of evaluating the learners understanding of weld testing techniques. Achievement of D2 is likely to depend on the learner's ability to satisfactorily perform the related tasks at P6 and M3.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Safe Working Practices in Welding	An activity based assignment that requires learners to investigate and identify health and safety legislation and safe working practices within a welding workshop.	A report with appropriate references to the source of information. The report outlines the legislation and safe working practices applicable to the welding environment.
P2, P3	Preparing the Working Environment	An activity based assignment that encourages learners to consider and plan the work they do in a welding activity. To include tools, equipment, safety checks, consumables and the information required prior to starting a welding activity.	A plan outlining individual tasks which records the consumables, information, tools and equipment needed for the activity.
P4, M2, D1	Positional Welding and Visual Examination of Welds	A practical activity where welded joints are produced by the learner. The joints should be visually examined supported by a report that reviews the quality of the welds and identifies changes to the welding process or technique.	A practical producing the required welded joints. A quality report recording visual irregularities including photographs or diagrams supported by witness statements.
P5, P6, M3, D2	Testing of Different Types of Joint	A practical activity where the learner produces welded joints and tests them by using destructive or non-destructive test methods. The activity is supported by a reflective written activity.	A practical producing the required welded joints. A quality report recording the type of test and the test results, including photographs or diagrams and supported by witness statements.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Fabrication Techniques and Sheet Metal Work	Applications of Welding Technology
		Welding Principles

This unit has links with the following units from the Level 2 SEMTA National Occupational Standards in Fabrication and Welding Engineering:

- Unit 4: Joining Materials by the Manual Metal Arc Welding Process
- Unit 5: Joining Materials by the Manual MIG/MAG and Other Continuous Wire Welding Processes
- Unit 6: Joining Materials by Manual TIG and Plasma-arc Welding Processes
- Unit 7: Joining Materials by the Manual Gas Welding Process
- Unit 8: Producing Fillet Welded Joints using a Manual Welding Process.

The unit also supports the Level 2 NVQ in Performing Engineering Operations, particularly:

- Unit 27: Preparing and Using Manual Metal Arc Welding Equipment
- Unit 28: Preparing and Using Manual TIG or Plasma-Arc Welding Equipment.
- Unit 29: Preparing and Using Manual MIG, MAG and other continuous Wire Welding Equipment
- Unit 30: Preparing and Using Gas Welding Equipment.

Essential resources

Centres delivering this unit will need access to appropriate welding equipment, consumables and materials as outlined in the unit. Centres must also have access to appropriate destructive and non-destructive test equipment.

Employer engagement and vocational contexts

The materials and processes used in the delivery of this unit should be in the context of the learners' workplace or based on case studies of local employers. Learners may benefit from industrial visits to provide an understanding of welding in an industrial context and to appreciate the range of processes and materials used in industry. Visits could also consider the modes of testing welds in industry to enhance the learning experience.

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

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

Indicative reading for learners

Textbooks

Jeffus L – *Welding Principles and Applications* (Delmar Learning, 2007) ISBN 1418052752

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

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing the welds that they have completed to visually examine the quality of welds and identify weld irregularities
Self-managers	planning and organising their time and resources when selecting the correct tools, equipment and consumables and carrying out welding techniques.

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

Skill	When learners are …
Creative thinkers	continuously exploring the effects of changing welding parameters and techniques generating ideas as to the cause of weld defects either by visual examination or destructive or non-destructive testing
Reflective learners	analysing the outcomes of changing welding parameters and techniques visually examining their weld samples for defects and irregularities and understanding their causes.

Functional Skills – Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking and listening to peers and those supervising when reviewing the quality of welds produced, and the results of testing
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate sources of information during welding tasks eg job instructions, safety instructions, quality specifications
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing health and safety legislation and common hazards associated with welding planning and justifying the tools and equipment required for welding, and listing consumables writing a report to show the results of destructive or non-destructive tests.

Unit 17: Fabrication Techniques and Sheet Metal Work

Unit code: T/600/0414

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners the knowledge and skills needed to safely measure, mark out, cut, form and assemble fabricated structures using sheet metal.

Unit introduction

This unit gives learners with no previous experience of fabrication or sheet metal work an opportunity to work with the principles, materials and processes used in industry.

Learners will perform a range of practical tasks which may include the use of metallic and non-metallic materials. Different types of materials will be used including sheet, plate and sections. At each stage in the process learners will select appropriate hand and machine tools and check that they are properly prepared for use and in a safe condition.

The process starts with marking out an accurate pattern. The material's properties may influence the location of the shape on its surface so the underpinning knowledge provides an informed approach to marking out procedures.

The next stage requires the material to be cut to the correct shape and size. An appropriate forming process is then required to produce a three-dimensional shape according to the job specification. Assembly of the components will be carried out using mechanical, thermal or adhesive joining processes. Continuous assessment will be carried out to ensure that the learners' skills are developed enabling them to work to a required standard, and to the tolerances in a given specification.

This unit is appropriate for learners who are employed or are being prepared for employment in an industrial environment where fabrication and sheet metal work are an integral part of a manufacturing process.

Learners will be expected to demonstrate an understanding of their responsibilities in terms of both health and safety and organisational practices and procedures within the fabrication industry. The unit will help learners understand the safety precautions required when working with fabrication tools and machinery.

Learning outcomes

On completion of this unit a learner should:

1 Know the safe working practices used in a fabrication workshop and relevant health and safety legislation

2 Be able to measure and mark out materials for fabricated structures

3 Be able to cut and form materials safely in a sheet metal fabrication environment

4 Be able to join and accurately assemble fabricated structures.

Unit content

1 Know the safe working practices used in a fabrication workshop and relevant health and safety legislation

Safe working practices: general workshop and site safety eg equipment set-up and shut down, guarding of machinery and power tools, manual handling of sheet metal, plate and rolled section materials, personal protective equipment (PPE), burrs on sheet materials, slips, trips and falls; when using processes eg marking out mediums, working with laser marking out equipment, lifting long and heavy components, cutting materials; general maintenance, action to be taken when tools and equipment are dangerous or poorly maintained, maintenance and use of compressed air and electric power tools; safe disposal of waste materials

Legislation: aspects applicable to fabrication and sheet metal work eg Health and Safety at Work Act 1974, Control of Substances Hazardous to Health (COSHH) regulations 2002, Supply of Machinery (Safety) Regulations 1992 Provision and Use of Work Equipment Regulations (PUWER) 1998, Health and Safety (First Aid) Regulations 1981, Manual Handling Operations Regulations 1992, Lifting Operations and Lifting Equipment Regulations 1998, Personal Protective Equipment at Work Regulations 1992, Control of Noise at Work Regulations 2005

2 Be able to measure and mark out materials for fabricated structures

Measuring and marking out: measuring tools eg rule, tape rule, protractor, height gauge; marking out tools eg scriber, centre punch, chalk line, square, trammel, dividers, templates, surface plate, chalk, blueing or paint; features eg datum lines and centre lines, square and rectangular profiles, circles, curved profiles, cutting detail, hole centring and circular and linear outlining; laser measuring and marking equipment; calibration of equipment; quantity eg single 'one off' components and batch production

Material types: forms of supply; sheet, plate or section materials eg hot-rolled black, cold-rolled; thickness up to and including 3 mm; range of material types appropriate to assembly eg bar and section lengths and profiles, cutting detail for flat covers and plates, frames or structures, fish plates, gussets, spars and brackets, pipe and tube sections, structural support pads, bed plates, columns, beams or struts, simple seatings (boiler saddles and tank cradles)

Materials: metallic (ferrous and non-ferrous) eg mild steel, tinned steel, galvanised steel, aluminium, stainless steel, brass, copper; non-metallic eg plastics and rubbers, common forms eg sheet, extrusions and mouldings, uses in fabricated assemblies eg seals, gaskets, trims, panels and screens

3 Be able to cut and form materials safely in a sheet metal fabrication environment

Cutting: hand tools eg tin snips, hacksaw, files; hand power tools eg drill, nibbler; machine tools eg bench shears, guillotine, band saw, pillar drill, punching and cropping machines; operations eg straight cuts, external curved contours, round holes; cutting action of hand tools and machinery eg shear and material removal (filing and drilling)

Forming: tools and equipment eg hammers, mallets, stakes and formers, hand or powered bending machines, hand or powered rolling machine; safety checks on tools and equipment eg hammer shafts are secure, striking faces on stakes and formers are free from defects and damage, machine guards and safety devices, forming tools; operations eg bends, folds, curved panels, cylindrical sections, ducting or trunking

4 Be able to join and accurately assemble fabricated structures

Joining processes: permanent and non-permanent joints, thermal eg temporary tack welding, soldering or brazing, resistance spot welding; mechanical fasteners eg hollow or solid riveting, self piercing rivets, threaded inserts, structural fasteners, bolts, screws; adhesives eg structural adhesives, epoxides, acrylics and their toughened variants

Assemblies: type of assembly eg frames, tanks, ducting, guards, hoods, panels, sectional trunking, square, rectangular and box sections, cylindrical sections, conical sections, reduction pieces; types of components in the assemblies eg sheet metal covers, pre-fabricated square and rectangular components, pre-fabricated cylindrical and conical components, brackets, flanges, pipes, light rolled angle, channel or tee section

Quality and accuracy standards: understand achievable tolerances in respect of the type of material, joining, and assembly processes; correctly assemble and align in accordance with the specification; overall dimensions are within specification tolerances; overall dimensions are within geometric tolerances eg square, straight, angles free from twists, pitches of erection holes meet specification requirements, assemblies have secure and firm joints; clean and free from burrs and sharp edges

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe safe working practices used in the fabrication industry and identify relevant health and safety legislation	**M1**	explain the roles and responsibilities of employers and their employees in the application of health and safety legislation applicable to the fabrication industry	**D1**	analyse a pattern that has been marked out and suggest a method of marking out a large quantity of these parts for fabrication
P2	measure and mark out different types of material for a fabricated structure [SM3]	**M2**	explain the cutting action of one machine and one hand tool which may be used in the production of sheet metal fabrications.	**D2**	compare and discuss the advantages and disadvantages of using a permanent and a non-permanent joint when joining sheet metal and sectional materials.
P3	demonstrate the safe use of cutting and forming equipment in the production of two sheet metal fabrications [SM3, SM4]				
P4	use a given quality standard to accurately join and assemble materials to produce a fabricated structure. [IE4, SM3]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using tutor-led demonstrations followed by practical tasks during which learners can gain experience of working with the appropriate tools and equipment. Learners will benefit from understanding the value of working with sheet and sectional materials in order to produce a quality product.

Learning outcome 1 should be embedded in tutor-led demonstrations and reinforced through continuous observation and assessment. Learners must understand the health and safety requirements and responsibilities of those working in industry, including risk assessment of potential hazards.

Learners will be given the opportunity to use a range of different techniques in each of the four areas within the fabrication process, ie measuring and marking out, cutting, forming and joining. Underpinning knowledge can be delivered through a combination of practical demonstrations and classroom-based sessions focusing on the theoretical aspects of the processes and techniques.

Learners will perform a range of tasks designed to improve their knowledge and understanding of the tools and materials used in an industrial environment. Formative tasks should be short and progressive to ensure that learners are both competent and confident in their ability to proceed to the next stage of the process. Learners should be encouraged to evaluate their performance by completing formative tasks which may be self or peer assessed. This should be reinforced with appropriate formative feedback from the tutor.

The summative tasks will include techniques and processes from the four outlined areas. When learners have achieved the required level of knowledge and skill in a given area they should complete relevant summative tasks before moving to the next formative stage progressing through each area of the process. This allows the learner to achieve learning outcomes as soon as possible as knowledge and skills are acquired, which permits their increasing competence to be demonstrated.

Work-based learners should be encouraged to relate the learning outcomes to the processes and techniques used at work, but they should also gain knowledge and skills in the fabrication processes used throughout the industry. Centres should relate tasks to the needs of local industries to prepare learners not currently employed so that they enter employment with the appropriate skills and knowledge.

Note that the use of 'eg' in the unit content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching and workshop session: • induction into workshops and general safety and emergency procedures • identify specific processes used in the fabrication and sheet metal work industries.
Class taught session: • explain safe working practices • identify health and safety legislation related to fabrication and sheet metal working environments.

Topic and suggested assignments/activities and/assessment
Prepare and carry out assignment 1 (P1, M1)
Class taught session: • stock material types – sheet, tube, sections, plate • types of material, metallic, non-metallic • tools and equipment required when measuring and marking out.
Workshop practical session: • measurement techniques and tools • marking of sheet, tube and sectional materials as used in industry • marking out according to material type and surface form.
Prepare for and carry out assignment 2 (P2, D1)
Class taught session: • safety when using cutting tools and machinery • cutting tools types of hand operated, power tools, and machines • tool maintenance • tool set up, consumables and use • cutting action – shear, materials removal.
Workshop practical followed by individual learner practice: • safety in the workshop when using cutting equipment • correct tool set up and maintenance • material characteristics when cutting • cutting external profiles • cutting internal profiles and shapes • cutting of sheets and sections – blanking, cropping.
Class taught session: • safety when using forming tools and machinery • bending and folding theory, types of machine • use of rolling machinery • forming with hammers and mallets.
Workshop practical followed by individual learner practice: • safety in the workshop when using forming equipment • bending and folding – safety, set up, maintenance, springback • rolling – safety, set up, maintenance • hand power tools used for forming operations • manual forming processes – hammers, mallets stakes and formers.
Prepare for and carry out assignment 3 (P3, M2)

Topic and suggested assignments/activities and/assessment
Class taught session: • safety in the workshop and in industry during assembly • thermal joining processes • mechanical fastening • adhesives • types of assembly and best use of materials • quality standards – dimensional accuracy, tolerances and geometrical tolerances • recording and interpreting accuracy and tolerances.
Workshop practical followed by individual learner practice: • preparation of joints for assembly • safe joining and assembly techniques • joining materials – thermal, mechanical and bonding with adhesives • working to specifications and checking assembled components.
Prepare for and carry out assignment 4 (P4, D2).

Assessment

To achieve all pass criteria learners will need to demonstrate their skills using all four stages of the fabrication process. Learners will use their knowledge and understanding to produce a fabricated assembly using sheet materials (P4) using thermal and mechanical joining processes and techniques. The criteria P2 and P3 should occur naturally if the tasks are designed around the range of processes and materials identified in the unit content.

Some of the evidence will be in the form of tutor observation and oral questioning from practical sessions. To provide evidence of knowledge and understanding of the criteria, centres could also consider the use of a logbook or portfolio to record the processes and techniques used to perform the tasks. The inclusion of photographic evidence, drawings and a written description of each stage of the task would enable learners to demonstrate their competence with regard to using tools and equipment. Health and safety legislation and working practices (P1) relative to the task should be included in each description plus references to the safe operation of specific tools and equipment.

To achieve a merit grade, learners will need to demonstrate their understanding of health and safety legislation as it applies to those working in the fabrication industry. Learners will also be able to explain the cutting action of specific tools. They will need knowledge of the principles of the shearing process, and material removal processes such as drills and files. Learners' knowledge of hand tools, power tools and machinery used for cutting will be covered during practical sessions. However, they should be given the opportunity to research the subject using both written and information technology sources. The evidence for each of the merit criteria is most likely to be in the form of written answers to a focused task set by the tutor.

To achieve a distinction grade, learners need to demonstrate an understanding of the principles and applications of the marking out and joining methods used in the fabrication of sheet metal and sheet metal assemblies. Learners can do this by explaining the advantages and disadvantages of using permanent and non-permanent joining methods and the alternative methods of marking out. Tutors will need to be satisfied that the learners' work is distinctive based on the written answers to set questions or tasks.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1	Working Safely in the Fabrication Industry	Learners have been asked to produce a report on safety in the fabrication workshop.	A report with appropriate references to the source of information. The report outlines the legislation and safe working practices applicable to the sheet metal fabrication industry.
P2, D1	Measuring and Marking Out	Learners are given guidelines in order to measure and mark out materials using standard tools and equipment. This is done in preparation for cutting and forming a fabricated structure.	A practical activity for which learners mark out different types of materials accurately and using appropriate tools and equipment. A short report that considers methods of marking out a quantity of components.
P3, M2	Cutting and Forming	Learners produce two sheet metal fabrications using the materials already marked out.	A demonstration that requires the learner to cut materials having selected appropriate equipment. The learner will also form the materials having set up and used the equipment correctly. All areas of this assessment should be performed in a safe manner. A report or presentation should be used to identify one hand tool and one machine that are used in the cutting of sheet metal and other fabrication materials. The learner will explain, in detail, the cutting action that is used in each case.
P4, D2	Joining and Assembly	Learners work to a given quality standard so that joining techniques are used to produce fabrications and assemblies. It would be beneficial if this activity uses the materials formed in P3.	A practical where the learner will produce an accurate assembly to given tolerances. The learner will use a combination of permanent and non-permanent joining methods in the form of mechanical fastenings, adhesives or thermal joining processes. The specification should include a checklist for dimensional accuracy and geometric and dimensional tolerances. A report will be used to compare a permanent and non-permanent method of joining sheet metal materials. This will be used to discuss the advantages and disadvantages of both.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Engineering Marking Out	Fabrication Processes and Technology

This unit has links with the SEMTA National Occupational Standards and can contribute towards the knowledge and understanding required for the Level 2 NVQ in Fabrication and Welding Engineering, particularly:

- Unit 21: Marking Out Components for Fabrication
- Unit 22: Cutting Sheet Metal to Shape using Hand and Machine Tools
- Unit 23: Forming Sheet Metal using Hand and Machine Tools
- Unit 24: Producing Sheet Metal Assemblies
- Unit 29: Bonding Engineering Materials using Adhesives.

The unit also links with Unit 22: Producing Sheet Metal Components and Assemblies from the Level 2 NVQ in Performing Engineering Operations.

Essential resources

To deliver this unit it is essential that centres have 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.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Where learners are employed the materials and processes used should be in the context of the learners' workplace, or may be based on case studies of local employers for those preparing for employment. Learners may benefit from industrial visits to provide an understanding of fabrication techniques and sheet metal work in an industrial context, and to appreciate the range of processes and materials used in industry.

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

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

Indicative reading for learners

Textbooks

Kenyon W – *Basic Welding and Fabrication* (Longman, 1987) ISBN 9780582005365

Robinson A – *The Repair of Vehicle Bodies* (Butterworth-Heinemann, 2006) ISBN 9780750667531

Wakeford R E – *Sheet Metal Work* (Special Interest Model, 1987) ISBN 9780852428498

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information in quality standards to join and assemble materials
Self-managers	organising time and resources and prioritising actions when measuring, marking out, cutting and forming materials.

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

Skill	When learners are …
Creative thinkers	assembling a fabricated structure to a required quality standard.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	working with guideline dimensions whilst measuring and marking out
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	working with dimensional and geometric tolerances and assessing inaccuracies
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking and listening to peers and tutors in a range of contexts applicable to the process of sheet metal fabrication
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading and interpreting information in guidelines, quality standards and safety related text to complete summative and formative tasks
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	writing of reports to effectively communicate an understanding of current health and safety legislation.

Unit 18: Engineering Marking Out

Unit code: J/600/0417

QCF Level 2: BTEC Firsts

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit aims to give learners the skills needed to carry out marking out operations in a practical environment, in preparation for machining operations and component manufacture.

Unit introduction

The manufacture of a product always starts from raw materials that have to be formed and shaped into the components parts. The aim of this unit is to give learners the knowledge and use of skills needed for the measurement and marking out of components in preparation for machining operations. This first step in the manufacture or development of a product is critical to all the processes that follow.

The unit gives learners an opportunity to consider how to care for and use measuring and marking out equipment. It also introduces them to work planning skills to enable them to carry out a range of marking out exercises including the selection of appropriate measuring, marking out and work-holding equipment. Learners will work with square, rectangular, circular and irregular shaped workpieces.

An important aspect of this unit is the consideration of safe working practices and good housekeeping in an engineering workplace environment delivered where possible, in a practical context.

Learning outcomes

On completion of this unit a learner should:

1 Know about marking out methods and equipment for different applications

2 Be able to mark out engineering workpieces to specification.

Unit content

1 Know about marking out methods and equipment for different applications

Measuring and marking out methods: equipment required; work-holding method and device(s); materials and consumables required; datum face(s) and/or reference points to be used

Measuring and marking out equipment: tools eg engineer's rule, scriber, centre punch, dividers, odd-leg callipers, engineer's square, scribing block, vernier protractor, vernier height gauge, dial test indicators, slip gauges; use and care of work-holding devices eg surface tables/plates, angle plates, v-blocks and clamps; calibration of measuring and marking out equipment; marking out mediums eg lacquer, whitewash

Applications: square/rectangular eg bar stock, sheet materials; circular/cylindrical eg bar stock, tubes, turned components, flat disks; irregular shapes eg castings, forgings, odd shaped components

2 Be able to mark out engineering workpieces to specification

Work plan: reading engineering drawings and/or job instructions; planning the sequence of marking out operations; identifying materials and equipment required

Marking out: preparation of material eg identification of type of material (steel, cast iron, aluminium, plastics), checking for visual defects, cleaning component to remove protective coatings/rust/grease/dust, removing burrs and sharp edges; setting and positioning workpieces eg using squares, dial test indicators, slip gauges, packing pieces, jacks; marking out to a planned sequence of operations eg datum and centre lines, square/rectangular profiles, angles/angular profiles, circles, linear hole positions, radial hole positions, pattern development (cones, pyramids); centre punching of hole centres

Safe working practices: personal protection and hygiene procedures eg overalls, eye protection, barrier creams; appropriate behaviour in the working environment; maintaining a tidy and safe work area; appraisal of health and safety risks to self and others

Housekeeping: leaving the work area in a safe condition; cleaning of equipment; disposal of waste; storage of measuring and marking out equipment

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	select suitable measuring and marking out methods and equipment for three different applications [IE1]	**M1**	recommend corrective action for unsafe or defective marking out equipment	**D1**	justify the choices of datum, work-holding equipment and measurement techniques used to mark out the three different applications.
P2	describe the measuring and marking out equipment used for the three different applications	**M2**	carry out checks to ensure that the marked out components meet the requirements of the drawing or job description.		
P3	prepare a work plan for marking out each of the three different applications				
P4	mark out the three different applications to the prepared work plan [SM3]				
P5	demonstrate safe working practices and good housekeeping. [SM4, EP4]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using lectures, tutor demonstrations and practical engineering activities. A practical approach to delivery should be used and access to a fully equipped workshop with measurement and marking out equipment is essential. Learners should be given an opportunity to work with the full range of equipment as listed in the unit content and mark out raw material and components across the full range of applications including square/rectangular, circular/cylindrical and irregular shapes.

The delivery approach taken may be to introduce and develop the skills, methods, techniques and equipment to use when working with square bar and/or sheet metal then carry out an assessment activity. Once this has been achieved, learners should move on to circular/cylindrical shaped workpieces, etc.

When delivering the unit, centres should endeavour to provide the widest possible range of experiences with marking out and measuring tools and, also with the range of workpieces and materials (eg steel, cast iron, aluminium, plastics). This experience should not be limited to current or planned employment sectors but used to extend the learner's appreciation of other areas of engineering.

Delivery of the practical marking out activity will require access to an engineering workshop environment, relevant tools and equipment. During the delivery of this phase of the unit, the learners could be provided with a range of simple marking out tasks to enable them to practice their skills and to provide an opportunity for support and guidance to be given. Each task should be designed so that it requires the learners to plan and then complete the work activity. The opportunity to work with individuals during the delivery of this practical work can be used to good effect to underpin learning. In particular, it can be used to reinforce planning, marking out practices and skills, help them to deal with problems experienced or to support them in order to achieve the task.

Note however, that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content assessment model, workshops, library and IT resources • explain safe working practices, personal protection, hygiene procedures, appropriate behaviour in the working environment and importance of maintaining a tidy and safe work area • explanation of the engineering drawing terms and abbreviations used in the marking out process. Individual learner exercise: • identify drawing types, terms and abbreviations.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain importance of work planning prior to marking out operations • explain planning the sequence of marking out operations • identify marking out equipment material requirements. Individual learner activity: • read engineering drawings and plan equipment requirements and marking out operations. Tutor demonstration: • marking out sequence – simple component drawing on paper using drawing equipment. Individual learner activity: • practise using equipment to mark out simple components on drawing paper.
Whole-class teaching: • explain marking out work holding methods, equipment requirements, materials and mediums used • explain how to use, calibrate, and care for marking out equipment and tools. Tutor demonstration: • demonstrate use of work holding equipment and marking out methods. Workshop activity: • learners practise using measuring and marking out tools and equipment • mark out a simple component using equipment.
Whole-class teaching: • explain procedures, equipment requirements and marking out applications for square round and irregular shapes. Tutor demonstration: • procedures, equipment and marking out techniques used to mark out square round and irregular shapes. Workshop activity: • learners practise using techniques and equipment to mark out square, round and irregular shapes.
Prepare for and carry out assignment 1 (P1, P2, P3, P4, P5, M1, M2).
Whole-class teaching: • explain importance of leaving the work area in a safe and clean condition • explain storage of equipment and documentation requirements.
Prepare for and carry out assignment 2 (D1).
Feedback on all assessment tasks, unit evaluation and close.

Assessment

It may be possible to integrate the work of this unit with other units in the qualification or to use work-based assessment evidence. The assessment criteria require learners to carry out three different measuring and marking out activities for different applications including square/rectangular, circular/cylindrical and irregular shapes (note that square/rectangular means either square or rectangular application). For example, marking out a piece of sheet metal for an inspection cut-out and inspection cover location holes, marking out a circular shaft that needs to be drilled through its diameter and marking out a casting for holes to be drilled and tapped to receive a flange. Careful choice of components ensures full coverage of all the learning outcomes, criteria and unit content with just these three tasks. However, in the unlikely situation that this cannot be achieved, then more components could be introduced in either practise or theory as applicable to the criteria and content covered. The preferred approach would be to increase the range of actual marking out exercises carried out by the learner to cover the missing criteria/content item. Choice of the three different applications should also provide for the widest possible coverage of the examples in the unit content. That is, the range of work-holding devices required for the three applications may include for task 1 – the use of a surface plate only; task 2 – surface plate, v-block and clamps; task 3 – surface table, angle plate and clamps or other variations applicable to the task. This should also be applied to the measuring and marking out equipment. Likewise, if sheet metal is chosen for the square/rectangular application then bar stock should be used for the circular/cylindrical application. It would not be acceptable or sufficient to carry out three very similar tasks with similar marking out requirements and similar equipment demands.

To achieve a pass, learners should be able to select suitable measuring and marking out methods and equipment for three different applications – square/rectangular, circular/cylindrical and irregular shapes. Learners should then describe the measuring and marking out equipment to be used for these three different applications. Learners must then prepare a work plan for marking out each of the three different applications and mark them out using the prepared work plan. For each of these tasks to be completed satisfactorily learners should be able to demonstrate safe working practice and good housekeeping at all times.

To achieve a merit grade, learners should be able to recommend corrective action for unsafe or defective marking out equipment; this could be for the tools being used or the measuring instruments. Ideally, the evidence would be gathered naturally during work with the three applications and would be captured through a tutor observation record. This record would need to identify the equipment defect and the context within which it occurred plus the corrective action recommended by the learner. However, if this is not appropriate then centres may wish to simulate this by ensuring that a piece of defective marking out equipment is issued to the learner. It will be for centres to determine sufficiency in this criterion and it is not intended that this should be assessed in each of the applications. However, the criterion is trying to determine learners' understanding of the correct function of the equipment and their independence of action when something is not as it should be.

The second merit criterion requires the learner to be able to carry out checks to ensure that the marked out components meet the requirements of the drawing or job description. To be fully achieved, this criterion should be applied to all three applications undertaken by the learner. However, it is expected that if the learner fails to make sufficient checks on the first task but through their development, based on the first assessment feedback, they were then able to demonstrate this level of achievement in the remaining two tasks, then the assessor would be able to make the judgement that the criterion had been achieved. Again, the criterion is about independence and quality of work being the responsibility of the technician and not something that needs to be imposed.

To achieve a distinction grade the learner should be able to justify the choices of datum, work-holding equipment and measurement techniques used to mark out the three different applications. Clearly, this needs to be applied to each task set (application) and is intended to determine the ability of the learner to reflect on the what, why and how of each task. The evidence for this criterion is most likely to be in the form of a critically evaluative write-up of the task undertaken. Success in this criterion should be measured through determining the learner's ability to develop the skills of measurement and marking out through application. If learners are able to give good reasons for and substantiate their actions then they have achieved the highest level of independence expected of this unit at this level. It would be reasonable to assume that whatever marking out tasks these learners were subsequently set they would be able to apply to them this level of analysis and evaluation.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, P4 and P5	Assignment 1 Task 1 Engineering Marking Out	A practical activity requiring learners to prepare a work plan select suitable measuring and marking out methods and equipment. Carry out marking out activities for three different applications including square/rectangular circular/cylindrical and irregular shapes.	Practical assessment. Ideally, the evidence would be gathered naturally during work with the three applications and would be captured through tutor observation record and supporting photo.
M2	Assignment 1 Task 2 Engineering Marking Out	Learners carry out checks to ensure that the marked out components meet the requirements of the drawing or job.	Completed work log sheet for each task identifying sequence of operation description of equipment, materials used and quality checks.
M1	Assignment 1 Task 3 Engineering Marking Out	Learners to recommend corrective action for unsafe or defective marking out equipment.	Tutor observation record identifying the equipment defect plus the corrective action recommended by the learner.
D1	Assignment 2: Choices of Datum, Work Holding Equipment and Measuring Techniques	A written activity requiring learners to justify the choices of datum, work-holding equipment and the measurement techniques used.	A report containing a critically evaluative write-up of the task the report will Identifying problems encountered and suggested improvements.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Using and Interpreting Engineering Information	Engineering Drawing for Technicians
	Fabrication Techniques and Sheet Metal Work	

This unit has close links with the Level 2 NVQ in Fabrication and Welding Engineering, Unit 21: Marking Out Components for Fabrication.

The unit can also contribute towards the knowledge and understanding of the Level 2 NVQ in Performing Engineering Operations, Unit 22: Producing Sheet Metal Components and Assemblies.

Essential resources

Access to a workshop fully equipped with a range of measurement and marking out equipment is essential. A range of workpiece materials, components and drawings will also be required to enable the learner to gain the range of experience and coverage expected.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

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

Indicative reading for learners

Textbook

Tooley M – *BTEC First in Engineering* (Newnes, 2006) ISBN 0750680601

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when selecting suitable measuring and marking out methods and equipment for marking out activities
Self-managers	organising time and resources, prioritising actions when marking out the three different applications to a prepared work plan
Effective participators	identifying improvements to working practice and good housekeeping.

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

Skill	When learners are …
Independent enquirers	resolving problems by recommending corrective action for unsafe or defective equipment
Team workers	collaborating with others when carrying out marking out activities
Reflective learners	reviewing progress and monitoring performance when carrying out checks to ensure that the marked out components meet the requirements of the drawing evaluating their own experience and learning when justifying the choices of datum, work-holding equipment and measurement techniques used in marking out applications.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Use appropriate checking procedures and evaluate their effectiveness at each stage	measuring marking out and carrying out checks for accuracy
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing safe working and good housekeeping. practices
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading information and drawings for component marking out applications
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing measuring and marking out equipment writing a report justifying the choices of datum work holding and equipment used for marking out applications.

Unit 19: Electronic Circuit Construction

Unit code: L/600/0418

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will enable learners to select electronic components for a given function, read circuit diagrams and construct simple electronic circuits.

Unit introduction

This unit will introduce learners to the skills and related theory required when selecting electronic components and constructing simple circuits when working as an electronics technician.

The unit will enable learners to read simple circuit diagrams and understand the fundamental principles involved when selecting electronic components for a given task. They will also develop the ability to construct simple electronic circuits using a variety of construction techniques.

Learners will firstly gain an understanding of the safe working practices needed when working with electronic components and circuits and the hazards and risks that can occur when constructing electronic circuits in a workshop or laboratory.

Learners will develop an understanding of the function of electronic components and their representation in circuit diagrams. They will then investigate the various methods used to construct electronic circuits and will select appropriate electronic components in order to build a number of complete circuits.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use safe working practices in the electronics laboratory/workshop

2 Know about electronic components and circuit diagrams

3 Know about the manufacture of electronic circuit boards

4 Be able to construct an electronic circuit.

Unit content

1 Be able to use safe working practices in the electronics laboratory/workshop

Hazards: sharp edge hand tools eg cuts and abrasions, swarf from cutting component leads and drills; soldering irons eg burns, fumes, lead content; toxic substances, chemical compounds and fumes eg Beryllium oxide, lead, solvents, etching fluid

Safe working practices: safe use of hand tools eg drills, soldering irons, wire cutters and strippers, pliers, knives and scalpels, screwdrivers; use of personal protective equipment (PPE) eg safety glasses; handling and storage of components and test equipment; use of first aid procedures eg for electrical shock, electrical and acid burns; procedures for establishing risk; cable colour coding of mains equipment; selection and fitting of a fuse for a device of known power; checking earth connections; replacement of a mains plug to a three-core cable; polarity issues eg power supplies, cells and batteries, electrolytic capacitors, semiconductor devices

2 Know about electronic components and circuit diagrams

Component types: power sources eg cells, batteries; transformers; inductors/chokes, switches, plugs and sockets; audio and visual indicators eg lamps and neons; resistors eg carbon composition, carbon film, metal film, wire wound, variable resistors, light dependent resistors, tolerances, colour codes; capacitors eg ceramic, polyester, polypropylene, metalised paper, mylar, electrolytic, tantalum, polarisation issues, colour codes, values; semiconductors eg diodes, light emitting diodes (LED), transistors – bipolar and field effect (FET); integrated circuit components eg logic gates, operational amplifiers, timers

Circuit diagrams: use of block schematic; component symbols labelling/legends values; inter connections – linkages; national and international standards.

3 Know about the manufacture of electronic circuit boards

Types of circuit boards: breadboard/protoboards; strip and tag boards; printed circuit boards (pcb)

Circuit board manufacture: designing layout; producing artwork; etching; drilling holes; populating board; soldering onto pcb

4 Be able to construct an electronic circuit

Circuit construction techniques: soldering techniques eg avoidance of dry joints, use of heat sinks; wire-wrapping; component pin/terminal identification eg labelling; power supply connections; noise limitation considerations; double layer boards; surface mount technology

Types of circuit: eg single transistor circuits (amplifier, sensor and switch), combinational logic circuits, alarm circuits, audio and optical circuits

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the potential hazards related to constructing electronic circuits	**M1**	explain the function and operation of four different electronic components	**D1**	propose a method used to construct a given electronic circuit and justify your choice.
P2	use safe working practices in the electronics workshop/ laboratory [SM4]	**M2**	explain the advantages and disadvantages of the three types of electronic circuit board.		
P3	describe the purpose of six different types of electronic component				
P4	read a given circuit diagram to identify the electronic components in the circuit [IE4]				
P5	describe the manufacture of the three types of electronic circuit boards				
P6	use two methods of construction for a given electronic circuit. [SM3]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit should be based on a planned programme of practical laboratory work, supported by related theory. Learners should study the fundamentals of circuit construction and have the opportunity to apply these to a wide range of component types and circuit functions.

This unit is designed to develop the underpinning knowledge and skills of learners in the field of electronic circuit construction. All four learning outcomes involve a large amount of practical investigative work. Learning outcomes 1 and 4 have the most practical content whilst learning outcomes 2 and 3 provide the supporting knowledge of components and circuit manufacture essential for working in an electronics workshop or laboratory.

In delivering learning outcome 1, tutors should provide support in the form of demonstrations, guided discussion, case studies and presentations on potential hazards and safe working in an electronics workshop/laboratory. Learners should be instructed on the correct operation and performance on the range of hand tools to be encountered.

For learning outcome 2 learners should be introduced to the applications of a wide variety of passive and active electronic components. They need experience of the use of power sources, audio and visual indicators, resistors, capacitors, semi-conductors and integrated circuits. To be able to know about components and circuit simulation tools the use of simple systems such as Electronics Workbench may be useful to show component representation.

Learning outcome 3 will involve introducing learners to the different types of and various techniques employed for the manufacture of electronic circuits, including that of PCB design.

For learning outcome 4 tutors should ensure that learners have adequate access to electronic components, tools and pre-prepared printed circuit boards for a minimum of two electronic circuits.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and assessment • introduction to safe working practices and hazards in electronics laboratories and workshops, including PPE handling and storage of components and equipment • explain safety issues relating to power supplies, cells and batteries, electrolytic capacitors and semiconductor devices.
Group practical exercise: • identifying hazards specific to learners' own working environment • demonstration and practise of safe use of hand tools • demonstration of how to fit a plug to mains cable selecting an appropriate fuse.
Prepare for and carry out assignment 1 (P1).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the purpose and function of the different power sources, inductors, switches and plugs/sockets and indicators • introduce and explain the purpose and function of various types of resistor and capacitor • explain the purpose and function of semiconductors and integrated circuit components. Practical class activities: • identifying and sketching various types of components from physical specimens and component catalogues.
Whole-class teaching: • explain representation of components on circuit diagrams. Practical class activity: • reading and identifying components from a range of simple circuit diagrams involving a range of components.
Whole-class teaching: • describe the different types of circuit boards and explain how to interconnect components to form the complete circuit – including input and output connections and power supplies with the aid of component layout and circuit diagrams. • demonstrate the correct use of soldering irons when soldering components on to strip and tag boards • explain and demonstrate construction of electronic circuits using PCB, including designing the layout of the components and interconnection tracks and power supplies • explain the construction of electronic circuits using multi-layer pcbs and the use of surface mounts technology, and other methods of connecting wires. Practical class activities: • constructing simple electronic circuits using breadboard (eg protoboards) • constructing the same simple electronic circuits using soldering irons on strip/tag boards.
Prepare for and carry out assignment 2 (P3, P4, P5, M1, M2, D1).
Prepare for and carry out assignment 3 (P2 and P6).
Feedback, unit evaluation and close.

Assessment

The summative assessment of learners for this unit will be on an individual basis. However, group working and the sharing of tools and equipment is reasonable for the practical sessions and can add to the learning experience.

Some of the assessment for this unit will occur naturally through tutor observation and questioning – for example P2 and P6 may well be assessed by these means. To support this assessment approach learners should provide supporting evidence, for example, the use of a logbook to record the series of practical experiments and construction activities. The log could contain a description of the task undertaken, the instructions provided (annotated to record progress or difficulties), a list of tools, components, equipment provided and their condition, relevant photographs that have been annotated to explain procedures and problems encountered, etc. Such supporting activity evidence would then validate the tutor or witness observation/oral questioning records and vice versa. The use of witness testimonies to confirm that the learner has met the relevant assessment criteria should be encouraged.

The first assignment should be designed to cover the pass criteria for P1 this could be by means of a written task to identify hazards related to working in an electronics workshop or laboratory. This could be in the form of a report or a response to written questions.

The second assignment could be designed to cover P3, P4 and P5 and could also be extended to cover M1, M2 and D1. This could be by means of a written task to describe the purpose of given electronic components (P3), identify electronic components from their symbols on a circuit diagram (P4) and describe three alternative methods of constructing an electronic circuit (P5). For P4 the circuit diagram should ideally involve at least six different components. The assignment could be extended in order to allow learners to correctly identify and describe the function of further electronic components (M1) and explain the design and manufacture of circuit boards (M2). This section of the assignment could be further extended to cover D1.

The third assignment should be in the form of a practical activity which involves the construction of a given simple electronic circuit using two different methods of construction (P6). Note that it is not essential that the constructed circuits are in a working condition however, it is important that they are constructed to meet the given specification. Evidence for P2 could also be gathered in the third assignment. This could be by means of accurate observation or witness statements recording that safe working practices were used.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Potential Hazards and Safe Working Practices in the Electronic Workshop	An activity requiring learners to investigate and identify hazards and safe working procedures when working in an electronics workshop or laboratory.	A report containing written responses about potential hazards and safe working practices. Alternatively a series of written or aural questions directly related to potential hazards and safe working practices could be used.
P3, P4, P5, M1, M2, D1	Electronic Components, Circuit Diagrams and the Construction of Electronic Circuits	A written activity based on the function of electronic components, their representation in circuit diagrams and the construction of electronic circuits.	A report containing written responses about the purpose and function of electronic components, their representation in circuit diagrams and the construction of electronic circuits. Alternatively a series of written or aural questions directly related to the function of electronic components, their representation in circuit diagrams and the construction of electronic circuits.
P2, P6	Construct Electronic Circuits to a Given Specification Using Safe Working Practices	A practical activity using two methods of constructing a given simple electronic circuit.	A practical activity supported by witness statements/observation records, physical evidence and annotated photographs.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Electronic Devices and Communication Applications	Electronic Circuit Design and Manufacture
	Operation and Maintenance of Electronic Systems and Components	Principles and Applications of Electronic Devices and Circuits

This unit can contribute knowledge and understanding towards the SEMTA Level 2 NVQ in Performing Engineering Operations, Unit 36: Assembling and Testing Electronic Circuits.

Essential resources

As much of the unit is practically based learners will require access to suitable electronic workshops/laboratories and relevant tools when carrying out the construction of electronic circuits. Learners will need to be provided with suitable electronic components and other hardware such as cables, connectors and circuit boards.

This unit is intended to provide learners with a practical introduction to the construction of electronic circuits. Therefore, it is essential that learners have access to catalogues of electronic components and wide range of diagrams for suitable electronic circuits.

Whilst not essential access for learners to computer simulation programmes such as Multisim (National Instruments) would greatly enhance their understanding.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers.

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

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

Indicative reading for learners

Textbooks

Sinclair I and Lewis G – *Electronic and Electrical Servicing* (Newnes, 2002) ISBN 0750655682

Tooley M – *BTEC First Engineering* (Newnes, 2006) ISBN 9780750680608

Tooley M – *Electronic Circuits – Fundamentals and Applications: Fundamentals and Applications* (Newnes, 2006) ISBN 9780-750669238

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	reading circuit diagrams to identify individual components
Self-managers	using safe working practices to anticipate, take and manage risks organising their own time and resources and prioritising actions when constructing electronic circuits.

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

Skill	When learners are …
Independent enquirers	when using the internet and paper-based resources to investigate electronic components and circuits
Reflective learners	when considering the relative advantages and disadvantages of differing approaches to the construction of the same electronic circuit
Effective participators	when identifying potential hazards and developing safe working methods.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	when using computer programs to simulate circuit operation
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	when using the internet or other computer-based resources to identify electronic components and circuits
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing potential hazards and safe working practice describing differing methods of constructing electronic circuits.

Unit 20: Using Specialist Secondary Machining Techniques

Unit code: R/600/0419

QCF Level 2: BTEC Firsts

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit gives learners the opportunity to explore, select and use appropriate specialist secondary machining techniques.

Unit introduction

The aim of this unit is to provide a detailed knowledge and use of less traditional manufacturing processes that are mainly associated with generating and forming of shapes through machining techniques. It introduces the learner to these more specialist techniques, giving a deeper understanding of the practical process. Learners will develop skills and understanding in selecting, investigating and using secondary manufacturing techniques involving shaping with loss of volume. They will manufacture a component using an appropriate specialist secondary machining technique, during this process they will perform checks for accuracy and demonstrate the fundamental and safety requirements of these techniques.

Learning outcomes

On completion of this unit a learner should:

1 Know how a range of specialist secondary machining techniques are used

2 Be able to use a specialist secondary machining technique safely to accurately make a workpiece.

Unit content

1 Know how a range of specialist secondary machining techniques are used

Specialist secondary machining techniques eg:

- ◊ honing: machine types eg horizontal, vertical
- ◊ lapping: machine types eg rotary disc, reciprocating
- ◊ shaping, planning and slotting: machine type eg shaping, planning, slotting, milling machine with slotting attachment
- ◊ broaching: machine type eg horizontal, vertical
- ◊ electro discharge: machine type eg spark erosion, wire erosion
- ◊ gear cutting: machine type eg gear hobbing, gear shaping, bevel gear cutting, gear planing, gear shaving

2 Be able to use a specialist secondary machining technique safely to accurately make a workpiece

Features of the workpiece: materials eg ferrous, non-ferrous, non-metallic; workpiece eg:

- ◊ for honing: holes eg through, blind, tapered; operation eg roughing, finishing, polishing
- ◊ for lapping: faces eg flat, parallel, angular; operation eg roughing, finishing, polishing
- ◊ for shaping, planing and slotting: faces eg flat, square to each other, parallel, angular; other features eg steps/shoulders, slots/grooves, keyways, splines, serrations; holes eg square, hexagonal
- ◊ for broaching: holes eg flat sided, square, hexagonal, octagonal; other features eg keyways, splines, serrations, special forms
- ◊ for electro discharge: holes; faces eg flat, square, parallel, angular; forms eg concave, convex, profile, square/rectangular; other features eg threads, engraving, cavities, radii/arcs, slots
- ◊ for gear cutting: machined gears eg external spur, internal spur, single helical, double helical, chain sprockets, serrations, splines, straight bevel

Working safely: moving parts, machine guards, handling cutting fluids, insecure components, emergency stop, machine isolation, wearing appropriate protective clothing and equipment, keeping the work area clean and tidy; safe working relevant to specific specialist secondary machining techniques eg:

- ◊ for honing and lapping: eg handling and storing stones, airborne particles
- ◊ for shaping, planning and slotting: eg handling and storing tools, effects of backlash in machine slides and screws
- ◊ for broaching: eg handling and storing broaches, breakage of broaches, handling cutting oils
- ◊ for electro discharge: eg electrical components, handling dielectrics, fumes, handling and storing electrodes and wires
- ◊ for gear cutting: eg handling and storing tools or wheels, handling cutting oils, fumes

Checks for accuracy: components to be free from burrs and sharp edges; use of appropriate tools and instruments, checks for dimensions and surface texture; checks relevant to specific specialist secondary machining techniques eg:

- ◊ for honing: components to be free from stone/disc marks, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 0.2μm (8 μin), checks for parallelism and ovality/lobbing
- ◊ for lapping: components to be free from stone/disc marks, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 0.2μm (8 μin), checks for parallelism and flatness
- ◊ for shaping, planning and slotting: components to be free from false tool cuts, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6μm (63 μin), flatness and squareness within 0.125 mm per 25 mm (0.005 inch per inch) or, angles within +/- 1.0 degree, checks for eg squareness, angles, flatness, spline or serration fit, slot width and position, keyway position
- ◊ for broaching: components to be free from false tool cuts, dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface texture 1.6μm (63 μin); checks for squareness, spline/serration fit, keyway width and position
- ◊ for electro discharge: components to be free from false starts; dimensional tolerance to BS EN 22768-1 or BS 4500, surface texture 0.8μm (32 μin) or 18VDI; checks for eg parallelism, angle/taper, squareness, profile
- ◊ for gear cutting: components to be free from false starts; dimensional tolerance to BS EN 22768-1 or BS 4500, surface texture 1.6μm (63 μin); spur and helical gear to BS 436 Pt1 or BS 1967; involute splines to BS 3550 1963 Class 1; straight splines and serrations to BS 2059 or BS 1953 Class 1; checks for eg blanks, lead and helix angle, tooth thickness, involute form, composite error rolling test, concentricity

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe how three different specialist secondary machining techniques are used	**M1**	identify the features of a workpiece and explain why they are important to check during machining	**D1**	justify the choice of a specialist secondary machining technique for a given workpiece.
P2	machine a given workpiece safely [SM3]	**M2**	explain why the features of a workpiece may be produced inaccurately.		
P3	carry out necessary checks for accuracy on a given workpiece and record the results				
P4	suggest methods of working safely when using a specialist secondary machining technique. [SM4, RL5]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit supports the skills, understanding and knowledge required for several specialist material removal techniques and, as such, a practical approach to delivery should mainly be used. Work-based learners are likely to have a defined technique or range of techniques they are using or being trained to use in their place of work and these techniques should be used during delivery. While only one learning outcome is associated with the machining of a product the assessment throughout relies on evidence generated by this activity and is a large part of the unit.

Each learner should be allowed to study in detail at least one of the techniques listed to allow safe use in the workshop. Learners will however, need to have knowledge of least another two techniques. In the case of work-based learners these techniques may well be determined by their chosen skill route.

Tutors should ensure that learners are aware of the design of the machine tool and how shapes can be produced using specialist secondary machining techniques.

The major part of this unit involves learners using a specialist secondary technique when operating a machine safely. Obvious care needs to be taken to ensure that all learners work in a safe manner and workshop briefings and formative tests may be required to establish that this is the case. Learners should also be taught how to monitor progress during machining and how to make adjustments to the technique although, at this level, they could rely on a technician for this skill. To check the accuracy of workpieces subjected to material removal tutors should ensure learners are familiar with appropriate tools and instruments to check the accuracy of the workpiece. Such tools may be micrometers, texture gauges etc., and those associated with checking for accuracy against the standards listed.

Learners must be made aware of, and have access to, relevant UK health and safety legislation and know the importance of using the techniques safely. Tutors should always ensure that each learner has the correct protective clothing and that machines are correctly guarded before operation.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to engineering workshop • identifying different specialist machine tools • health and safety briefing, legislation and assessment of risk. Class exercise: • carrying out risk assessments. Workshop activity: • identify safety devices and equipment.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the principles of honing, lapping, shaping, broaching, electro-discharge and gear cutting. Workshop activity: • identifying individual component parts and features of machines and safety precautions.
Workshop activities: • identify key features of a range of components. Whole-class teaching: • use of measurement tools, techniques and gauges to determine appropriate levels of accuracy. Learner activity: • using tools and techniques to check given components for accuracy.
Workshop activity: • workshop demonstration on the use of a manufacturing technique and the use of guards/safety devices, lubricants etc.
Closely supervised small-group machining activity.
Learner exercise: • using appropriate techniques to manufacture a component to a given standard.
Preparation and carry out assignment 1 (P2 and P3).
Whole-class teaching: • investigation of the key features of engineering components and how/why they might be produced inaccurately. Learner activity: • analysing given components in order to investigate the key features and whether inaccuracies have occurred in their manufacture.
Preparation for and carry out assignment 2 (P4, M1 and M2)
Whole-class teaching: • use of appropriate specialist secondary machining techniques for a range of different applications. Individual learner activity: • analysing given components in order to determine the most appropriate specialist secondary machining technique.
Preparation for and carry out assignment 3 (P1 and D1).
Review of unit delivery and assessment.

Assessment

This unit requires a variety of evidence to be gathered to support assessment. Some evidence will be in the form of written responses when learners are asked to describe machining techniques and suggesting health and safety aspects. Other evidence will be in the form of process type evidence when witness statements or observation records will be required to capture the process of machining a workpiece safely.

To achieve a merit grade, learners will need to demonstrate that they can explain the importance of checking features when machining a workpiece and understand what causes inaccuracies when machining a workpiece.

The required evidence for these criteria is likely to be in the form of a written response to tasks set for the learner.

To achieve a distinction grade, learners will need to demonstrate skills in justifying a choice of one of the techniques when given a workpiece to machine. This technique is likely to be one from their chosen skill route. Judgements need to be made about whether the technique would succeed and whether it is likely to meet the needs and features of the workpiece.

It is important to maximise the opportunities for assessment through practical tasks. A possible scenario would be to use a total of three assignments. It may be best to set a practical machining task in the first of these to include the machining of a workpiece (P2) and checks for accuracy (P3). Evidence for these criteria could be in the form of annotated photographs and a witness statement. The learner would need to make a record of all measurements taken to complete the requirements of P3.

Once the practical activity has been carried out successfully a written assignment could be given to generate the evidence required for M1 and M2. The tasks for this should refer to the workpiece that learners have already machined and are familiar with. Another task could then be included to ensure that they suggest the safety requirements as required by criteria P4.

The last assignment could include a written task to describe three different techniques (P1) and one to justify the choice of a particular technique for a workpiece in relation to their own skills pathway (D1).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P2, P3	Practical Machining Task	An activity requiring learners to machine a given workpiece using a specialist secondary machining technique and perform checks during the process to ensure an appropriate degree of accuracy throughout.	A practical demonstration supported by witness statements/observation records and annotated photographs to accompany the artefact produced by the learner. Records of measurements taken.
P4, M1, M2	Working Safely in Engineering and Features of a Workpiece	An activity requiring learners to produce a written report showing the safe working practices when using a specialist secondary machining technique and reflecting on the features of the workpiece produced in Assignment 1 and the reasons for inaccuracies.	A report containing written responses identifying the principles and practice involved in working safely when using a given specialist secondary machining technique and written responses commenting on the features of the workpiece produced in Assignment 1 and the reasons why inaccuracies could or did occur.

Criteria covered	Assignment title	Scenario	Assessment method
P1, D1	The Choice of Specialist Secondary Machining Technique	An activity requiring learners to describe three secondary machining techniques and give a justification for the one they would select for a given workpiece.	A report containing written responses describing three secondary machining techniques and justifying one for a given workpiece.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering Suite:

Level 1	Level 2	Level 3
	Working Safely and Effectively in Engineering	Engineering Secondary and Finishing Techniques and Processes
	Interpreting and Using Engineering Information	Computer Aided Manufacturing
	Selecting and Using Secondary Machining Techniques to Remove Material	
	Part Programming CNC Machines	

This unit can contribute towards the requirements of the following units in the Level 2 NVQ in Mechanical Manufacturing Engineering:

- Unit 11: Operating Special-Purpose Machines
- Unit 12: Operating Gear Cutting Machines
- Unit 13: Operating Electro-Discharge Machines
- Unit 14: Operating Honing and Lapping Machines
- Unit 15: Operating Broaching Machines
- Unit 16: Operating Shaping, Planing or Slotting Machines.

Essential resources

To meet the needs of this unit it is essential that the centre has access to some if not all of the range of machines and related auxiliary equipment specified in the unit content. Centres should have a range of tools suitable to measure the accuracy of the workpieces to be machined.

Employer engagement and vocational contexts

Much of the work for this unit can be generated from real engineering drawings from local employers. Company visits will also allow learners to observe secondary machining techniques in an industrial context.

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

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

Indicative reading for learners

Textbooks

Bray S – *Grinding, Honing and Polishing* (Special Interest Model Books, 2009) ISBN 1854862529

Timings R L – *Basic Manufacturing* (Newnes, 2004) ISBN 0750659904

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Reflective learners	suggesting methods of working safely when using a specialist secondary machining technique
Self-managers	anticipating, taking and managing risks to machine a workpiece safely organising time and resources when using specialist secondary machining techniques.

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

Skill	When learners are …
Self-managers	monitoring and adjusting machining parameters to machine a given workpiece correctly and safely.

Functional Skills – Level 2

Skill	When learners are …
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating the use of secondary machining techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing methods of reducing risk and working safely describing different specialist secondary machining techniques and the importance of carrying out checks for accuracy during and after manufacture.

Unit 21: Production Planning for Engineering

Unit code: J/600/0420
QCF Level 2: BTEC Firsts
Credit value: 5
Guided learning hours: 30

Aim and purpose

This unit will give learners an understanding of how to prepare a production plan and the importance of selecting appropriate manufacturing processes, considering scales of production and types of equipment.

Unit introduction

Planning is a necessary function for any organisation that produces something. Within manufacturing engineering this function is often complex due to the rate of change, number of parts involved and the occurrence of unplanned events. Effective production planning is therefore essential in ensuring that activities and resources are co-ordinated over time to achieve goals with as little resource consumption as possible.

This unit aims to provide a broad understanding of the technique of production planning. It develops learners' confidence in understanding the factors that affect the selection of appropriate processes for manufacturing organisations. The unit also aims to provide an understanding of a product specification and a production plan and some of the information generated from them.

Learners will be able to appreciate the fundamental requirements of selecting appropriate manufacturing processes, considering features such as scales of production and types of equipment. Learners will also be able to use a product specification to identify materials and components for manufacture and prepare an outline production plan. It is important that the learner is able to interpret drawings to a level of competence to allow planning requirements to be identified.

Learning outcomes

On completion of this unit a learner should:

1 Know about scales of production and the processes and equipment used in manufacturing organisations

2 Be able to prepare and cost an outline production plan from a given product specification.

Unit content

1 Know about scales of production and the processes and equipment used in a manufacturing organisation

Scales of production: jobbing; small batch; repeated batch; continuous production

Manufacturing process: representation by block diagram; key stages of production to include material and component preparation, material processing, product assembly and finishing, packaging and dispatch

Types of equipment: special dedicated; general purpose; computerised; automated

2 Be able to prepare and cost an outline production plan for a given engineering activity

Production plan: details required for an engineering activity eg sequence of activities/processes, documentation needed (drawings, specifications etc), raw and consumable materials to be used, bought-in components needed, tools and equipment required, speeds and feeds, quality and inspection requirements, health and safety precautions, environmental or legislative requirements

Product specification: information required for product manufacture eg production drawings, production quantities and delivery rates, quality specifications, parts and materials to be used, processing methods specified in the design

Related data and information: calculation of processing time, cost of plant and labour, cost of materials and components

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the different scales of production that are found in manufacturing organisations	**M1**	explain how different types of equipment might relate to the different scales of production in manufacturing organisations	**D1**	justify the production plan for a manufactured product given its product specification.
P2	describe, using a block diagram, the key stages of production that are found in manufacturing organisations	**M2**	modify an outline production plan for a given product specification where the scale of production is to be increased from jobbing to repeated batch production.		
P3	state a use for the different types of equipment found in manufacturing organisations				
P4	produce an outline production plan from a given product specification where only a small unit quantity is required				
P5	prepare related information to support an outline production plan. [IE4]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit lends itself to a practical investigative approach. Certain areas of the unit content rely on a good understanding of the way manufacturing organisations use different scales of production. Tutors will need to provide a broad overview of the different scales of production and types of equipment available to support the processing of engineered products. Learners are required to prepare an outline production plan which will be used to calculate processing times and cost information. The plan should be prepared from a given product specification. This should include sufficient information for the learner to be able to formulate a plan which shows a sequence and method of production, listing tooling, speeds and feeds, materials and components where applicable. The plan should also show features of the inspection and health and safety precautions to be taken. A broad awareness of both mechanical and electrical materials and components would be helpful to enable correct selection and application. A good understanding of the reasons for using a particular material or component is required.

For most of the unit case study material can be used to support learning. Employed learners will be able to relate study to their own organisation and might be more motivated if they share that experience with others. Industrial visits will help underpin the breadth of knowledge and understanding of scales of production, range of processes and equipment used. Alternatively the use of video material may be helpful.

The learning outcomes could be delivered in order and developed step by step throughout the unit. In this way, learners will begin to recognise a range of types of equipment and scales of production and their application in manufacturing processes. Example product specifications should be used to explain to learners how the different parts inform what goes into the production plan. At this level it is appropriate to give learners a template production plan with sections to be completed by the learner to show the details required to make the product. Work-based learners may, however, have a typical plan from their own workplace.

Formative assessment will play an important part in the learners' general development, especially with for achievement at the higher grades. The ability to review and evaluate is required at distinction level and formative work in the delivery phase will encourage learners to consider how the production plan is fit for purpose given the product specification.

It is appropriate that the teaching and learning strategies used to deliver the unit take into account what evidence needs to be available for portfolio assessment.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the different scales of production and different types of equipment, giving typical examples of each • explain the key stages of production and show how they can be represented in a block diagram • explain typical material and component preparation processes and assembly and finishing processes • explain quality control, packaging and dispatch procedures.
Individual learner activity: • investigate the different types of equipment and relate them to scales of production. Investigate the manufacturing process for a given or chosen case study. Prepare for and carry assignment 1 (P1, P2, P3 and M1).
Whole-class teaching: • explain the different types of information required for an engineering activity. Individual learner activities: • identify the possible scales and key stages of production from given product details • identify a possible parts list and possible processing methods for given products.
Whole-class teaching: • explain and discuss direct and indirect cost of plant, labour, materials and components. Individual learner activity: • estimate total manufacturing unit costs from given data.
Whole-class teaching: • describe typical production plan formats • discuss health and safety precautions that might need to be included in a production plan.
Whole-class teaching: • explain and demonstrate the calculation of processing time and production costs • explain what changes to the plan are needed if the scale of production is to be increased to repeated batch production.
Individual learner activities: • draw up a block diagram representing the key stages in the production of a given product where only a small quantity is required. Draw up a production plan for a product and calculate processing times and production costs. Prepare and carry out assignment 2 (P4, P5, M2 and D1).
Review of unit delivery and assessment.

Assessment

It is important that the assessment strategies used should be designed to suit the needs of learners and the local environment. Good assessment strategies are most likely to be supported by proper presentation of appropriate evidence. The portfolio should not contain course notes, research etc unless it is to become part of the required evidence and assessment.

The first three pass criteria and the first merit criteria relate to the first of the two learning outcomes. As such they lend themselves to be assessed in a single assignment with a variety of tasks. The remaining criteria (P4, P5, M2 and D1), relate to the second learning outcome and also lend themselves to being assessed in a single assignment with a variety of tasks.

The assessment of learners' understanding of scales of production, processes and equipment used in an organisation requires evidence in the form of a range of statements, descriptions and a well presented block diagram. For learners working at merit level it is expected that they are able to extend this range of evidence when explaining how different types of equipment might relate to the different scales of production. Working under guidance to produce a production plan from a given product specification would be suitable. It is expected that the given specification will have a materials and parts list to enable the learner to calculate other related data and information. The product specification needs to have scope to be put into a context where, instead of a small quantity required, it can be amended to have a requirement of repeated batch production.

A typical task may have a scenario where a prototype product produced by jobbing needs to go into production to meet a customer's needs for a delivery scheduled over a period of time in batches. There needs to be enough scope in the scenario to alter a range of aspects of the production plan. Although the range must be appropriate to the product under consideration it is expected that some processes, tools and equipment and speeds and feeds would be amended.

A further task could be set to assess the learner's ability to justify the use of the production plan, making full reference to the product specification.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3 and M1	Scales of Production, Processes and Equipment	An activity requiring learners to investigate the different scales of production and how they relate to manufacturing processes and equipment.	A report in which learners give a description of the different scales of production and the key stages involved. Learners also give a use for the different types of equipment and relate them to scales of production.
P4, P5, M2 and D1	Production Plans	An activity in which learners produce a production plan and prepare related information.	Learners produce, modify and justify a production plan for a given product, using related information.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Preparing and Controlling Engineering Manufacturing Operation	

This unit can contribute towards the requirements of the Level 2 NVQ in Performing Engineering Operations, Unit 62: Producing Engineering Project Plans.

Essential resources

Centres should provide learners with access to a range of product specifications, data handbooks and manufacturers' information manuals.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' workplace or be based on case studies of employers.

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

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

Indicative reading for learners

Textbook

Timings R L – *Basic Manufacturing* (Newnes, 2004) ISBN 0750659904

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating related information to support an outline production plan.

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

Skill	When learners are …
Reflective learners	setting goals with success criteria for their production plan inviting feedback on their own work and dealing positively with praise, setbacks and criticism evaluating their experiences and learning to inform future progress
Self-managers	seeking out challenges or new responsibilities and showing flexibility when priorities change dealing with competing pressures, including personal and work-related demands responding positively to change, seeking advice and support when needed.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Identify the situation or problem and the mathematical methods needed to tackle it	calculating processing time and the cost of labour, plant, materials and component
Select and apply a range of skills to find solutions	calculating processing time and the cost of labour, plant, materials and component
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	using and interpreting data and information to support an outline production plan
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the different scales of production and explaining how different types of equipment relate to them.

Unit 22: Application of Quality Control and Measurement in Engineering

Unit code: L/600/0421

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will give learners the knowledge and skills needed to inspect engineered components to ensure geometrical and dimensional accuracy.

Unit introduction

Engineered components and products are designed for a specific purpose and to function successfully they must be fit for that purpose. Therefore they must be competitively priced and reliable. Engineering companies operate quality assurance programmes to ensure that all parts of their organisation work towards supplying a quality product or service. Quality control is an essential part of these programmes and is used to ensure that a component or product fully conforms to the designer's specifications. This involves inspection at the key stages of manufacture for dimensional and geometric accuracy and for attributes such as surface texture and roughness. Automated inspection equipment is sometimes used but manual inspection is still essential for a great many products.

The aim of this unit is to give learners a broad understanding of the techniques associated with quality control and measurement. The unit introduces learners to a range of techniques commonly used when measuring dimensional, geometrical and surface attributes. The unit also aims to provide an understanding of the activities of the quality control department and the documentation typically used. Learners will develop practical skills in the selection and use of equipment in a range of inspection techniques. The concept of tolerancing will be introduced and learners will come to recognise and appreciate the points of inspection required to support quality control.

Learning outcomes

On completion of this unit a learner should:

1 Know about quality and quality control as applied to manufacturing products

2 Be able to use measuring equipment to monitor the quality of given products

3 Be able to use comparators and gauges to monitor the quality of given products

4 Know about dimensional tolerances and grades of fit.

Unit content

1 Know about quality and quality control as applied to manufacturing products

Quality: definition of quality eg fitness for purpose, safe to use, meeting the customer's requirements; quality standard ISO9000; costs of quality eg internal failure costs, external failure costs, appraisal costs, prevention costs

Quality control: quality control department, documentation used, role of inspection, frequency of inspection; provision for traceability; calibration

2 Be able to use measuring equipment to monitor the quality of given products

Measuring equipment: those associated with the attributes to be measured eg micrometers (external, internal, depth), steel rules, vernier calipers, surface plate, straight edge, engineers try-square, bevel protractors, combination sets, roughness comparison specimens

Attributes to be measured: dimensional eg length, diameter, depth, flatness, parallelism, angle; geometrical eg profiles, roundness, concentricity, accuracy of form; surface texture; roughness

Simple engineered products: those suitable for measuring attributes; dimensional, geometrical, surface texture; those suitable for use with measuring equipment

3 Be able to use comparators and gauges to monitor the quality of given products

Comparator types of equipment: dial test indicators eg plunger type, lever type; simple mechanical comparator eg Sigma comparator; inside caliper, outside caliper

Use of gauges: dimensional accuracy eg slip gauges, length bars; geometrical accuracy eg radius gauges, profile templates, Go and Not Go gauges (plug gauges, gap gauges, taper plugs, ring gauges)

Simple engineered products: eg those suitable for measuring attributes; dimensional, geometrical, surface texture; those suitable for use with gauges and comparators; those suitable for applying tolerances

4 Know about dimensional tolerances and grades of fit

Tolerances: concept of tolerances; ISO system of limits and fits, hole basis system, use of British Standards eg BS 4500; types of fit; clearance, transition, interference

Simple engineered products: those suitable for measuring dimensional accuracy; assembled components; those suitable for applying tolerances

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 define what is meant by quality, as applied to manufactured components and products [IE4]	**M1** explain how effective quality control can reduce the cost of a manufactured product	**D1** evaluate the importance of keeping accurate and accessible quality control documentation in a manufacturing operation
P2 describe the role of the quality control department in a manufacturing operation	**M2** explain the importance of calibration of measuring equipment, comparators and gauges	**D2** justify the use of a given method of measurement and inspection for a given manufactured product.
P3 describe the importance of traceability in quality control	**M3** explain the principle of a hole-based system of limits and fits.	
P4 use measuring equipment to inspect a simple engineered product for dimensional and geometric accuracy and surface texture [SM3]		
P5 use comparators to inspect a simple engineered product for dimensional accuracy [SM3]		
P6 use gauges to inspect a simple engineered product for dimensional and geometric accuracy [SM3]		
P7 identify the specified fit between assembled components from given tolerance limits.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

The unit requires practical activities which might be run in parallel with presentations covering the philosophy and administration of quality control. Learning outcome 1 is concerned with the concepts of quality and functions of a quality control department. It should be stressed that the pursuit of quality must be the concern of all personnel whatever their role and an overview of ISO9000 should be given.

Learning outcomes 2 and 3 require a good understanding of the way measurement and inspection is carried out using a range of equipment. Learners need to acquire a broad overview of the different types of equipment available and hands-on experience in their use. A range of engineered products and components could be made available for learner inspection to ensure independence and authenticity.

Learning outcome 4 is concerned with tolerancing and limits and fits. Learners will need to be familiar with the concept of a hole-based system and the characteristics of different types of fit. They should then be able to identify the type of fit specified between components by referring the dimensional tolerances to the appropriate ISO and British Standards.

The unit gives learners an opportunity to gain knowledge through case study material for those aspects of the unit relating to quality and quality control procedures. Industrial visits will provide additional knowledge and understanding of these areas, particularly in the range of documentation used in a quality control department. Industrial visits will also be helpful in allowing learners to see measurement equipment being used in industry. The teaching and learning strategies used to deliver this unit should take into account that evidence needs to be available for portfolio assessment.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and methods of assessment • define quality and explain quality standards and the costs of quality • explain the role of the quality control department in a manufacturing/engineering context • explain traceability and calibration. Industrial visit: • view real quality control department and the range of documentation used.
Individual learner research: • use of case studies to investigate quality and quality control in engineering • preparation for assignment 1 (P1, P2, P3, M1 and D1).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain and demonstrate the use of a range of measuring equipment to measure dimensional and geometrical attributes of engineered products. Whole-class practical sessions: • practising the use of measuring equipment to check quality of products. Industrial visit: • see use of measuring equipment in industrial setting.
Whole-class teaching: • explain and demonstrate the use of a comparator types of equipment and gauges to measure dimensional and geometrical attributes of engineered products. Whole-class practical sessions: • practising the use comparators and gauges to check quality of products.
Individual learner research: • investigating and practising the use of measuring equipment, comparators and gauges to measure a range of engineered products • preparation for assignment 2 (P4, P5, P6, M2 and D2).
Whole-class teaching: • explain the concept of tolerances and describe the different systems of limits and fits and types of fit • demonstrate and practise use of ISO and British standards.
Individual learner research: • investigation into systems of limits and fits and the use of standards • preparation for assignment 3 (P7 and M3).
Feedback, unit evaluation and close.

Assessment

This unit could be assessed through the use of three assignments.

The first assignment, covering learning outcome 1, could be in the form of a written report in which learners provide a description of quality and quality control (P1, P2 and P3). This should also give learners the opportunity to achieve the related merit and distinction criteria (M1 and D1) through the quality of learners' responses or the use of additional tasks.

The second assignment will require learners to carry out a series of practical tasks, demonstrating the use of measuring and inspection equipment in order to achieve P4, P5 and P6. Learners will need to keep a log/portfolio showing evidence of achievement. Witness statements or other observation records will be required to verify achievement. Portfolios should not contain course notes, research etc, unless it is to become part of the evidence for assessment. Tutors will need to ensure that the engineered products used for assessment are suitable for measuring and for use with measuring equipment, comparators and gauges.

An additional written task needs to be given to learners in order to cover M2 and D2, which are concerned with the application, use and calibration of measuring and inspection equipment.

The third assignment, covering P7, will require learners to identify the grade of fit specified on engineering drawings. This could be achieved through oral questioning, or a short written assignment could be used which could include a task giving learners an opportunity to achieve M3.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1 and D1	Quality and Quality Control	Learners provide a description of the main aspects of quality and quality control.	A written report describing quality and the role of quality control in manufacturing.
P4, P5, P6, M2 and D2	Monitoring Accuracy of Engineered Products	Learners use measuring instruments, comparators and gauges to inspect engineered products for dimensional and geometrical accuracy.	A practical assignment, supported by tutor observation/witness statements and a written report or logbook of the tasks undertaken. A further written task explaining/justifying the importance of measurement equipment and techniques.
P7 and M3	Tolerances and Limits and Fits	Learners need to identify the grade of fit specified on engineering drawings.	Record of oral questioning or a written report detailing principles of limits and fits.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Using Computer Aided Drawing Techniques in Engineering	
	Engineering Marking Out	

The unit supports the knowledge and understanding associated with some aspects of Level 2 NVQ in Performing Engineering Operations particularly Unit 6: Applying Quality Control in Engineering.

Essential resources

Centres will need to provide a range of measuring equipment, comparators and gauges. A range of engineered components and products suitable for measuring and inspecting will also be required together with engineering drawings on which tolerances are specified.

Employer engagement and vocational contexts

Much of the work for this unit can be based on real engineering drawings and documents from local employers. The components used for inspection can be those produced by learners either in their own workplace or from workshop activities carried out in the centre. Company visits will allow learners to observe quality control procedures and techniques in an industrial context.

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

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

Indicative reading for learners

Textbook

Timings R L – *Basic Manufacturing* (Newnes, 2004) ISBN 0750659904

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to quality and quality control
Self-managers	organising time and resources and prioritising actions when carrying out inspections on engineered products.

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

Skill	When learners are …
Reflective learners	reviewing progress and acting on outcomes when carrying out measurement and inspection of engineered products
Team workers	collaborating with others when working in small groups to inspect engineered products.

Functional Skills – Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	describing quality and quality control in an engineering context
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	investigating and researching quality and quality control in manufacturing engineering
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing quality and quality control in an engineering context.

Unit 23: Casting and Moulding Engineering Components

Unit code: Y/600/0423
QCF Level 2: BTEC Firsts
Credit value: 10
Guided learning hours: 60

Aim and purpose

This unit aims to give learners a broad knowledge of casting and moulding processes and the different methods used in the initial production of metal and plastic components.

Unit introduction

Many engineering components are initially formed to shape by casting molten metal into prepared sand or metal moulds. Over the years this process has been refined to suit the introduction of new materials and the demands of quantity of production. In some processes the cast component is almost ready for use and requires only a little cleaning and trimming (fettling). In others it is produced slightly oversize and, after fettling, it is machined accurately to the required dimensions.

The aim of this unit is to provide learners with a broad understanding of casting and moulding processes. It introduces learners to the methods by which molten metal is prepared for casting and how sand moulds and cores are produced. The unit also covers investment casting, a process used to produce components with complex shapes. Learners are introduced to the processes of gravity and pressure die casting where the molten metal is poured or injected into metal moulds. The injection moulding of plastics has some similarities with pressure die casting and this too is covered together with vacuum forming procedures and the wet lay-up techniques used for producing fibre reinforced composite components.

Learners will form an appreciation of the fundamental requirements of each process, the working techniques used and the relevant health and safety considerations.

Learning outcomes

On completion of this unit a learner should:

1 Know about material melting processes and component removal

2 Know how sand and investment casting processes are used

3 Know how a range of die casting processes are used

4 Know how plastic moulding processes are used.

Unit content

1 Know about material melting processes and casting removal

Methods of melting material: scale eg single melt, batch melt, continuous melt, combined methods; types of furnace eg cupola, induction, rotary, bale out, lift out crucible, tilting crucible, direct or indirect arc, air circulating ovens for thermoplastic melting; material eg ferrous alloys, non-ferrous alloys, thermoplastics; measurement of temperature eg pyrometers

Component removal and finishing: techniques eg knocking castings out of moulds, removing components from the moulding material or dies, de-coring, removing runner/riser/feeder system; processes used eg manual, vibratory tables/grids, punch-out mechanisms, chemical leaching; tooling used eg work-holding devices (vice, clamps, jigs and fixtures), disc/angle grinder, pedestal grinder, slitting saw, band saw, laser cutter, linisher, pneumatic chipping hammers, wire brush, scraper, hacksaw, file, abrasive stone, abrasive paper, hammer; blasting eg air, water, sand; plastic trimming knives and cutters

Safety: guards/screens; personal protective equipment (PPE); identification of hazards

2 Know how sand and investment casting processes are used

Sand casting: drag; cope; pattern; cores eg horizontal, vertical; runners; risers; moulding parts eg boxes, boxless; moulding sand eg oil sand, green sand, chemically bonded gas activated, chemically bonded resin/catalyst, resin bonded heat activated; mould and core production eg by hand, by machine (jolt/squeeze, jolt/squeeze/rollover, mixer/slinger, mixer/vibratory table, squeeze, blown, blown vibratory, blow/blow squeeze)

Investment casting: wax patterns eg single waxes, wax assemblies; mounting of wax patterns eg handles, bars, hangers; slurry; producing shells/moulds eg manually, automatically, combined manual and semi-automatic, single, multiple; curing shells/moulds eg natural air, forced air, gas activated

Safety: guards/screens; personal protective equipment; identification of hazards

3 Know how a range of die casting processes are used

Gravity die casting: die location eg floor, fixed base, movable base, carousel, conveyor/roller track; types of die eg split die with no secondary movement, split die with one secondary movement, split die with two or more secondary movements, split die with no cores, split die with one core, split die with two or more cores, water cooling; use of cores

Pressure die casting: types eg high pressure hot chamber, high pressure cold chamber, squeeze process; types of die eg split die with no secondary movement, split die with one secondary movement, split die with two or more secondary movements, split die with no cores, split die with one core, split die with two or more cores, core assembly with external cores, core assembly with internal cores, water cooling; use of cores

Safety: guards/screens; personal protective equipment; identification of hazards

4 Know how plastic moulding processes are used

Injection moulding: materials eg polystyrene, polyethylene, acetal; equipment eg injection moulding machines, machine tooling

Vacuum forming: materials eg polycarbonate, polysulphon, acrylic, polyvinyl chloride and acrylonitrile butadiene styrene (ABS) thermoplastic sheet; equipment eg vacuum forming machines, machine tooling

Wet lay-up composite moulding: materials eg polyester, epoxy, phenolic and vinyl ester resins, glass, carbon, polyethylene and aramid fibres; moulding techniques eg mould preparation, spray and brush application of resin, use of roller to remove voids and air pockets

Safety: storage and handling of materials; personal protective equipment; ventilation; identification of hazards

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	identify a method of producing molten material safely for a given scale of casting or moulding production [IE1]	**M1**	explain the importance of identifying hazards and wearing personal protective equipment when melting metals and removing and finishing castings	**D1**	justify the use of an investment casting process for a given component
P2	describe the safe removal and finishing for a given casting or moulding	**M2**	explain when die casting would be used in preference to sand casting	**D2**	justify the use of a pressure die casting process for a given component
P3	describe the process of sand casting when used safely to manufacture a given component	**M3**	explain when a wet lay-up technique would be used in preference to injection moulding or vacuum forming.	**D3**	justify the use of a moulding process for a given component.
P4	describe the process of investment casting when used safely to manufacture a given component				
P5	describe the gravity die casting process when used safely to produce a given component				
P6	describe the pressure die casting process when used safely to produce a given component				
P7	describe the injection moulding process when used safely to produce a given component				
P8	describe the vacuum forming process when used safely to produce a given component.				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

A practical approach to delivery would be most appropriate for this unit. Learners should have the opportunity to view a wide range of processes and equipment. This could be achieved through industrial visits and the extensive use of video and PowerPoint presentations. Access to the internet and manufacturers' literature will also be beneficial.

The learning outcomes are ordered logically to lead learners through the material preparation processes, the casting extraction and finishing processes, preparation of moulds and dies, and the casting process. A fourth learning outcome covers moulding processes. The four learning outcomes could be delivered step by step throughout the unit as each casting or moulding process is introduced. The identification of hazards, safe working practices and the use of safety equipment should be an integral part of delivery.

It is desirable, although not essential, that learners have the facilities to understand how moulds and castings are produced using a low melting point alloy. An appreciation of the complete production process from metal preparation to fettling of the castings can then be obtained, together with the associated health and safety issues. Again, it is desirable although not essential, that learners should have the facilities to help them understand how moulding is an appropriate way to get a product into a three-dimensional shape effectively.

It should be noted that practical competences are not assessed in this unit but if the content is delivered in a practical manner learners will be better motivated and gain a better understanding of the processes involved.

Achievement at merit and distinction levels will be demonstrated through the learner's autonomy when carrying out tasks and their ability to evaluate and justify the use of certain processes. Formative assessment will play an important part in the general development of the learner and especially in the achievement of these higher level abilities.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and methods of assessment • explain the different scales of melting or casting, the types of furnace used and ways of measuring temperature • describe melting methods used for different materials • explain the ways in which castings are removed and the processes and tooling used • explain blasting methods and ways in which plastic castings are finished.
Individual learner research: • investigate melting processes and their applications for different materials and finishing processes • prepare for and carry out assignment 1 (P1, P2 and M1).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain sand casting processes and describe the use of cores • explain the different moulding parts and use of moulding sand • describe the forms of mould and core production • explain the use and mounting of wax patterns for investment casting • explain the production and curing of shells/moulds. Industrial visit: • visit to local company to view production of components through sand and/or investment casting, including melting of materials and component removal.
Individual learner research: • using case studies to investigate sand and investment casting processes and applications • prepare for and carry out assignment 2 (P3, P4 and D1).
Whole-class teaching: • explain the different locations used for gravity die casting, the different types of die and explain the use of cores • describe the types of pressure die casting, the different types of die used and explain the use of cores. Industrial visit: • visit to local company to view production of components using die casting methods, including melting of materials and component removal.
Individual learner research: • using case studies to investigate different die casting processes and applications • prepare for and carry out assignment 3 (P5, P6, M2 and D2).
Whole-class teaching: • describe the different materials for which injection moulding is used and explain the use of moulding machines and equipment • describe the different materials for which vacuum forming is used and explain the use of vacuum forming machines and equipment • describe the different materials for which wet lay-up composite moulding is used and explain the use of moulding techniques. Group/practical activity: • using vacuum forming machines to produce basic components.
Individual learner research: • using case studies to investigate different plastic moulding processes and applications • prepare for and carry out assignment 4 (P7, P8, M3 and D3).
Whole-class teaching: • describe the safe working practices that need to be followed when working with molten materials, using different casting and plastic moulding processes and removing castings.
Feedback, unit evaluation and close.

Assessment

Evidence of learning outcomes can be collected from well-planned assignments, unseen tests and reports of workshop activities. Evidence can also be presented in the form of a portfolio containing reports of investigations and case studies.

It is possible that integrative assignments might be used to link this unit with others in the programme. If this course is adopted, the evidence for specific learning outcomes will need to be clearly identified.

A series of four assignments could be used for the assessment of this unit, requiring the various production processes to be described in their entirety. These may take the form of workshop reports where facilities are available for hands-on experience.

The first assignment, covering P1, P2 and M1 could be in the form of a written report or an information leaflet for new apprentices about melting processes and removing castings. Alternatively, as these criteria apply to opposite ends of the casting and moulding process it may be possible to assess them in conjunction with the other criteria.

A second assignment, covering P3, P4 and D1 could be in the form of a written report describing the sand and investment casting methods used by a particular manufacturer. This is likely to based on case-study materials or a report from an industrial visit.

A similar approach could be used for the third assignment, covering P5, P6, M2 and D2, requiring learners to produce a written report on the die casting processes used by a manufacturer.

The final assignment, covering P7, P8, M3 and D3 would also require a description of the different plastic moulding processes. This could again be based on a particular manufacturer and could be in the form of a written report.

To achieve a merit grade learners will need to relate a given component and scale of production to the most appropriate process and equipment. They will also be required to clearly identify the hazards and safety equipment associated with a given process. To achieve a distinction grade, learners will need to justify the use of a particular process with reference to the scale of production and the design requirements of the finished component.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2 and M1	Melting Processes and Casting Removal	Learners produce a leaflet or poster for new apprentices.	A written assignment, based on industrial visits or case study material.
P3, P4 and D1	Sand and Investment Casting Processes	Produce a report on a manufacturer's different sand and investment casting processes.	A written assignment, based on industrial visits or case study material.
P5, P6, M2 and D2	Die Casting Processes	Produce a report on pressure and gravity die casting used by a manufacturer.	A written assignment, based on industrial visits or case study material.

Criteria covered	Assignment title	Scenario	Assessment method
P7, P8, M3 and D3	Plastic Moulding Processes	Investigate plastic moulding processes and produce an article for an engineering magazine.	A written assignment, based on industrial visits or case study material.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Selecting Engineering Materials	Liquid Metal Casting Processes

This unit contributes towards the underpinning knowledge requirements of the following units in the Level 2 NVQ in Material Processing and Finishing:

- Unit 4: Producing Sand Moulds Manually
- Unit 5: Producing Sand Cores Manually
- Unit 6: Producing Sand Moulds or Cores with Mechanical Assistance
- Unit 7: Producing Sand Moulds or Cores Automatically
- Unit 10: Preparing Materials for Moulding and Core Making
- Unit 13: Melting Metal for Casting
- Unit 14: Casting Metal by Manual Means
- Unit 15: Casting Metal using Mechanical Means
- Unit 18: Producing Metallic Castings using the Gravity Die Process
- Unit 19: Producing Metallic Castings using Pressure Die Process
- Unit 20: Knocking Out and De-Coring Metallic Castings
- Unit 23: Fettling Metallic Castings
- Unit 50: Making Composite Mouldings using Wet Lay-up Techniques
- Unit 53: Carrying Out Vacuum Forming of Composite Materials.

The unit can also contribute knowledge and understanding towards the Level 2 NVQ in Performing Engineering Operations, particularly:

- Unit 43: Producing Composite Mouldings Using Wet Lay-up Techniques
- Unit 48: Producing and Preparing Sand Moulds and Cores for Casting
- Unit 50: Producing Cast Components by Manual Means.

Essential resources

Centres must have access to range of sand cast, investment cast and die cast components. Technical literature and videos from equipment suppliers should also be available. Learners should have some hands-on experience of casting and moulding; as a minimum this would require the provision of casting boxes, core moulding boxes, green sand, core sand, simple casting and core patterns and moulding tools. A low melting point alloy might be used to complete the process and personal protective clothing and equipment must be provided.

Employer engagement and vocational contexts

Due to the resources required for many of the processes covered by this unit, centres should try to link with local industry to ensure that learners have access to suitable videos and literature or can view casting and moulding processes and products.

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

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

Indicative reading for learners

Textbook

Health and Safety Executive – *Health and Safety in Engineering Workshops* (Health and Safety Executive, 2004) ISBN 0717617173

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve when trying to identify the most suitable method of producing molten material safely for a given scale of production.

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

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work when investigating casting and moulding processes.

Functional Skills – Level 2

Skill	When learners are …
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating different casting and moulding techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing and reporting on the casting and moulding processes and their suitability for different components.

Unit 24: Operation and Maintenance of Fluid Power Systems and Components

Unit code: H/600/3387

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit provides learners with a knowledge and understanding of fluid power systems, circuits, and components. Learners will also develop the skills needed to safely carry out maintenance activities on a range of pneumatic and hydraulic systems used in industry.

Unit introduction

In every engineering workshop, processes and service operations need maintaining. The maintenance engineer is a key member of staff in ensuring the process or service continues to operate safely. This unit is about those aspects of fluid power systems and components that a maintenance engineer is likely to be involved with.

Learners will gain an understanding of fluid power diagrams, symbols, systems and their components. They will also develop an understanding of the operation of components such as pumps, reservoirs, air service units, control valves, actuators, sensors, regulators, compressors, pipes and hoses.

Learners will develop the skills needed to locate faults and carry out scheduled and corrective maintenance activities on pneumatic and hydraulic systems and components in accordance with approved procedures. In carrying out these activities learners will need to use a range of tools and fault-finding and diagnostic techniques. Learners will be able to identify and locate faults at unit, component and system level. They will then remove, replace and/or repair the faulty component and carry out tests to ensure that the system performs to specification.

Learners will gain an understanding of the procedures that must be followed before handing over maintained and/or installed equipment and confirming that the equipment is now ready to run in a safe and operable condition. They will be expected to demonstrate safe working practices when carrying out fault location and maintenance activities and the necessary safeguards to protect their own safety and that of others in the workplace.

Learning outcomes

On completion of this unit a learner should:

1 Know the health and safety regulations and precautions that need to be observed when working with fluid power systems

2 Be able to read and interpret fluid power symbols and diagrams

3 Know the construction, operation and practical application of fluid power system components and equipment

4 Be able to carry out testing, fault diagnosis and maintenance activities on fluid power equipment and systems.

Unit content

1 Know the health and safety regulations and safe practices that need to be observed when working with fluid power systems

Health and safety regulations: eg Health and Safety at Work Act 1974, Control of Substances Hazardous to Health (COSHH), Management of Health and Safety Regulations, Pressure Systems and Transportable Gas Containers Regulations 1989 (SI 1989 No 2169), The Pressure Vessels Directive

Safe practices: practices to be followed when assembling, testing and maintaining pneumatic equipment and systems eg use of personal protective equipment, correct lifting and handling techniques, releasing pressure from systems, maintaining a tidy work area, correct disposal of waste materials, permit to work, isolation, risk assessment, reporting of injuries

2 Be able to read and interpret fluid power symbols and diagrams

Symbols: pneumatic and hydraulic symbols for common components, devices and equipment eg pumps, cylinders, compressors, filters, receivers, spools, regulators, actuators, accumulators, valves, bearings, sensors, filters

Diagrams: eg circuit diagrams, block diagrams, system layout diagrams, displacement step diagrams, related documentation (component and equipment data sheets, functional charts, operating instructions)

3 Know the construction, operation and practical application of fluid power system components and equipment

Components: eg pumps, directional, flow, pressure and non-return valves, linear and rotary actuators, hydraulic and pneumatic motors, hoses/pipework, fittings, seals, air service units

Equipment: construction; operation; application; types eg pneumatic, hydraulic, vacuum

4 Be able to carry out testing, fault diagnosis and maintenance activities on fluid power equipment and systems

Testing: regulations and codes of practice relating to the testing of pneumatic and hydraulic equipment and systems; test equipment eg pressure indicators, flow indicators, measuring devices, self-diagnostic equipment; procedures and techniques for carrying out tests

Instruments: eg measuring devices, pressure indicators, flow indicators, self-diagnostic equipment

Maintenance routines: regular maintenance activities on fluid power components, devices and systems eg inspection and functional testing, removing and replacing units/components, setting, aligning and adjusting replaced components, removing air lines and hoses, leak detection, replacing seals, filters, gaskets, carrying out adjustments as necessary; recording of condition; recommended frequencies for maintenance; the use of maintenance manuals and documentation; the need to record maintenance and final test; handover procedures

Faults: terminology used eg 'symptom', 'fault', 'cause'; typical faults in pneumatic and hydraulic components and equipment; symptoms of non-complex faults and their causes

Fault diagnosis techniques: eg visual examination, unit substitution, input to output, inspection and sampling, six point (collect the evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system), fault/repair reporting; emergent sequence

Diagnostic aids: eg functional charts, diagrams, flow charts, trouble shooting charts, component data sheets, operation and maintenance manuals, software-based records and data

Problem: eg intermittent, partial failure/out-of-specification output, complete breakdowns

Report findings: eg scheduled maintenance report, corrective maintenance report, other company-specific reports, job cards, maintenance log

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	identify the relevant health and safety regulations that need to be followed when working with fluid power systems [IE4]	**M1**	explain the importance of applying safe working practices when carrying out maintenance on a fluid power system	**D1**	analyse a given fluid power system for ease of maintenance
P2	describe the safe practices that need to be followed when assembling, testing and maintaining a fluid power system	**M2**	explain the relationship between component faults and the malfunction of a given fluid power system.	**D2**	compare two fault diagnosis techniques when carrying out maintenance work on a fluid power system.
P3	identify the symbols used to represent seven given fluid power system components				
P4	interpret a fluid power circuit diagram and explain the function of the circuit components shown				
P5	describe the construction and operation of six fluid power system components				
P6	describe the construction, operation and application of a type of fluid power equipment				
P7	use two instruments to carry out testing and maintenance routines on a given fluid power system [SM3]				
P8	use two fault diagnosis techniques and two diagnostic aids to identify a fluid power system problem and report the findings. [SM3, IE2]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

This unit should be delivered using lectures, tutor demonstrations and practical engineering activities. During the delivery of the unit, centres must ensure sufficient coverage of the learning outcomes and content. Learning outcomes 2 and 3 are best suited to a practical approach, although learners will at first need a broad overview of different pneumatic and hydraulic diagrams, systems and components to enable correct selection and application of maintenance, diagnostic and testing techniques. A good knowledge and understanding of the circuits and components prior to diagnosing faults or maintaining systems is essential.

Learners must be made aware of, and have access to, relevant UK health and safety legislation and know the importance of the use of appropriate risk assessment. Tutors should ensure that each learner has the correct PPE and that the system is safe for operation. It is also important that learners work in a safe manner when using equipment or working on fluid power systems.

The unit should be delivered by focusing on developing learners' diagnostic and practical skills together with an understanding of pneumatic systems maintenance, construction and operation.

The delivery approach will be determined through an analysis of learners' needs and, in particular, through consideration of the range of industries that the centres are working with or preparing their learners for. However, it is expected that learners' experience should be sufficiently varied to provide them with the underpinning knowledge and skills needed to apply fault-finding techniques and repair and maintain pneumatic systems in most industrial settings. It would not be appropriate for this unit to be taught without any practical application, as the use of theory lessons and simulation exercises does not have the same value that real practical experience in a working environment can bring.

The learning outcomes are ordered logically and it would be reasonable to develop them sequentially throughout the unit. In this way, the learner will be able to apply health and safety precautions and knowledge of circuit diagrams and components before attempting to locate faults and maintain systems. For example, a short introduction to a component (or a range of components), the function of the component within the larger system, the tools necessary to carry out the maintenance task and their limits with any safety considerations – followed by practise.

Centres are encouraged to find innovative ways of bringing the unit to life for the learner and giving it true relevance. This will generally be achieved through the use of practical 'hands-on' experiences for the learner, which can be achieved in a learning environment or through actual work place experience. The learners could be provided with access to workshops and the necessary tools, materials and equipment to carry out practical exercises on fault finding, repair and maintenance of fluid power systems. Learners can also be given a range of system and component faults on which to practice their skills.

Each task should be designed so that it requires the learners to prepare the work environment, prepare for the activity and then complete the work activity. The opportunity to work with individuals during the delivery of this practical work can be used to good effect to underpin learning. In particular, it can be used to reinforce working practices/skills, help them to deal with problems affecting the engineering processes being experienced or to support them when they need to work with others more effectively in order to achieve the task.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, assessment model and method of working • introduction to relevant health and safety legislation and regulations. Explain their purpose and the importance of adhering to them • describe the main safe working practices to be followed when working with fluid power systems and equipment. Practical workshop activities: • tour of centre workshops to highlight main areas of risk. Demonstrate safe working practices eg use of PPE, safe lifting and handling techniques etc.
Preparation for and carry out assignment 1 (P1 and P2).
Whole-class teaching/practical demonstration: • explain pneumatic circuits and component symbols including valve symbols, energy transmission symbols, control symbols, compressors/air receivers/pumps, miscellaneous symbols eg reservoir tanks, air service units, filters/pipes/hoses • demonstrate the use and interpretation of different types of fluid power diagram. Explain the use of related documentation. Learner activity: • using and interpreting diagrams and identifying symbols and components.
Prepare for and carry out assignment 2 (P3, P4).
Whole-class teaching/practical demonstration: • explain the function, construction, operation and application of pneumatic and hydraulic components. Practical workshop activity: • identifying and examining the construction and operation of a range of pneumatic and hydraulic components.
Prepare for and carry out assignment 3 (P5, P6).
Whole-class teaching: • explain and demonstrate diagnostic test equipment, fault finding aids, software-based fault diagnostic techniques • explain the importance of preparation for work activities, including: ◊ relevant safety procedures and equipment requirements ◊ circuit drawings, specifications, materials and components ◊ job instructions and documentation for work activity • explain the terminology used and methods of fault diagnosis • introduction to fluid power system fault location, testing, and maintenance. Practical workshop activities: • examine examples of typical faults found in fluid power systems • practise use of fault finding instruments on fluid power systems.

Topic and suggested assignments/activities and/assessment
Industrial visit: • view practical application of fluid power systems and review the operation and maintenance arrangements in a modern industrial setting.
Whole-class teaching/demonstration: • explain frequencies for maintenance, maintenance routines, maintenance recording documentation • introduction to the practical work activity • explanation and tutor demonstration of inspection and testing complete systems and components. Practical workshop activities: • learners obtain all necessary drawings and equipment and carry out fault-finding, repair and maintenance of fluid power components and systems.
Practical workshop activities: • further practical exercises on fault-finding, repair and maintenance of fluid power components and systems • carry out commissioning test and complete final handover documentation. Whole-class teaching/group work: • discuss possible improvements to working practices.
Prepare for and carry out assignment 4 (P7, P8, M1, M2, D1 and D2).
Feedback on all assessment tasks, unit evaluation and close.

Assessment

Much of the assessment evidence for this unit could come from practical activities. These can be carried out solely for the purpose of this unit but, equally, could be the activities associated with other units or from work-based evidence.

There are clear links between the pass, merit and distinction criteria and it is helpful if these links are both explained to the learner and considered in the design of assessment instruments.

Learning outcomes 1, 2 and 3 are probably best assessed through the use of written assignments. Learning outcome 4 is likely to be combination of both written assignments and practical exercises, supported by tutor observation reports and learners' portfolio work logs and other documentation.

Four assignments could be used for the assessment of this unit. The first, relating to learning outcome 1 would cover P1, P2, and M1. This could be a written assignment that asks for a description of the relevant health and safety regulations and safe working practices that need to be followed when working with fluid power systems. Evidence could be in the form of a written report, or alternatively an information leaflet or poster. Learners should also be asked to explain the importance of applying safe working practices (M1).

A second written assignment could be used to cover P3 and P4, based on a given list of components and a fluid power circuit containing a minimum of six different components. Learners would first need to identify the symbols used to represent seven different fluid power components. They would then need to identify and describe the function of six fluid power components from the diagram.

The third assignment will require learners to provide a description of the construction and operation of fluid power components and a type of equipment (pneumatic, hydraulic or vacuum).

The fourth assignment should be based on practical testing and fault diagnosis on a fluid power system. Assessment evidence is therefore likely to be in the form of witness statements and annotated photographs along with the learner's report/log of the work carried out. Learners should also provide an explanation of how component faults contribute and have an effect on the functioning of a fluid power system (M2). A further written task can be set, based on learners' experiences of fault-finding and maintenance on fluid power operation or control systems. To achieve a distinction, learners should be asked to analyse the system for ease of maintenance (D1) and compare diagnosis techniques (D2).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Fluid Power Health and Safety	Produce an information leaflet for new apprentices identifying aspects of health and safety relevant to fluid power systems.	A written assignment requiring learners to identify relevant safety legislation and describe safe practices that should be adhered to in relation to fluid power system operation and maintenance. They will also need to explain the importance of applying safe working practices when carrying out maintenance.
P3, P4	Fluid Power Diagrams	Learners need to interpret a circuit diagram in order to identify the components that are needed.	A written assignment requiring learners to identify seven fluid power symbols. Learners to identify and explain the function of the components in a given circuit diagram.
P5, P6	Fluid Power Components and Equipment	Learners need to describe the construction of fluid power components and the operation of a piece of fluid power equipment to a new member of staff.	A written assignment requiring learners to describe the construction of six components and the construction, operation and application of a type of fluid power equipment.

Criteria covered	Assignment title	Scenario	Assessment method
P7, P8, M2, D1, D2	Fluid Power System Fault Location, Testing and Maintenance	Learners must prepare for and carry out testing, maintenance and fault diagnosis, activities on fluid power equipment and systems. They then need explain the relationship between the component faults and the system malfunction. Learners should provide a report analysing the system for ease of maintenance and comparing the diagnostic techniques used.	Tutor observation records of the practical activity to include preparation, for the diagnosis, repair and or maintenance task include commissioning documentation. Report containing fault list, system malfunction record of test results and visual observations. Written report analysing the system for ease of maintenance comparing and contrasting the diagnostic techniques used to locate faults identification of how work activity can be improved.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Engineering Maintenance Procedures	Health and Safety in the Engineering Workplace
	Operation and Maintenance of Mechanical Systems and Components	Electro, Pneumatic and Hydraulic Systems and Devices
	Operation and Maintenance of Electrical Systems and Components	
	Operation and Maintenance of Electronic Systems and Components	

This unit supports the National Occupational Standards for the Level 2 NVQ in Engineering Maintenance and Installation, particularly:

- Unit 4: Handing Over and Confirming Completion of Maintenance or Installation Activities
- Unit 16: Carrying Out Fault Location on Fluid Power Equipment and Circuits
- Unit 17: Carrying Out Maintenance Activities Fluid Power Equipment
- Unit 18: Carrying Out Scheduled Maintenance Tasks on Fluid Power Equipment.

The unit also supports the Level 2 NVQ in Performing Engineering Operations, Unit 21: Maintaining Fluid Power Equipment.

Essential resources

In order to gain the relevant practical skills required for this unit it is essential that learners have access to:

- fluid power system circuits and components
- pneumatic and hydraulic system test rigs
- fluid power circuit drawings and computer simulation software
- appropriate test equipment
- data books and specifications
- current health and safety legislation and regulations and related publications.

Employer engagement and vocational contexts

This unit should be delivered and assessed in a vocational context. Learners will require access to workshops equipped with modern pneumatic components and equipment to enable learners to gain a practical awareness and enable them to apply their knowledge and understanding in a practical situation and this could be in the work place. The use of witness statements enabling the learner to carry out assessment in their own place of work is also recommended.

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

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

Indicative reading for learners

Textbooks

Health and Safety Executive – *Essentials of Health and Safety at Work* (Health and Safety Executive, 2006) ISBN 0717661792

Timings R L – *Basic Manufacturing* (Newnes, 2004) ISBN 9780750659901

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	analysing and evaluating information relating to health and safety regulations, judging its relevance to working with fluid power systems
Self-managers	anticipating, taking and managing risks when carrying out fault location, testing, and maintenance activities on pneumatic equipment and systems in a safe and approve manner working towards an engineering maintenance activity showing initiative, commitment and perseverance organising time, resource and prioritising actions to prepare for and carry out an engineering maintenance activity
Team workers	collaborating with others when identifying faults and maintaining pneumatic systems.

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

Skill	When learners are …
Reflective learners	reviewing progress during practical activities and acting on the outcomes
Creative thinkers	questioning their own and others' ideas during group work activities on the assessment when identifying faults and maintaining pneumatic systems
Effective participators	identifying improvements that benefit others as well as themselves when identifying faults and maintaining pneumatic systems discussing issues of concern with respect to the relevant health and safety precautions/legislation relevant to fault diagnosis and maintenance of pneumatic systems seeking resolution with colleagues/tutor where needed.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using software based systems for circuit simulation construction and fault diagnosis
Manage information storage to enable efficient retrieval	using software based data systems when diagnosing faults
ICT – Develop, present and communicate information	
Present information in ways that are fit for purpose and audience	using software based systems when handing over and commissioning system
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking and listening to colleagues and others when carrying out fault location, testing, and maintenance activities on pneumatic equipment and systems
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading current safety legislation to select the information required enabling the learners to complete tasks safely. reading information to enable learners to prepare for and carry out fault diagnosis, location, testing, and maintenance activities on pneumatic equipment and systems in a safe and approve manner
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining the importance of applying safe working practices when carrying out maintenance on a fluid power writing a report analysing the system for ease of maintenance, comparing and contrasting the diagnostic techniques used to locate faults and identifying how a work activity can be improved.

Unit 25: Applying Continuous Improvement and Problem-solving Techniques

Unit code: D/600/0424

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners an opportunity to investigate and apply continuous improvement and problem-solving techniques.

Unit introduction

Engineering companies can no longer dictate the type, quantity and cost of their products. This is becoming the customer's role, who is now demanding responsive delivery, consistent quality, good customer service, and most important of all a competitive price. One way to improve business performance is by empowering the people who make up the organisation. This means the top level management, middle management, supervision and all other employees all have a part to play in improving the performance of their organisation.

This unit covers the background, main concepts and techniques of continuous improvement (Kaizen) and problem solving in the lean manufacturing environment. It involves benchmarking the process before and after the Kaizen activity in order to set quantifiable targets for improvement. The unit focuses on improvements which give reduced product cost, improved safety, improved quality, improvements to working practices and procedures, reduction in lead time and reduction of waste. It then covers the main quality tools required to collect and analyse a wide range of manufacturing data. The unit then goes on to cover the application of continuous improvement and problem-solving techniques in the work area and the associated issues of successfully implementing such changes in the manufacturing environment.

Learning outcomes

On completion of this unit a learner should:

1 Know the quality gurus' philosophies

2 Understand the concept and techniques of continuous improvement

3 Be able to use quality tools to solve manufacturing problems

4 Be able to use continuous improvement and problem-solving techniques.

Unit content

1 Know the quality gurus' philosophies

Crosby: four absolutes; 14-point improvement plan

Deming: 14-point quality management plan; Plan, Do, Check, Act (PDCA) cycle

Juran: breakthrough; customer–supplier chains; quality trilogy

Ishikawa: company-wide quality; quality circles; quality tools

2 Understand the concept and techniques of continuous improvement

Concept: small incremental steps of continuous improvement and its benefits over large-step changes; improvement of product cost, safety, quality, working practices and procedures; reduction in lead time and reduction/elimination of the '7 wastes' and the '6 hidden losses'

Techniques: PDCA methodology; root cause analysis; improvement idea generation and evaluation; planning improvements; Gantt charts; installing improvement

Benefits of a lean manufacturing environment: improved quality, reduced costs and improved delivery schedule performance

3 Be able to use quality tools to solve manufacturing problems

Quality tools: eg process flow charts, check sheets, tally charts, bar charts, histograms, Pareto charts, scatter diagrams, Ishikawa diagrams, root cause paths, 5 whys, brainstorming and statistical process control

Manufacturing problems: eg poor quality, excessive transportation of material, parts and resources, excessive operator motion, over production, over processing, minor stoppages, breakdowns, running machines at reduced speeds and process start up losses

4 Be able to use continuous improvement and problem-solving techniques

Implementation of an improvement activity: implementation of the corrective actions; implementation planning; protecting the plan; contingency planning; process monitoring; time line graphs; creation of, or updating existing standard operating procedures; visual management to communicate the work of the Kaizen activity to participants and others

Implementation issues: time, cost and resource constraints; lack of training and education; poor communication between functions of the organisation; poor management/supervisory skill levels; fear of change itself

Selection of the work area: based on an area's performance against selected key performance indicators eg right first time, overall equipment effectiveness, people productivity, stock turns, delivery schedule achievement, value added per person, floor space utilisation and product cost reduction; quantifiable objectives and targets; health and safety requirements of the work area

Applying problem-solving techniques: team selection; team roles and responsibilities; structured approach to problem solving; data collection; identifying and using the appropriate quality tools; identifying the root cause of the problem; determination and selection of permanent corrective actions; decision making; identifying criteria for givens and wants; assessing criteria; generating alternatives; determining risks

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	describe the quality gurus' philosophies	**M1**	describe the strengths and weaknesses of applying each quality guru's philosophy	**D1**	compare the continuous improvement concept with the large step change approach
P2	describe the concepts of continuous improvement	**M2**	describe the benefits of minimising wastes and losses in a lean manufacturing environment.	**D2**	evaluate the improvement process and quality tools and techniques used during an improvement activity.
P3	explain how the use of continuous improvement techniques can lead to benefits in a lean manufacturing environment				
P4	use three quality tools to solve a manufacturing problem [IE1, IE4]				
P5	state what is required to implement an improvement activity and describe the implementation issues that may arise				
P6	use continuous improvement and problem-solving techniques in a work area. [SM3]				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

The approach to delivery for this unit may be to work in a particular manufacturing sector and work area only, eg automotive or assembly. However, a generic approach covering a range of sectors and work areas is more likely. Centres will determine their approach through an analysis of their learners' needs and, in particular, through consideration of the range of industries that the centre is working with or preparing their learners for. Whichever approach is taken it is expected that learners' experience should be sufficiently varied to provide them with the sound underpinning knowledge and skills needed to effectively apply continuous improvement and problem-solving techniques in most industrial settings.

The learning outcomes are ordered logically and it would be reasonable to develop them sequentially throughout the unit. In this way, learners will begin to recognise the range of tools and techniques and their function and limits related to specific situations in the manufacturing environment. It is strongly recommended that a variety of learner centred delivery methods be used including group discussions, team and individual problem-solving activities, research, industrial visits, presentations and tutor-led learning. This approach will help to retain a more practical approach rather than spending too much time on theory. For example, a short introduction to a quality tool, the function of the tool within the continuous improvement process and its possible limitations – followed by a practical workshop gathering data and using the specific tool to analyse a particular problem. Once the learner has the necessary knowledge and skills to work with a sufficient range of tools and techniques other aspects can then be introduced. These include forms of waste and losses in the manufacturing environment, key performance indicators, workplace organisation and standard operating procedures.

A blend of learning materials should be used to stimulate the learner and place the unit in context. These should include CD ROMs, internet research, specific study packs on lean manufacturing topics, worksheets, industrial case studies, videos/DVDs and textbooks for extended study where appropriate.

Achievement at merit and distinction will be demonstrated through the learner's autonomy when carrying out tasks and their ability to know when to seek advice. Therefore, it is important that during the delivery/learning phase these skills are encouraged. Formative assessment will play an important part in the general development of the learner but especially their achievement of these higher-level abilities. Analytical and evaluative skills are also required at distinction level and again formative work in the delivery phase will enable centres to encourage the learner to consider how the improvement techniques being applied could be improved.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • outline the purpose and use of continuous improvement and problem solving in engineering and manufacturing • identify the accepted quality gurus and outline the main points of each of their philosophies. Individual/small-group activities: • research the work of Crosby, Deming, Juran and Ishikawa and identify similarities and differences.
Whole-class teaching: • describe the concept of continuous improvement and explain the use of different techniques • explain issues relating to cost, safety, quality and general working procedures and practices. Individual/small-group activity: • investigate the principles of continuous improvement, and its impact upon company performance • learners investigate procedures and practices of own company or those of a given local employer • practise the use of practical tools and techniques, eg Gantt chart.
Prepare for and carry out assignment 1 (P1, P2, P3, D1).
Individual/small-group activity: • using own company or case studies based on local employers, investigate the overall benefits of a lean manufacturing environment and the use of continuous improvement techniques.
Whole-class teaching: • outline the various quality tools that are used in industry • explain and discuss the problems associated with manufacturing. Consider poor quality, out sourcing, maintenance and other issues. Individual/small-group activity: • select the most appropriate quality tools for given example organisations.
Prepare for and carry assignment 2 (P4, P5, M2, D2).
Whole-class teaching: • explain the means of planning and monitoring and the use of timelines • describe the use of standard operating procedures • describe the use of visual management techniques in relation to Kaizen activities • discuss issues relating to implementation – management support, training needs, and motivation, legislation and union responses. Small-group activity: • research visual management systems and techniques and apply to own company or a given organisation. Review standard operating procedures and the possible application of Kaizen.
Prepare for and carry out Assignment 3 (P5).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain the main constraints and problems that can arise when implementing an improvement activity. Individual/small-group activities: • select a work area and consider the overall performance level compared to best practice • using case study material review a variety of company based schemes.
Individual/small-group activities: • apply simple problem-solving techniques to possible situations in own company or for a given case-study organisation. Consider application to company and sophistication of techniques used • review data collection, agreement on corrective actions and overall decision making.
Prepare for and carry out Assignment 4 (P6).
Unit review and evaluation.

Assessment

Evidence of learning outcomes can be collected from case studies, assignments and projects, which should enable the learner to demonstrate knowledge and understanding of the concept of continuous improvement and problem-solving in the manufacturing environment.

An assignment could be developed on the quality gurus' philosophies to satisfy P1 and then linked to M1 by asking the learner to explore the strengths and weaknesses of these philosophies. The learner could then be assessed on P2, P3 and D1 by using an integrated assignment that covers the concept and techniques of continuous improvement and asks the learner to compare and contrast this technique against the large step change approach. The learner would then generate a report in response to this assignment which may include charts, diagrams and photographs.

P4 could be evidenced by engaging the learner in a range of different manufacturing case studies, with the associated data. The learner can then be asked to analyse this data, find the root cause of the problem and suggest appropriate improvement activities. Evidence generated through these practical exercises should include showing the use of standard forms and tools, as well as the written response to the appropriate improvements that may be installed.

Assessment of M2 may be through a report based on lean manufacturing and the concept of minimizing all forms of waste and losses within the manufacturing environment.

Assessment and grading criteria P5, P6, and D2 could be assessed using a project connected with the learner's employment or to engineering or manufacturing activities within the learning environment. The learner should be able to select a work area, assess the performance of the area and then apply the appropriate continuous improvement and problem-solving techniques in order to make improvements. The learner can then go on to explain the issues they encountered during this practical exercise, evaluate their improvement methodology and suggest how this may alter their approach to future improvement activities. The evidence must be generated in a form suitable for inclusion in the learner's portfolio. This could include standard forms (eg PDCA forms, data gathering forms, minutes of team meetings), quality tools, images (eg photographs, scanned images, completed charts, diagrams, plans and engineering drawings), course notes and solutions to class-set problems.

Learners should be encouraged to begin work on their portfolio at the start of the unit and collect evidence systematically as they progress. They should also be encouraged to cross-reference the evidence in their portfolio to the individual learning outcomes. In order to help this process, tutors should guide learners and, where appropriate, provide standard documentation/forms (for individual completion) that support assessment and portfolio building.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, D1	Investigation into the Principles of Continuous Improvement	Outline basic principles, Gurus etc. Guidance on application to own organisation.	Structured investigation.
P4, P5, M2, D2	The Application of Basic Quality Tools and Techniques	Consider the application to given examples. Supported by an analysis of their effectiveness.	Assignment.
P5	A Survey of Visual Management Techniques	Given examples and an investigation into own company.	Investigation.
P6	The Application of Basic Problem-solving Techniques to Manufacturing Technology	Given examples leading to conclusions.	Structured assignment.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Engineering Maintenance Procedures	Six Sigma Quality
	Production Planning for Engineering	Quality and Business Improvement
	Application of Quality Control and Measurement in Engineering	Teamwork in a Continuous Improvement Environment
	Workplace Organisation and Standard Operating Procedures	

This unit can contribute skills, knowledge and understanding towards several units of the Level 3 NVQ in Business Improvement Techniques, particularly:

- Unit 5: Applying Continuous Improvement Techniques
- Unit 13: Applying Problem-solving Techniques.

Essential resources

Learners will need access to an up-to-date reference library and an engineering workshop.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers. Company visits will enhance this particular part of the unit very well.

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

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

Indicative reading for learners

Textbooks

Bicheno J – *The New Lean Toolbox* (Picsie Press, 2004) ISBN 0954124413

Imai M – *Gemba Kaizen – a Commonsense Low Cost Approach to Management* (McGraw-Hill, 1997) ISBN 0070314462

Womack J and Jones D – *Lean Thinking* (Free Press, 2003) ISBN 0743231643

Journal

International Journal of Operations and Production Management

Magazines

Engineering Technology

Manufacturing Engineer

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	identifying questions to answer and problems to resolve when using quality tools to solve a manufacturing problem analysing and evaluating information relating to quality tools when solving a manufacturing problem
Self-managers	organising their time and resources and prioritising actions when using continuous improvement and problem-solving techniques.

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

Skill	When learners are ...
Reflective learners	describing the factors affecting manufacturing systems.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using software-based quality systems
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating continuous improvement techniques
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the concepts of continuous improvement and explaining how they can lead to benefits in a lean manufacturing environment.

Unit 26: Workplace Organisation and Standard Operating Procedures

Unit code: M/600/0427

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners the opportunity to investigate and evaluate workplace organisation and the application of standard operating procedures. Learners will gain an understanding of the methodologies used to improve quality, efficiency and safety in the workplace.

Unit introduction

This unit covers workplace organisation and the 5S/5Cs methodology, visual management techniques and standard operating procedures.

The 5S/5Cs methodology is a process of improving the workplace (manufacturing, office, stores etc) and is the foundation of continuous improvement. It is concerned with a team approach to the cleaning and organising of machines, equipment, tools and materials in the work area. It leads to reduced breakdowns, higher productivity, improved quality, improved safety and a better workplace.

Visual management is the combination of visual control and visual display. Up-to-date information of various kinds helps a business to keep employees updated in a relatively cost effective manner. It may take the form of a chart, diagram or a list of items and would normally be displayed in paper format. The unit covers other ways of visually presenting information such as flashing beacons (to warn people of machine or process problems) and LED alpha/numeric boards to display output or level meters, fixed to the outer skin of vessels which are normally not easily checked.

As the standard of work improves, through continuous improvement activities, manufacturing processes and operations need to standardise the way in which the work is done. Standard operations are crucial to producing components that meet the needs of Quality Cost Delivery (QCD) that is core to the customer requirement. In modern manufacturing, 'pull systems' are more and more reliant on the operations within the system being stable. Repeatability in terms of output and quality is key to ensuring that production flows at the correct rate. If any part of a process is unreliable because that process in not under control (variability in the manufacturing process) then just in time delivery cannot be achieved.

Learning outcomes

On completion of this unit a learner should:

1 Understand the principle of the 5S/5C process

2 Know how visual display techniques are used

3 Know about methods of visual control

4 Be able to produce a standard operating procedure (SOP).

Unit content

1 Understand the principles of the 5S/5Cs process

Principles of 5S/5Cs: understand the need for workplace (Gemba) organisation; identify the correct location for machines, tools, equipment and inventory; Sort out/Clear out; Straighten/Configure; Shine/Clean; Standardise/Conformity; Self Discipline/Custom and practice; 5S/5Cs audits; the implementation process

Benefits of 5S/5Cs: promote teamwork; promote safer working environment; more efficient workplace; improve quality; foundation for continuous improvement

Selection of work area: to reduce all forms of wastes and losses; reduce product costs; improve quality; reduce lead times; improve safety

Red tagging procedures: red tag system; red tag ledger; quarantine area; red tag audit

2 Know how visual display techniques are used

Principles of visual management: problems with traditional reporting systems eg lack of ownership, complexity, inaccuracy, corrupted reports, poor circulation, currency and validity of information; inputs/process/outputs; information required to develop a local visual management system; benefits of visual management

Visual display: where to apply visual display; good practice eg accurate and relevant, eye catching, simple; location; team boards; storyboards; PDCA worksheets; business and local key performance indicators eg QCD measures, skills matrices, health and safety, 5S/5Cs scores, autonomous maintenance worksheets, standard operating procedures

3 Know about methods of visual control

Visual control: where to apply visual control; good practice eg accurate and relevant, eye catching, simple; location; shadow boards; colour coding of equipment; floor footprints; kanban card systems; electronic line status systems; andon lights

4 Be able to produce a standard operating procedure (SOP)

The principle of standardised work: the significance of standardised operations; rules of the standardised job; takt time; line balancing; aid to training

Standard operating procedure documentation: standard operating procedures; standard combination sheets; standardised work charts; functions eg sequence of operations, key quality and safety points, work elements, element times, manual, walking, machine, cycle and takt times, equipment and machine layout

Producing and/or updating SOPs: the application of standard operations using the PDCA philosophy; issues of implementing standardised work; priority of improvement; responsibilities

Benefits of SOPs: predictable output in terms of cost, quality and delivery, safer working practices, foundation for training and continuous improvement

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	explain the principles of the 5S/5Cs process	**M1**	explain the benefits of implementing 5S/5Cs principles	**D1**	compare the traditional reporting systems found in manufacturing with the modern principles of visual management
P2	state the benefits of the 5S/5Cs process when applied to a given work area	**M2**	explain how a work area may be selected for improvement	**D2**	explain how standard operations improve key performance indicators.
P3	describe the red tagging procedure	**M3**	describe the functions of a standard operating procedure, standard combination sheet and a standard work chart.		
P4	apply the principles of visual management to describe two examples of visual display found in a manufacturing environment				
P5	describe two examples of visual control found in a manufacturing environment				
P6	describe the principles of standardised work				
P7	produce a standard operating procedure [IE1, IE4]				
P8	state the benefits of introducing a standard operating procedure.				

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

The delivery approach for this unit may be to work in a particular manufacturing sector and work area only, eg automotive or assembly. However, a generic approach that covers a range of sectors and work areas is more likely. Centres will determine their approach through an analysis of their learners' needs and in particular, through consideration of the range of industries that the centre are working with or preparing their learners for. However, it is expected that the learners' experience should be sufficiently varied to provide them with the sound underpinning knowledge and skills needed to effectively improve workplace organisation and standard operating procedures in most industrial settings.

The learning outcomes are logically ordered and it would be reasonable to develop them sequentially throughout the unit. In this way, the learner will begin to recognise the range of techniques related to specific situations in the manufacturing environment. It is strongly recommended that a variety of learner centred delivery methods be used, including group discussions, team and individual problem-solving activities, research, industrial visits, presentations and teacher led learning. This approach will help retain a more practical approach rather than spending too much time on theory. For example, a short introduction to an element of 5S/5C and the function of the activity within the continuous improvement process – followed by a practical workshop using the specific method to improve the workplace. Once the learner has the necessary knowledge and skills, other aspects can then be introduced, such as visual display and control in the manufacturing environment and standard operating procedures.

A blend of learning materials should be used to stimulate the learner and place the unit in context. These should include CD ROMs, internet research, study packs on lean manufacturing topics, worksheets, industrial case studies, videos/DVDs and textbooks for extended study where appropriate.

Achievement at merit and distinction will be demonstrated through the learner's autonomy when carrying out tasks, plus their ability to know when to seek advice. Therefore, it is important that during the delivery/learning phase these skills are encouraged. Formative assessment will play an important part in the general development of the learner but especially their achievement of these higher-level abilities. Analytical skills are required at distinction level and again formative work in the delivery phase will enable centres to encourage the learner to consider how the principles and techniques being applied could be improved.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduce the principles of 5S/5Cs and outline the main benefits • explain the purpose of selection of work area • describe red tagging procedures. Small-group activity: • learners reflect on own experience or company with respect to the benefits, challenges and effectiveness of continuous improvement. Individual learner activities: • select a work area for evaluation based upon own organisation or case study of local business.
Prepare for and carry out assignment 1 (P1, P2, M1).
Whole-class teaching: • introduction to the principles of visual display techniques • explain the problems that can occur with traditional reporting systems and describe the benefits of visual management. Small-group activity: • discuss information required to develop a local visual management system.
Prepare for and carry out assignment 2 (P3, P4, P5, M2, D1).
Whole-class teaching: • explain the principles of visual control, coding systems, kanban and workshop management re tooling and systems. Small-group activities: • investigate the use of visual control in a local or national manufacturer.
Whole-class teaching: • explain the philosophy of standardised working and the use SOPs. Small-group activities: • apply philosophy of standardised working to own experience, off the job training or other local examples • carry out a review of SOP documentation – own company or local case studies • discuss the benefits of SOP in terms of productivity, quality and profitability.
Prepare for and carry out assignment 3 (P6, P7, P8, M3, D2).
Unit review and evaluation.

Assessment

Evidence of learning outcomes can be collected from case studies, assignments and projects, which should enable the learner to demonstrate knowledge and understanding of workplace organisation and standard operating procedures in a modern manufacturing environment.

An integrated assignment could be developed asking the learner to state the principles of 5S/5C and the benefits this would have on a work area. The learner could then go on to explain how a work area can be selected for improvement. This would link P1, P2, M1 and M2 and introduce the learner to the fundamentals of workplace organisation.

An assignment may be generated asking learners to describe the red tagging procedure and thus satisfy P3. The evidence created should be in the form of a report including examples of standard documentation, diagrams and photographs.

P4 and P5 could be linked by asking the learner to write a report on visual management techniques and requesting the learner to focus on at least two examples of visual display and control in detail. These examples could then be compared with traditional reporting systems to cover D1. The learner should be encouraged to include in the report a wide variety of images, charts and diagrams.

Learners could be set an assignment requiring them to describe the principles of standardised work, its documentation, its function and an explanation on how standardised operations improve an organisation's performance to link P6, M3 and D2. Again, the learner should include and make reference in their report to examples of standard documentation used to create standardised jobs in manufacturing. This assignment could also cover P7 and P8 by asking learners to compile a standard operating procedure for an activity connected with the learner's employment or an engineering activity within the learning environment and consider the benefits of its introduction. This again would support the opportunity to achieve criteria D2. The evidence must be generated in a form suitable for inclusion in the learner's portfolio. This may include standard forms (eg PDCA forms, data gathering forms), minutes of team meetings, standard operating procedures, images (eg photographs, scanned images, completed charts, diagrams, plans and engineering drawings), course notes and solutions to class-set problems.

Learners should be encouraged to begin work on their portfolio at the start of the unit and collect evidence systematically as they progress. They should also be encouraged to cross reference the evidence in the portfolio to the individual learning outcomes. In order to help this process, tutors should guide learners and, where appropriate, provide standard documentation/forms for individual completion that support assessment and portfolio building.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1	Applications of 5S/5Cs	Learners have been asked to investigate the benefits of adopting 5S/5C methodology in their workplace.	Written investigation/ report.
P3, P4, P5, M2, D1	Basic Visual Systems	Learners carry out a review of visual systems as applied in their company.	Written investigation/ report.

Criteria covered	Assignment title	Scenario	Assessment method
P6, P7, P8, M3, D2	Standard Operating Procedures in the Manufacturing Workshop	Learners carry out a review of SOPs in their company.	Written investigation/ report.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Applying Continuous Improvement and Problem-solving Techniques	Teamwork in a Continuous Improvement Environment

Achievement of the learning outcomes of this unit will contribute skills, knowledge and understanding towards several units of the Level 3 NVQ in Business Improvement Techniques, particularly:

- Unit 4: Applying Workplace Organisation
- Unit 9: Creating Visual Management Systems.

Essential resources

To deliver this unit centres will need to have an up-to-date reference library with computer aided learning resources and appropriate journals.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the work can be set in the context of learners' work placements or be based on case studies of local employers.

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

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

Indicative reading for learners

Textbooks

Bicheno J – *The New Lean Toolbox* (Picsie Press, 2004) ISBN 0954124413

Imai M – *Gemba Kaizen – a Commonsense Low Cost Approach to Management* (McGraw-Hill, 1997) ISBN 0070314462

Womack J and Jones D – *Lean Thinking* (Free Press, 2003) ISBN 0743231643

Journal

International Journal of Operations and Production Management

Magazines

Engineering Technology

Manufacturing Engineer

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying questions to answer and problems to resolve and carrying out research in order to produce a standard operating procedure.

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

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Self-managers	organising time and resources and prioritising actions.

Functional Skills – Level 2

Skill	When learners are …
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	explaining and discussing 5S/5Cs and visual management methodologies
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	Investigating and researching the use of workplace organisation and standard operating procedures
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining and describing 5S/5Cs and visual management methodologies.

Unit 27: PC Hardware and Software Installation and Configuration

Unit code: A/600/0429

QCF Level 2: BTEC Firsts

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners the knowledge and skills needed to install, test and configure computer hardware and software and assemble complete PC systems.

Unit introduction

The use and complexity of personal computers (PCs) is an ever-expanding field. As such there is an increasing need for skilled individuals who can upgrade when appropriate and perform maintenance on the wide range of PC units available.

The output devices used with computer systems, for example monitors and printers, need to be appropriately connected and configured to meet user needs and comply with health and safety requirements. Similarly, input devices such as keyboards and scanners must be connected to the PC system.

The PC system is modular in construction to allow for upgrading of hardware, component failures and installation of new devices, thus prolonging the computer's working life. In order to function the hardware and software must be brought together and harmonised in order to operate in an efficient manner.

This unit aims to give learners the knowledge and skills needed to install, test and configure computer hardware and software and assemble complete PC systems.

The unit looks at the various hardware components that make up a complete system, such as system power supply, motherboards, microprocessors and memory devices. Learners will also gain an understanding of different software, its application and associated legal issues. The learning experience is drawn together through the commissioning, configuration and testing of a complete PC system.

Learning outcomes

On completion of this unit a learner should:

1 Know the basic operation of standard PC systems

2 Be able to install and configure standard PC hardware components

3 Be able to install and configure standard software packages including the operating system

4 Be able to commission, configure and test complete PC systems.

Unit content

1 Know the basic operation of standard PC systems

Basic operation of PC systems: block diagram identifying main system components eg input/output, central processing unit (CPU), arithmetic logic unit (ALU), control unit, storage, bus system, system clock; analogue and digital signals; Binary system; coding of American standard code for information interchange (ASCII) and UNICODE; system unit (types, cooling system, power supply)

Input devices: image processing eg digital cameras, wand scanner, flatbed scanners, video camera; hand devices eg keyboards, touch screens, mouse, joystick, trackball, digitiser tablet and crosshair, touchpad, microphones, sensing devices

Output devices: monitors; printers eg bi-directional, impact, character, dot-matrix, inkjet, laser, thermal, line, graph plotter; sound systems; storage devices; modems

2 Be able to install and configure standard PC hardware components

Motherboards: formats eg baby advanced technology (AT), ATX, NLX; power supply types; voltage regulator eg linear, switched; peripheral component interconnection (PCI), industry standard architecture (ISA), memory slots; onboard adapters

Microprocessors: types eg dual core, quad-core, Pentium 4, Celeron, Centrino, AMD-Sempron and alternatives; CPU eg sockets, cooling systems, processor speed, over-clocking

Memory types: volatile; permanent; hard disk eg tracks, sectors and clusters, virtual file allocation table (VFAT); defragmentation; cache; semiconductor eg random-access memory (RAM), DRAM (EDO, SDRAM), ROM, PRAM, EPROM, EAROM, EEPROM (flash PROM); chip types eg single and dual in line memory module (SIMM/DIMM); Optical Laser Discs eg CD, CD ROM, CD-R, CD-RW, DVD, DVD-ROM, DVD-R, DVD-RAM, DVD+RW, DVD-RW and FMD-ROM; external eg universal serial bus (USB) flash memory, tape backups (quarter-inch cartridge, digital audio tape (DAT))

Display systems: liquid crystal display (LCD) projectors; thin film transistor liquid crystal display (TFT-LCD); graphic adaptors; monitor size; resolution; refresh rate; power supply requirements; standards; health and safety

Standard interfaces and bus systems: internal eg industry standard architecture (ISA), extended ISA (EISA), local bus peripheral component interconnection (PCI) and video electronic standards association (VESA); external eg serial and parallel ports (computer output on microfilm (COM) and line printer terminal (LPT)), small computer systems interface (SCSI), universal serial bus (USB); video, mouse and keyboard connectors

Power supply units: ATX; ATX12; voltage levels; regulation; noise levels; cooling; dust considerations

Install and configure hardware: internal eg system power supply, hard disk, RAM, adaptor cards, hard drives, sound cards, graphics cards; peripherals eg printers, scanners, cameras; configure for system; interrupt request (IRQ) considerations; use safe working practices eg manual handling/lifting, general electrical mains safety, electrostatic strap, loose clothing, tidy work areas

3 Be able to install and configure standard software packages including the operating system

System software: features eg utilities, testing, virus protection, device drivers, applications, file system structure and file types

Install and set up software applications: installation eg standard, custom; copyright and licensing considerations; setting operating characteristics; uninstall

Operating System (OS): types eg disk operating system (DOS), Windows family, UNIX, network operating system (NOS)

Install and set up an operating system: OS types and relationships; operating system eg install, upgrade; basic input/output system/complementary metal oxide semiconductor (BIOS/CMOS) set-up; bootstrap and start-up/shutdown procedures; recovery procedures

4 Be able to commission, configure and test complete PC systems

Assemble PCs to requirements: assemble PC to a pre-defined specification to meet specific requirements using safe working practices eg manual handling/lifting, general electrical mains safety, electrostatic strap, loose clothing, tidy work areas

Install software components: install operating system and system software

Configure and test PCs: run tests on hardware components; operating conditions eg determine, set-up optimum; documentation eg system, configuration procedures

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 identify the different types of computers and describe the basic operation of a PC system	**M1** compare the features and operation of different standard bus systems, interfaces and their connectors	**D1** produce a detailed specification for a PC system to meet user requirements
P2 identify input and output devices to meet two different given needs	**M2** plan the installation of an operating system and select appropriate options during the set up to meet operating requirements	**D2** evaluate the various set up options for a PC system.
P3 describe the main hardware components found in a PC system	**M3** design documentation for system details, configuration procedures and test results for a PC system.	
P4 carry out installation and configuration of three hardware components using safe working practices		
P5 install and configure two different software applications, customising one of them		
P6 install an operating system and confirm hardware is functioning correctly		
P7 assemble a PC system to a specification [IE1, CT1]		
P8 test and configure a PC system. [IE1]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

The delivery of this unit should be a mixture of sound underpinning knowledge of computer-based technology and practical activities. Learners must study the fundamentals of computer-based hardware and software with particular reference to current technologies and commercial trends. Learners should have the opportunity to apply this knowledge and understanding by building PCs through the modular construction of modern systems and configuring the various software aspects. The peripherals that allow for input and output of data need to be understood, correctly connected and configured to computer-based systems.

The practical element should form an important part of the learning experience and therefore safe working practices, good housekeeping and awareness of others' safety must be embedded.

The learning outcomes are ordered logically and could be developed sequentially throughout the unit. In this way, the learner will obtain the knowledge, understanding and practical skills needed to undertake installation, configuration and maintenance of a wide range of PC units.

Practical tasks should make the learner see the relevance of the theory in achieving the implementation and subsequent appropriate functioning of personal computer system(s) to meet user requirements.

Tutors could provide demonstrations such as the configuration of software that could be followed by learners undertaking similar activities. Then, through workstation interrogation, learners could confirm each other's settings and check that they comply with given standards and specifications.

Unit delivery should encourage the learner to take control of their learning as much as possible and to seek advice and guidance when required. Formative feedback on technical knowledge and learners' practical abilities should be given throughout the unit. This will play an important part in the learners' general development but especially their achievement of merit and distinction grades.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and assessment • introduce the different types of computers and explain the basic operation of PC systems • explain the purpose and use of input devices including different types of image processing and hand devices • explain the purpose and use of monitors, printers, sound systems, modems and storage devices.
Individual learner research: • investigating operation of PC systems and purpose and use of input and output devices. Prepare for and carry assignment 1 (P1 and P2).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • explain and demonstrate the installation and configuration of motherboards, microprocessors and types of memory • explain and demonstrate the installation and configuration of display systems, standard interfaces, bus systems and power supply systems. Practical workshop sessions: • practise installation and configuration of hardware components.
Individual learner research: • investigating hardware components, practising hardware installation and configuration. Prepare for and carry out assignment 2 (P3, P4, M1).
Whole-class teaching: • explain the main features of software packages and demonstrate how to install, configure and customise software applications • explain the main types of operating systems and demonstrate their installation and set-up • explain and demonstrate safe working practices. Practical workshop sessions: • practise installation and configuration of software applications and operating systems.
Individual learner research: • investigating software applications and practising software/OS installation and configuration. Prepare for and carry out assignment 3 (P5, P6, M2).
Whole-class teaching: • explain and demonstrate how to assemble a PC according to a specification to meet specific requirements • explain and demonstrate safe working practices • explain and demonstrate how to configure and test PC systems. Practical workshop sessions: • practise the commissioning, installation and configuration of complete PC systems.
Individual learner research: • investigating and practising the installation and configuration of complete PC systems • prepare for and carry out assignment 4 (P7, P8, D1 and D2).
Unit summary and review.

Assessment

Learners' summative assessment will be carried out on an individual basis, but, for practical exercises and acquisition of knowledge, group working and the sharing of tools and equipment is acceptable. The making of a complete computer-based system, with its various types of units, cables, hardware components, peripherals and software configuration should make for an enjoyable and rewarding learning experience.

A proportion of the assessment for this unit will be through tutor observation and questioning. To support this assessment approach the learner should provide supporting evidence such as the use of a logbook record of installation and/or software configuration carried out. The log could contain a description of the task undertaken, the instructions provided (annotated to record progress or difficulties), a list of tools/equipment provided and their condition, photographs that have been annotated to explain procedures and problems encountered etc. Such supporting activity evidence would then validate the tutor or witness observation/oral questioning records and vice versa.

The links through the grading criteria to the higher grade levels need to be explicit in the task/assignment brief, with assessment activities being conducted over a reasonable period of time within the teaching of the unit.

Grading criteria P1 provides an introduction to PC systems and could be assessed along with P2 in a written task, allowing for the exploration of a range of computers, system components, output devices and PC hardware features.

Evidence for P3 and P4 might be best achieved through tutor observation and subsequent questioning of underpinning knowledge.

The practical approach should be continued with grading criteria P5 and P6, with evidence being provided through tutor observation and records of questioning within learners' logbooks. Evidence of safe working practices should also be included.

Formative assessment will be needed prior to these practical tasks and learners need to be encouraged to consider what is required before being observed, any potential problems and the range of questions they are expected to answer. If time restraints are imposed, at this level they should be generous and the learner made fully aware of them before starting.

For grading criterion M1, learners will need to build on their knowledge of hardware components gained through the practical activities carried out for P3 and P4. A written task may be used to capture evidence of the comparison of the features and operation of different standard interfaces and bus systems. M2 should allow the learner to demonstrate a higher order of understanding of installation and set up of software, which could be presented through a presentation or written document. D2 leads on from M2 in asking learners to evaluate set up options in the wider aspects related to a PC system. This could be accomplished through a written report, containing appropriate screen shots and supporting research material.

Grading criterion M3 leads on from the system assembly, with annotated screen dumps of practical undertakings, coupled with documentation duly designed and completed against the PC system.

For the distinction criteria, learners should be able to produce an appropriate workstation specification, critically evaluate set up options and carry out verification of performance. For example, for grading criterion D1, the learner needs to produce a PC specification with reasons for hardware, software and peripheral selection against determined user requirements supplied perhaps through a scenario.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1 and P2	PC Systems	Produce an information leaflet or poster outlining the main types of PC systems.	A written assignment based on research gathered from magazines, journals and manufacturers' information.
P3, P4, M1	Hardware Installation	Install hardware components for a computer maintenance company.	A practical assignment, supported by tutor observation/witness statements and a written report or logbook of the task undertaken.
P5, P6, M2	Software Installation	Install software packages and an operating system for a computer maintenance company.	A practical assignment, supported by tutor observation/witness statements and a written report or logbook of the task undertaken.
P7, P8, D1 and D2	Assembling PC Systems	Assemble, test and configure a PC system for a local business.	A practical assignment, supported by tutor observation/witness statements and a written report or logbook of the task undertaken.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	Function and Operation of Electronic Systems and Components	
	Mobile Communications Technology	

Essential resources

To deliver this unit successfully, centres will need to have a range of tools, test equipment, hardware components and software, current standard workstations for modular fitting and configuration purposes and installation of software. To support underpinning knowledge the relevant standards and instruction manuals should be available. Learners will also need internet access to carry out appropriate research.

Safety equipment, along with a safe working environment, including appropriate health and safety notices, must be provided for all practical sessions.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers.

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

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

Indicative reading for learners

Textbooks

Lawson J – *A+ Certificate Computer Maintenance and Installation* (Butterworth-Heinemann, 2004) ISBN 0435456385

MacRae K – *Haynes Build Your Own Computer* (Haynes, 2003) ISBN 1859609732

Rosenthal M – *Build Your Own PC* (McGraw Hill, 2004) ISBN 0072255595

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	identifying and resolving problems that arise when assembling, testing and configuring a PC system
Creative thinkers	generating ideas and exploring possible ways to assemble PC systems that meet the requirements of a specification.

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

Skill	When learners are …
Reflective learners	setting goals with success criteria for their development and work
Self-managers	working towards goals, showing initiative, commitment and perseverance.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	installing, configuring and testing PC hardware and software components and systems
Troubleshoot	testing and configuring hardware, software and PC systems
English	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	investigating and researching the installation and configuration of a range of PC hardware and software systems and components
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the basic operation of PC systems and the main hardware and software found in them.

Unit 28: Mobile Communications Technology

Unit code: M/600/0430

QCF Level 2: BTEC Firsts

Credit value: 5

Guided learning hours: 30

Aim and purpose

This unit aims to give learners knowledge of mobile communications, their advantages and disadvantages and the implications of their use. The unit will also enable learners to set-up and configure a variety of mobile communication devices.

Unit introduction

The full range of mobile communications technology embraces more than just the telephone. Wireless technologies have become a commercially-successful mainstay in the information technology industry and almost all Personal Data Assistants (PDAs) and Personal Computers (PCs) being equipped with wireless connectivity as standard. Households often have more than one computer, and wireless networking enables the remote sharing of printers, file exchange and fast internet connection. This same technology has also liberated private and commercial networks from traditionally structured cabled solutions and has provided internet access in public places such as hotels, cafés and parks (via so called 'hotspots'). It has also revolutionised the home office environment by offering greater freedom and flexibility to the way that people live, work and talk to each other.

Mobile communication is not without its problems and challenges, most notably the malicious attempts by hackers to intercept and interfere with network data.

This unit shows learners the different wireless technologies that are currently available, the mobile devices which benefit them and how they can be used to offer solutions that would have previously been impossible. Additionally, learners will be shown how to create and configure simple wireless communication networks, securing them with current tools and available protocols. Consideration of the technology's impact on the individual, and society as a whole, will also be encouraged.

Learning outcomes

On completion of this unit a learner should:

1 Know about the characteristics and services available in mobile communications technologies

2 Know about the implications of mobile communications

3 Be able to use mobile communications technologies to meet user needs.

Unit content

1 Know about the characteristics and services available in mobile communications technologies

Current technologies and services: mobile communication technologies eg infrared, Bluetooth, Wi-Fi, GSM, GPRS, 2.5G, 3G, mobile VoIP; services eg text messaging, email, video conferencing, video phones, video and picture messaging, internet

Quality issues: standards available eg 802.11 (legacy) for Wi-Fi, IrDA for Infrared; data transfer rates; data capacity against cost; effective ranges; wireless access protocols (eg WAP); SMS protocols

Licensing issues: unlicensed frequencies eg 2.4Ghz; licensed frequencies eg cellular

Wireless networking: wireless access points eg internet hotspots; wireless network adaptors; wireless encryption methods eg WEP; interference from other devices

2 Know about the implications of mobile communications

Social implications: changes in social interaction eg text messaging, multimedia messaging, emails; health issues; other eg need for increased vigilance regarding criminal activities using mobile phones; mobile working

Moral and ethical implications: security of personal data; accidental theft of telecommunication services through weak security; hacking activities eg piggybacking, packet sniffing; legal issues; effects on communities eg erection of masts

Advantages: increased efficiency; greater flexibility; cable-free convenience

Disadvantages: security of data; effective range of equipment; interference; radiation

3 Be able to use mobile communications technologies to meet user needs

Mobile communication technologies: devices eg PDA, mobile telephones, wireless enabled PCs; configuration; connectivity; selection of device to meet user need; ad-hoc data transfer

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe current mobile communication technologies and services	**M1** compare different mobile communication technologies for a particular application	**D1** evaluate currently available mobile communication technologies and devices.
P2 describe quality, licensing and wireless networking issues	**M2** explain how social, moral and ethical implications of using wireless technologies may be addressed.	
P3 describe the social, moral and ethical implications of using wireless technologies [IE3, IE5]		
P4 describe the advantages and disadvantages of two different mobile communication devices [IE3]		
P5 set up and configure two different mobile communications technology devices to meet user needs.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

As much of this unit as possible should be delivered using practical exercises, including research into new technologies and their applications. Because mobile communications are permanently evolving, tutors should try to ensure that the latest commercially available technologies are covered and not necessarily just those listed in the unit content. It is expected that most of the theoretical aspects are delivered through lectures, backed up by handouts and that learners will have an understanding not only of the technologies, but also an appreciation of the standards developed to control the use of these technologies.

Learners should also have practical experience of using a number of the technologies suggested (including their most common applications). The use of case studies may be beneficial in helping the learner appreciate the technologies' impact on the home and commercial solutions.

Formal delivery can be consolidated by group work, small problem-solving exercises and presentations. Guest speakers representing wireless network users and mobile technology providers would be very useful.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit, scheme of work and methods of assessment • introduce and explain mobile communication technologies currently in use and the services available • explain the quality issues that can affect mobile communications • explain licensed and unlicensed frequencies • explain the networking issues that can affect wireless communications.
Individual learner research: • investigating mobile communication technologies and services. Prepare for and carry out of assignment 1 (P1, P2, M1 and D1).
Whole-class teaching: • explain and discuss the changes in social interaction and other social implications of mobile communications • explain and discuss the moral and ethical implications of mobile communications technology • discuss the advantages and disadvantages of using mobile communications.
Individual learner research: • investigating implications and advantages and disadvantages of mobile communication technology. Prepare for and carry out of assignment 2 (P3, P4 and M2).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • discuss applications of different mobile communication technologies. Practical group exercise: • using, connecting and configuring a range of mobile communication devices.
Individual learner research: • researching and practising using, connecting and configuring mobile communication devices. Prepare for and carry out assignment 3 (P5).
Feedback and unit summary.

Assessment

Evidence for this unit can be gathered from learners undertaking project work based around real-world case studies. It may be possible for learners to be assessed through one integrated assignment, although it is more likely that evidence will be built up from a number of tasks including practical exercises. Learners could use their own mobile devices for practical activities. A variety of strategies could be used to provide evidence including visual or online presentations, leaflets, posters or reports.

A series of three assignments could be used for the assessment of this unit.

The first assignment could combine P1, P2, M1 and D1 in a series of tasks requiring learners to provide a written description of the relevant and up-to-date technologies and services that are currently in use are available. Learners need to identify wireless frequencies used with the licensing needs of each. A brief section showing an appreciation of wireless networking with an overview of wireless networks access points, hardware and encryption will complete this evidence. A variety of strategies could be used to provide evidence, including visual or online presentations, leaflets, posters or reports.

M1 requires learners to compare different mobile communication technologies for a particular real-world application. Ideally, learners will identify suitable real-world applications themselves, but these could be supplied by the tutor. Learners should demonstrate a firm understanding of the technologies and devices available with a good awareness of potential security breaches and prevention.

For D1, learners should build on the evidence they produced for M1 to evaluate currently available mobile communication technologies and devices. To do this, learners will make informed judgements on the suitability of these different technologies, particularly through referencing real-world examples and applications as supporting arguments. The evidence produced for D1 will clearly evaluate the role and use of each mobile communications technology.

The second assignment is likely to be in the form of a series of written tasks. For P3, learners are expected to identify the social, moral and ethical implications of using wireless technologies. Learners could produce a table listing these in a column, showing some awareness of the social, moral and ethical implications for each in another column. The deeper impact they have on society might not be considered. For P4, learners should describe the benefits and risks of two different mobile communication devices. They need not cover these issues in great detail, but an introduction to data coding, error correction, and the relationship between cost and data transmission would be valuable here. For M2, learners will add to their evidence for P3 explaining how social, moral and ethical implications of using wireless technologies may be addressed. Whereas P3 identifies the implications, M2 explains what can be done to minimise negative aspects as well as including suggestions on how the more positive elements of mobile communications technology may evolve.

A practical assignment should be used for P5. Tutors should provide the 'defined needs' for which learners need to set up suitable communication technology devices. These can be based on case studies or real life applications and should contain a list of requirements that learners to meet when setting up and configuring two different mobile communications technology devices. The defined needs should each include some security element, such as restricting connection to a specified device or encrypting data. Evidence for this practical activity is expected to be a written report or presentation with witness statements, identifying how they met the defined needs.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1 and D1	Mobile Communication Technologies	A written assignment in which learners have been asked by a local company to produce a leaflet informing customers of current technology and services.	A written description of current mobile communication technologies and services and the issues relating to them, plus a comparison and evaluation of different technologies available.
P3, P4 and M2	Implications of Using Mobile Communications	A written assignment in which learners produce a poster illustrating the implications of mobile communications for an exhibition.	A written description of the implications and advantages and disadvantages of mobile communications.
P5	Using Mobile Communication Technologies	A practical assignment in which learners are asked by a local company to set up and configure two mobile communication devices.	A written report detailing outcomes of the practical task supported by tutor observation notes/ witness statement.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following units in the Engineering suite:

Level 1	Level 2	Level 3
	PC Hardware and Software Installation and Configuration	

Essential resources

Access to a sample range of mobile devices and wireless technologies is essential for practical exercises and assessment opportunities. Learners can also use their own devices to complement centre resources.

Employer engagement and vocational contexts

Much of the work for this unit can be set in the context of learners' work placements or be based on case studies of local employers.

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

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

Indicative reading for learners

Textbooks

Briere D, Hurley P and Ferris E – *Wireless Home Networking for Dummies* (John Wiley and Sons, 2008) ISBN 0470258896

Castells M, Qiu L and Fernandez-Ardevol M – *Mobile Communication and Society* (MIT Press Ltd, 2006) ISBN 0262033550

Davis H – *Absolute Beginner's Guide to Wi-Fi Wireless Networking* (Que, 2004) ISBN 0789731150

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	exploring the advantages and disadvantages of wireless technologies from different perspectives considering the influence of circumstances, beliefs and feelings when looking at the social, moral and ethical implications of wireless technologies.

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

Skill	When learners are …
Creative thinkers	trying out alternatives or new solutions and following ideas through when setting up and configuring mobile communication devices for different needs
Reflective learners	reviewing progress and acting on the outcomes when investigating and researching mobile communications technology.

Functional Skills – Level 2

Skill	When learners are …
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	setting up and configuring mobile communication devices and wireless technologies to meet user needs
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing the social and ethical implications of communications technologies
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	investigating and researching the use of modern communication technologies
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the social and ethical implications of communications technologies.

Unit 29: Mathematics for Engineering Technicians

Unit code: A/600/0253

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to give learners a strong foundation in mathematical skills. These skills will help them to successfully complete many of the other units within the qualification.

Unit introduction

One of the main responsibilities of engineers is to solve problems quickly and effectively. This unit will enable learners to solve mathematical, scientific and associated engineering problems at technician level. It will also act as a basis for progression to study other units both within the qualification, such as *Unit 28: Further Mathematics for Technicians*, and at BTEC Higher National level.

This unit enables learners to build on knowledge gained at GCSE or BTEC First Diploma level and use it in a more practical context for their chosen discipline. Learning outcome 1 will develop learners' knowledge and understanding of algebraic methods, from a look at the use of indices in engineering to the use of the algebraic formula for solving quadratic equations. Learning outcome 2 involves the introduction of the radian as another method of angle measurement, the shape of the trigonometric ratios and the use of standard formulae to solve surface areas and volumes of regular solids. Learning outcome 3 requires learners to be able to represent statistical data in a variety of ways and calculate the mean, median and mode. Finally, learning outcome 4 is intended as a basic introduction to the arithmetic of elementary calculus.

Learning outcomes

On completion of this unit a learner should:

1 Be able to use algebraic methods

2 Be able to use trigonometric methods and standard formula to determine areas

3 Be able to use statistical methods to display data

4 Be able to use elementary calculus techniques.

Unit content

1 Be able to use algebraic methods

Indices and logarithms: laws of indices ($a^m \times a^n = a^{m+n}$, $\frac{a^m}{a^n} = a^{m-n}$, $(a^m)^n = a^{mn}$), laws of logarithms ($\log A + \log B = \log AB$, $\log A^n = n \log A$, $\log A - \log B = \log \frac{A}{B}$) eg common logarithms (base 10), natural logarithms (base e), exponential growth and decay

Linear equations and straight line graphs: linear equations eg $y = mx + c$; straight line graph (coordinates on a pair of labelled Cartesian axes, positive or negative gradient, intercept, plot of a straight line); experimental data eg Ohm's law, pair of simultaneous linear equations in two unknowns

Factorisation and quadratics: multiply expressions in brackets by a number, symbol or by another expression in a bracket; by extraction of a common factor eg $ax + ay$, $a(x + 2) + b(x +2)$; by grouping eg $ax - ay + bx - by$; quadratic expressions eg $a^2 + 2ab + b^2$; roots of an equation eg quadratic equations with real roots by factorisation, and by the use of formula

2 Be able to use trigonometric methods and standard formula to determine areas and volumes

Circular measure: radian; degree measure to radians and vice versa; angular rotations (multiples of π radians); problems involving areas and angles measured in radians; length of arc of a circle ($s = r\theta$); area of a sector ($A = ½\, r^2\theta$)

Triangular measurement: functions (sine, cosine and tangent); sine/cosine wave over one complete cycle; graph of $\tan A$ as A varies from 0° and 360° ($\tan A = \sin A/\cos A$); values of the trigonometric ratios for angles between 0° and 360°; periodic properties of the trigonometric functions; the sine and cosine rule; practical problems eg calculation of the phasor sum of two alternating currents, resolution of forces for a vector diagram

Mensuration: standard formulae to solve surface areas and volumes of regular solids eg volume of a cylinder $= \pi r^2 h$, total surface area of a cylinder $= 2\pi rh + \pi r^2$, volume of sphere $= \frac{4}{3}\pi r^3$, surface area of a sphere $= 4\pi r^2$, volume of a cone $= \frac{1}{3}\pi r^2 h$, curved surface area of cone $=$ $\pi r \times$ slant height

3 Be able to use statistical methods to display data

Data handling: data represented by statistical diagrams eg bar charts, pie charts, frequency distributions, class boundaries and class width, frequency table; variables (discrete and continuous); histogram (continuous and discrete variants); cumulative frequency curves

Statistical measurement: arithmetic mean; median; mode; discrete and grouped data

4 Be able to use elementary calculus techniques

Differentiation: differential coefficient; gradient of a curve $y = f(x)$; rate of change; Leibniz notation $(\frac{dy}{dx})$; differentiation of simple polynomial functions, exponential functions and sinusoidal functions; problems involving evaluation eg gradient at a point

Integration: integration as reverse of differentiating basic rules for simple polynomial functions, exponential functions and sinusoidal functions; indefinite integrals; constant of integration; definite integrals; limits; evaluation of simple polynomial functions; area under a curve eg $y = x(x - 3)$, $y = x^2 + x + 4$

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	manipulate and simplify three algebraic expressions using the laws of indices and two using the laws of logarithms	**M1**	solve a pair of simultaneous linear equations in two unknowns	**D1**	apply graphical methods to the solution of two engineering problems involving exponential growth and decay, analysing the solutions using calculus
P2	solve a linear equation by plotting a straight-line graph using experimental data and use it to deduce the gradient, intercept and equation of the line	**M2**	solve one quadratic equation by factorisation and one by the formula method.	**D2**	apply the rules for definite integration to two engineering problems that involve summation.
P3	factorise by extraction and grouping of a common factor from expressions with two, three and four terms respectively				
P4	solve circular and triangular measurement problems involving the use of radian, sine, cosine and tangent functions				
P5	sketch each of the three trigonometric functions over a complete cycle				
P6	produce answers to two practical engineering problems involving the sine and cosine rule				
P7	use standard formulae to find surface areas and volumes of regular solids for three different examples respectively				

Grading criteria			
To achieve a pass grade the evidence must show that the learner is able to:		To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:	To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:
P8	collect data and produce statistical diagrams, histograms and frequency curves [IE4]		
P9	determine the mean, median and mode for two statistical problems and explain the relevance of each average as a measure of central tendency [IE4]		
P10	apply the basic rules of calculus arithmetic to solve three different types of function by differentiation and two different types of function by integration.		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Before starting this unit, learners should be able to demonstrate proficiency in basic mathematical concepts and the use of an electronic scientific calculator to carry out a variety of functions. As a guide to the level required, tutors should consult Unit 3: Mathematics for Engineering Technicians in the Edexcel BTEC Level 2 First Certificate and First Diploma in Engineering.

The learning outcomes are ordered logically and could be delivered sequentially. The use of algebraic methods is required before further skills can be developed and used within the unit. Much of learning outcome 1 can be practised in pure mathematical terms however, tutors could emphasis where these methods would be applied in an engineering context. Obviously much practise in these methods will prove a valuable foundation for the rest of the unit.

Once learners have mastered most of these methods, learning outcome 2 gives opportunities to apply these skills when solving circular and triangular measurement problems. The application of these skills should reflect the context/area of engineering that learners are studying. Formulae do not need to be remembered but correct manipulation of the relevant formulae is very important in solving these problems. Learners should have plenty of practise when drawing graphs for learning outcome 1 and sketching trigonometric functions in learning outcome 2.

During the delivery of this unit there should be opportunities for learners to use statistical data that they have collected from engineering contexts or situations. It is much better to put statistics, required by learning outcome 3, in an engineering context than use generalities such as learners' height, etc.

Again, for learning outcome 4 opportunities to practise differentiation and integration must be given to ensure learners understand these activities within the range of the content and before they are given assessment activities. The range of these calculus techniques are listed within the content.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to the unit content, scheme of work and assessment strategy • discuss the laws of indices giving examples of each and define a logarithm to any base followed by an explanation of how to convert a simple indicial relationship into a logarithmic relationship and vice versa • define a common logarithm and show how to work out common logarithms with a calculators (using log key) then lead in sketching the graph of a common logarithmic function. *Individual learner activity*: • tutor-led exercises on the solution of problems involving common logarithms. *Whole-class teaching*: • define a natural (Naperian) logarithm and explain how to use a calculator to evaluate a natural logarithm (using $\ln$ key) • lead the class in sketching the natural logarithmic graph and develop the laws of logarithms with reference to the laws of indices • discuss the relationship between common logarithms and natural logarithms. *Individual learner activity*: • tutor-led exercises on the use of logarithms and their laws to evaluate expressions in science and technology. *Whole-class teaching*: • recall the basic rules of transposition and explain how to solve simple linear equations before showing how a linear equation can be represented by a straight graph • explain the significance of the gradient (negative and positive) and intercept for the straight line law and then lead the class in the choice of suitable scales and plotting graphs from given data. *Whole-class teaching*: • recap last week's work on straight line graphs and demonstrate the importance of application of straight line law to experimental data. *Individual learner activity*: • tutor-led exercises in plotting straight line graphs and applying straight line law to experimental data.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • demonstrate how to solve a pair of simultaneous linear equations in two unknowns using elimination and substitution and then show how equations can be formed as a result of an engineering application (eg Kirchhoff's Laws) • explain how to solve a pair of simultaneous linear equations in two unknowns using the graphical method • explain and demonstrate how to factorise expressions containing two, three and four terms by extraction of a common factor and grouping. *Individual learner activities*: • tutor-led exercises in solution of simultaneous equations • tutor-led exercises in graphical solution of simultaneous equations • learner activity involving factorisation of different types of expression. *Whole-class teaching*: • explain factorisation of a quadratic expression and develop to find roots of a quadratic equation • explain and demonstrate the formula method of solving quadratic equations. *Individual learner activities*: • tutor-led exercises in the solution of quadratic equations by factorisation • tutor-led exercises in the solution of quadratic equations by using the formula.
Preparation for and carrying out **Assignment 1: Algebraic Methods** (P1, P2, P3, M1, M2).
Whole-class teaching: • define a radian and explain the relationship between radian and degree, then show how to convert radians to degrees and vice versa • demonstrate angular rotations and show how to solve problems involving areas and angles measured in radians • revise trigonometrical ratios (sine, cosine and tangent) and explain the use of a calculator to find different values in degrees and radians • explain the use of a calculator to construct a table of values from 0° to 360° (2π) for each of the three functions. Plot graphs of the three functions and demonstrate the use of graphs in evaluation of values of trigonometric ratios for angles between 0° to 360°. *Individual learner activities*: • tutor-led solutions of problems involving radians • tutor-led solution of problems involving functions (sine, cosine and tangent) • tutor-led solution of evaluation of values of trigonometric ratios between 0° to 360°.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • review previous weeks' work and summarise values of sine, cosine and tangent values (4 quadrant diagrams) then compare features of the three functions (periodic properties) • explain the use of the sine rule and conditions for solving non right angled triangles. *Individual learner activities*: • tutor-led solution of problems on triangular measurement. • tutor-led solution of practical problems (electrical and mechanical) involving the sine rule. *Whole-class teaching*: • explain the use of the cosine rule and conditions for use (eg where sine rule cannot be used) • explain and demonstrate the use of standard formulae to solve problems involving surface areas and volumes of regular solids. *Individual learner activities*: • tutor-led solution of practical problems (electrical and mechanical) involving just the cosine rule and then the use of both the sine and cosine rule together • tutor-led solution of problems on mensuration.
Preparation for and carrying out **Assignment 2: Trigonometric Methods and Standard Formulae** (P4, P5, P6, P7).
Whole-class teaching: • explain and demonstrate how statistical information can be displayed • explain and demonstrate evaluation of mean, median and mode for discrete data • explain and demonstrate evaluation of mean, median and mode for grouped data. *Individual learner activities*: • tutor-led solution of problems on data collection • tutor-led evaluation of problems involving mean, median and mode for discrete data • tutor-led evaluation of problems involving mean, median and mode for grouped data.
Preparation for and carrying out **Assignment 3: Statistical Methods** (P8, P9).
Whole-class teaching: • explain and introduce differentiation as a measure of the gradient by evaluating various gradients on straight lines and curves • introduce the idea of rate of change and explain the notation followed by an introduction of the general rule for differentiation and demonstration of use on simple algebraic functions • review the general rule for differentiation of simple polynomial functions and introduce and demonstrate the rules for exponential and sinusoidal functions. *Individual learner activities*: • tutor-led differentiation of simple algebraic functions • tutor-led differentiation of exponential and sinusoidal functions.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • consolidate all differential coefficients considered so far and explain and demonstrate valuation to find gradients and rates of charge • explain and introduce the basic rules for integration, the idea of indefinite integration and the constant of integration. *Individual learner activities*: • tutor-led evaluation of problems involving all functions (polynomial, exponential and sinusoidal) using graphical and checking by differentiating • tutor-led solution of problems on integration of simple polynomial, exponential and sinusoidal functions. *Whole-class teaching*: • introduce definite integration as indefinite integration with the addition of limits • demonstrate the evaluation of simple polynomial functions and show how integration can be used to evaluate the area under a curve. *Individual learner activities*: • revision documentation on differentiation and integration • tutor-led evaluation of problems on definite integration.
Preparation for and carrying out **Assignment 4: Calculus Techniques** (P10, D1, D2).
Feedback on all assessment tasks, guidance on remedial action if necessary. Unit evaluation and close.

Assessment

The assessment strategy used will need to cover all the learning outcomes and associated pass criteria but not necessarily all the topics included in the unit content.

Criterion P1 may be best assessed in the form of a short written test and could possibly also include criterion P3.

P2 could be assessed through an assignment using data from either *Unit 5: Mechanical Principles and Applications* and/or *Unit 6: Electrical and Electronic Principles*, which ideally would be delivered concurrently with this unit. If this not possible, learners should be given a range of data sufficient for them to plot the graph and work out the gradient, intercept and the equation. Data forcing them to draw the line of best fit, as opposed to a set of points directly on the graphical line, might be most appropriate.

For P4, learners could be given a range of different values and assessed by an assignment or a short formal test. The problems given should collectively cover radian, sine, cosine and tangent functions. When considering the content part of this learning outcome it is important that these problems give the learner the opportunity to convert multiples of π radians to degrees and vice versa. The circular measurement problems also need to cover the length of an arc and area of a sector as well as areas and angles measured in radians. Obviously the triangular measurement problems are more basic and only expect application of the three functions.

P5 requires learners to sketch each of the three trigonometric ratios and this is probably best done as a classroom exercise. Similarly, P6 could take the form of a written assignment where learners must produce answers to two practical engineering problems involving the sine and cosine rule (for example calculate the phasor sum of two alternating currents and evaluate the resultant and the angle between two forces).

Criterion P7 requires learners to calculate the surface areas and volumes for three different regular solids. This could be achieved through an assignment or perhaps by combining it with other criteria in a short formal test.

An assignment could be used for P8 where learners collect meaningful data (for example classification of workers within their company) and display this information using different graphical methods (for example bar charts). They also need to produce a histogram and plot frequency curves (for example resistance values of 100 resistors or external diameter of pins).

For P9, learners must provide evidence that they are able to determine and then explain the relevance of the mean, median and mode for a set of discrete and grouped data (for example time taken to produce components on a machine rounded to the nearest ten seconds and the 100 resistor values or diameters of pins from P8). This could be done by an assignment. P10 may be assessed through a short formal test, with learners being given a list of the standard differential coefficients and integrals to use.

For M1, learners will need to provide evidence that they can solve a pair of simultaneous linear equations in two unknowns (for example equations formed after the application of Kirchhoff's laws, power transmitted for different belt tensions in a mechanical system). It would be appropriate to use the same assessment method and instrument as P2, possibly combining these two criteria as one assessment activity.

M2 could also be assessed by assignment as it requires learners to evaluate the roots of a quadratic equation by factorisation and by the formula method (for example evaluation of an equation formed after the realisation of a practical situation).

Both the distinction criteria could be assessed through a written assignment. For D1, learners need to apply graphical methods to the solution of two engineering problems involving exponential growth and decay (for example growth of voltage in a capacitor, radioactive decay, application of Taylor's tool life equation $C = VT^n$) and then analyse the results by applying the appropriate method of differential calculus to check the results.

D2 requires learners to demonstrate that they can accurately evaluate two engineering problems involving definite integration (for example area under a velocity-time graph, area under a voltage-current graph).

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1, M2	Algebraic Methods	A written activity requiring learners to complete five tasks, one for each of the criteria.	A report containing written solutions to each of the five tasks carried out under controlled conditions.
P4, P5, P6, P7	Trigonometric Methods and Standard Formulae	A written activity requiring learners to use trigonometric methods and standard formula to determine areas and volumes.	A report containing the results of calculations, and graphic evidence to support the use of trigonometric methods and standard formula for the determination of areas and volumes.
P8, P9	Statistical Methods	A written activity requiring learners to collect and display data using different graphical methods, also evaluate the mean, median and mode for a set of discrete and grouped data.	A report containing bar charts, pie charts and the results of calculations to determine the mean, median and mode for a set of discrete and grouped data
P10, D1, D2	Calculus Techniques	A written activity requiring learners to produce calculations, graphical solutions and analysis to demonstrate use of calculus techniques.	A report containing the solutions to calculations, graphs and analysis of several calculus techniques. Carried out under controlled conditions.

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

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Mathematics for Engineering Technicians	Electrical and Electronic Principles
		Mechanical Principles and Applications
		Advanced Mechanical Principles and Application
		Further Mathematics for Technicians

Essential resources

Learners will need to possess an electronic scientific calculator and have access to software packages that support understanding of the principles and their application to engineering.

Employer engagement and vocational contexts

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

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

Indicative reading for learners

Textbooks

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Student Book* (Pearson, 2010) ISBN 9781846907241

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907265

Bird J – *Engineering Mathematics* (Elsevier Science & Technology, 2007) ISBN 9780750685559

Fuller A, Greer A, Taylor G W – *BTEC National Mathematics for Technicians* (Nelson Thornes, 2004) ISBN 9780748779499

Tooley M and Dingle L – *BTEC National Engineering, 2nd Edition* (Elsevier Science & Technology, 2007) ISBN 9780750685214

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	analysing and evaluating statistical information, judging its relevance and value.

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

Skill	When learners are ...
Creative thinkers	trying out alternatives or new solutions to mathematics problems
Reflective learners	reviewing progress when solving problems during the learner's activities and acting on the outcomes to make corrections to understanding/solutions
Team workers	collaborating with others when working on investigative group work to achieve a valid solution
Self-managers	organising time and resources, prioritising actions.

Functional Skills – Level 2

Skill	When learners are …
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	solving routine electrical and mechanical problems set within engineering contexts and situations
Identify the situation or problem and the mathematical methods needed to tackle it	recognising the relevant parameters and formulae to be applied to given electrical and mechanical situations
Select and apply a range of skills to find solutions	selecting and applying formulae to solve electrical/mechanical problems in engineering
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the results of solutions to electrical and mechanical problems to evaluate their effectiveness and reality at each stage of the calculation
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	speaking with and listening to peers and supervisors to establish an understanding of mathematical concepts and issues in engineering
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	selecting, reading and using appropriate mathematical data sources to solve engineering problems
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	taking notes and solving engineering mathematical problems to communicate accurate solutions effectively.

Further information

For further information please call Customer Services on 0844 576 0026 (calls may be recorded for training purposes) or visit our website (www.edexcel.com).

Useful publications

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

Edexcel Publications
Adamsway
Mansfield
Nottinghamshire NG18 4FN

Telephone: 01623 467 467
Fax: 01623 450 481
Email: publications@linney.com

Related information and publications include:

- *Accreditation of Prior Learning* available on our website: www.edexcel.com
- *Guidance for Centres Offering Edexcel/BTEC QCF Accredited Programmes* (Edexcel, distributed to centres annually)
- Functional Skills publications – specifications, tutor support materials and question papers
- *Regulatory Arrangements for the Qualification and Credit Framework* (Ofqual, August 2008)
- the current Edexcel publications catalogue and update catalogue.

Edexcel publications concerning the Quality Assurance System and the internal and external verification of vocationally related programmes can be found on the Edexcel website and in the Edexcel publications catalogue.

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

How to obtain National Occupational Standards

The National Occupational Standards for Engineering are available from:

SEMTA
14 Upton Road
Watford
Hertfordshire WD18 0JT

Telephone: 01923 238441

Professional development and training

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

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

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

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

Our customer service numbers are:

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

Calls may be recorded for training purposes.

The training we provide:

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

Our training is underpinned by the LLUK standards for those preparing to teach and for those seeking evidence for their continuing professional development.

Annexe A

The Edexcel BTEC qualification framework for the engineering sector

Progression opportunities within the framework.

QCF Level	General qualifications	BTEC full vocationally-related qualifications	BTEC Short Courses	NVQ/occupational
8				
7				
6				
5		HNC/D in Manufacturing Engineering HNC/D in Mechanical Engineering HNC/D in Operations Engineering HNC/D in Electrical/Electronic Engineering		Level 5 NVQ in Business Improvement Techniques (Lean Leadership)
4				Level 4 NVQ in Business Improvement Techniques
3	Advanced Diploma in Engineering	Edexcel BTEC Level 3 Diploma and Extended Diploma in Manufacturing Engineering Edexcel BTEC Level 3 Diploma and Extended Diploma in Mechanical Engineering Edexcel BTEC Level 3 Diploma and Extended Diploma in Operations and Maintenance Engineering Edexcel BTEC Level 3 Diploma and Extended Diploma in Electrical/Electronic Engineering		Level 3 NVQ in Business Improvement Techniques

QCF Level	General qualifications		BTEC full vocationally-related qualifications	BTEC Short Courses	NVQ/occupational
2	Higher Diploma in Engineering	GCSE Engineering GCSE Manufacturing	Edexcel BTEC Level 2 Certificate, Extended Certificate and Diploma in Engineering		Level 2 NVQ in Performing Engineering Operations Level 2 NVQ in Performing Manufacturing Operations Level 2 NVQ in Business Improvement Techniques
1	Foundation Diploma in Engineering		Introductory Certificate and Diploma in Engineering		Level 1 NVQ in Performing Engineering Operations Level 1 NVQ in Performing Manufacturing Operations
Entry					

Annexe B

Grading domains: BTEC Level 2 generic grading domains

Grading domain 1	Indicative characteristics – merit	Indicative characteristics – distinction
Application of knowledge and understanding (Learning outcome stem *understand* or *know*)	• Show depth of knowledge and development of understanding in given situations (for example explain why, make judgements based on analysis). • Apply and/or select relevant concepts. • Apply knowledge to different contexts. • Apply knowledge to non-routine contexts (ie assessor selection). • Make comparisons. • Show relationships between pass criteria.	• Synthesise knowledge and understanding across pass/merit criteria. • Evaluate concepts/ideas/actions. • Analyse/research and make recommendations. • Judges implications of application of knowledge/understanding. • Applies knowledge and understanding to complex activities/contexts.
Grading domain 2	**Indicative characteristics – merit**	**Indicative characteristics – distinction**
Development of practical and technical skills (Learning outcome stem *be able to*)	• Use advanced techniques/processes/ skills successfully. • Act under limited supervision/ demonstrate independence (note: pass cannot require support). • Apply to non-routine activities. • Demonstrate within time and/or resource constraints. • Produce varied solutions (including non-routine). • Modify techniques/processes to situations.	• Demonstrate creativity/originality/own ideas. • Apply skill(s) to achieve higher order outcome. • Select and use successfully from a range of advanced techniques/processes/skills. • Reflects on skill acquisition and application. • Justifies application of skills/methods. • Makes judgements about risks and limitations of techniques/processes. • Innovates or generates of application of techniques/processes for new situations.

Grading domain 3	Indicative characteristics – merit	Indicative characteristics – distinction
Personal development for occupational roles (Any learning outcome stem)	• Takes responsibility in planning and undertaking activities. • Reviews own development needs. • Finds and uses relevant information sources. • Acts within a given work-related context showing understanding of responsibilities. • Identifies responsibilities of employers to the community and the environment. • Applies qualities related to the vocational sector. • Internalises skills/attributes (creating confidence).	• Manages self to achieve outcomes successfully. • Plans for own learning and development through the activities. • Analyses and manipulates information to draw conclusions. • Applies initiative appropriately. • Assesses how different work-related contexts or constraints would change performance. • Takes decisions related to work contexts. • Applies divergent and lateral thinking in work-related contexts. • Understands interdependence.
Grading domain 4	**Indicative characteristics – merit**	**Indicative characteristics – distinction**
Application of generic skills (Any learning outcome stem)	• Communicates using appropriate technical/professional language. • Makes judgements in contexts with explanations. • Explains how to contribute within a team. • Makes adjustments to meet the needs/expectations of others (negotiation skills). • Select and justify solutions for specified problems.	• Presents self and communicates information to meet the needs of a typical audience. • Takes decisions in contexts with justifications. • Produces outputs subject to time/resource constraints. • Reflects on own contribution to working within a team. • Generate new or alternative solutions to specified problems.

Annexe C

Personal, learning and thinking skills

A FRAMEWORK OF PERSONAL, LEARNING AND THINKING SKILLS 11-19 IN ENGLAND

The framework comprises six groups of skills that, together with the Functional Skills of English, mathematics and ICT, are essential to success in learning, life and work. In essence the framework captures the essential skills of: managing self; managing relationships with others; and managing own learning, performance and work. It is these skills that will enable young people to enter work and adult life confident and capable.

The titles of the six groups of skills are set out below.

Team workers

Self-managers

Independent enquirers

Reflective learners

Creative thinkers

Effective participators

For each group there is a focus statement that sums up the range of skills. This is followed by a set of outcome statements that are indicative of the skills, behaviours and personal qualities associated with each group.

Each group is distinctive and coherent. The groups are also inter-connected. Young people are likely to encounter skills from several groups in any one learning experience. For example an independent enquirer would set goals for their research with clear success criteria (reflective learner) and organise and manage their time and resources effectively to achieve these (self-manager). In order to acquire and develop fundamental concepts such as organising oneself, managing change, taking responsibility and perseverance, learners will need to apply skills from all six groups in a wide range of learning contexts 11-19.

The Skills

Independent enquirers

Focus:

Young people process and evaluate information in their investigations, planning what to do and how to go about it. They take informed and well-reasoned decisions, recognising that others have different beliefs and attitudes.

Young people:

- identify questions to answer and problems to resolve
- plan and carry out research, appreciating the consequences of decisions
- explore issues, events or problems from different perspectives
- analyse and evaluate information, judging its relevance and value
- consider the influence of circumstances, beliefs and feelings on decisions and events
- support conclusions, using reasoned arguments and evidence.

Creative thinkers

Focus:

Young people think creatively by generating and exploring ideas, making original connections. They try different ways to tackle a problem, working with others to find imaginative solutions and outcomes that are of value.

Young people:

- generate ideas and explore possibilities
- ask questions to extend their thinking
- connect their own and others' ideas and experiences in inventive ways
- question their own and others' assumptions
- try out alternatives or new solutions and follow ideas through
- adapt ideas as circumstances change.

Reflective learners

Focus:

Young people evaluate their strengths and limitations, setting themselves realistic goals with criteria for success. They monitor their own performance and progress, inviting feedback from others and making changes to further their learning.

Young people:

- assess themselves and others, identifying opportunities and achievements
- set goals with success criteria for their development and work
- review progress, acting on the outcomes
- invite feedback and deal positively with praise, setbacks and criticism
- evaluate experiences and learning to inform future progress
- communicate their learning in relevant ways for different audiences.

Team workers

Focus:

Young people work confidently with others, adapting to different contexts and taking responsibility for their own part. They listen to and take account of different views. They form collaborative relationships, resolving issues to reach agreed outcomes.

Young people:

- collaborate with others to work towards common goals
- reach agreements, managing discussions to achieve results
- adapt behaviour to suit different roles and situations, including leadership role
- show fairness and consideration to others
- take responsibility, showing confidence in themselves and their contribution
- provide constructive support and feedback to others.

Self-managers

Focus:

Young people organise themselves, showing personal responsibility, initiative, creativity and enterprise with a commitment to learning and self-improvement. They actively embrace change, responding positively to new priorities, coping with challenges and looking for opportunities.

Young people:

- seek out challenges or new responsibilities and show flexibility when priorities change
- work towards goals, showing initiative, commitment and perseverance
- organise time and resources, prioritising actions
- anticipate, take and manage risks
- deal with competing pressures, including personal and work-related demands
- respond positively to change, seeking advice and support when needed
- manage their emotions, and build and maintain relationships.

Effective participators

Focus:

Young people actively engage with issues that affect them and those around them. They play a full part in the life of their school, college, workplace or wider community by taking responsible action to bring improvements for others as well as themselves.

Young people:

- discuss issues of concern, seeking resolution where needed
- present a persuasive case for action
- propose practical ways forward, breaking these down into manageable steps
- identify improvements that would benefit others as well as themselves
- try to influence others, negotiating and balancing diverse views to reach workable solutions
- act as an advocate for views and beliefs that may differ from their own.

PLTS performance indicator (suggested recording sheet)

Name:	Date:				
	Level of success 1 = low, 5 = high				
Independent enquirers					
Identify questions to answer and problems to resolve	1	2	3	4	5
Plan and carry out research, appreciating the consequences of decisions	1	2	3	4	5
Explore issues, events or problems from different perspectives	1	2	3	4	5
Analyse and evaluate information, judging its relevance and value	1	2	3	4	5
Consider the influence of circumstances, beliefs and feelings on decisions and events	1	2	3	4	5
Support conclusions, using reasoned arguments and evidence	1	2	3	4	5
Creative thinkers					
Generate ideas and explore possibilities	1	2	3	4	5
Ask questions to extend their thinking	1	2	3	4	5
Connect their own and others' ideas and experiences in inventive ways	1	2	3	4	5
Question their own and others' assumptions	1	2	3	4	5
Try out alternatives or new solutions and follow ideas through	1	2	3	4	5
Adapt ideas as circumstances change	1	2	3	4	5
Reflective learners					
Assess themselves and others, identifying opportunities and achievements	1	2	3	4	5
Set goals with success criteria for their development and work	1	2	3	4	5
Review progress, acting on the outcomes	1	2	3	4	5
Invite feedback and deal positively with praise, setbacks and criticism	1	2	3	4	5
Evaluate experiences and learning to inform future progress	1	2	3	4	5
Communicate their learning in relevant ways for different audiences	1	2	3	4	5

Team workers					
Collaborate with others to work towards common goals	1	2	3	4	5
Reach agreements, managing discussions to achieve results	1	2	3	4	5
Adapt behaviour to suit different roles and situations, including leadership roles	1	2	3	4	5
Show fairness and consideration to others	1	2	3	4	5
Take responsibility, showing confidence in themselves and their contribution	1	2	3	4	5
Provide constructive support and feedback to others	1	2	3	4	5
Self-managers					
Seek out challenges or new responsibilities and show flexibility when priorities change	1	2	3	4	5
Work towards goals, showing initiative, commitment and perseverance	1	2	3	4	5
Organise time and resources, prioritising actions	1	2	3	4	5
Anticipate, take and manage risks	1	2	3	4	5
Deal with competing pressures, including personal and work-related demands	1	2	3	4	5
Respond positively to change, seeking advice and support when needed	1	2	3	4	5
Manage their emotions, and build and maintain relationships.	1	2	3	4	5
Effective participators					
Discuss issues of concern, seeking resolution where needed	1	2	3	4	5
Present a persuasive case for action	1	2	3	4	5
Propose practical ways forward, breaking these down into manageable steps	1	2	3	4	5
Identify improvements that would benefit others as well as themselves	1	2	3	4	5
Try to influence others, negotiating and balancing diverse views to reach workable solutions	1	2	3	4	5
Act as an advocate for views and beliefs that may differ from their own	1	2	3	4	5

Note to learner: The circled number represents an indication of your PLTS performance so far.

Note to tutor: Indicate the level of success by circling the appropriate number during your feedback with the learner.

Summary of the PLTS coverage throughout the programme

Personal, learning and thinking skills	Unit									
	1	2	3	4	5	6	7	8	9	10
Independent enquirers		✓	✓	✓	✓	✓	✓	✓	✓	✓
Creative thinkers								✓		✓
Reflective learners					✓				✓	
Team workers	✓									
Self-managers	✓				✓	✓	✓		✓	
Effective participators	✓				✓	✓				
✓ – opportunities for development										

Personal, learning and thinking skills	Unit									
	11	12	13	14	15	16	17	18	19	20
Independent enquirers	✓	✓	✓		✓	✓	✓	✓	✓	
Creative thinkers					✓					
Reflective learners				✓						✓
Team workers										
Self-managers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Effective participators								✓		
✓ – opportunities for development										

Personal, learning and thinking skills	Unit									
	21	22	23	24	25	26	27	28		
Independent enquirers	✓	✓	✓	✓	✓	✓	✓	✓		
Creative thinkers							✓			
Reflective learners										
Team workers										
Self-managers	✓	✓		✓	✓					
Effective participators										
✓ – opportunities for development										

Annexe D

Wider curriculum mapping

Study of the Edexcel BTEC Level 2 Firsts in Engineering gives learners opportunities to develop an understanding of spiritual, moral, ethical, social and cultural issues as well as an awareness of citizenship, environmental issues, European developments, health and safety considerations and equal opportunities issues.

The Edexcel BTEC Level 2 Firsts in Engineering make a positive contribution to wider curricular areas as appropriate.

Spiritual, moral, ethical, social and cultural issues

The qualification contributes to an understanding of moral and ethical issues, for example when learners are dealing with colleagues and customers.

Citizenship issues

Learners will have the opportunity to develop their understanding of citizenship issues, for example in terms of their rights and responsibilities in the engineering workplace.

Environmental issues

Learners will have the opportunity to develop their understanding of environmental issues in relation to engineering, for example many by considering the influence that engineering processes can have on the environment and the ways that this impact can be reduced.

European developments

Much of the content of the Edexcel BTEC Level 2 Firsts in Engineering applies throughout Europe even though delivery is in a UK context.

Health and safety considerations

The Edexcel BTEC Level 2 Firsts in Engineering are practically based and health and safety issues are encountered throughout the units.

Equal opportunities issues

Equal opportunities issues are implicit throughout the Edexcel BTEC Level 2 Firsts in Engineering.

Wider curriculum mapping

Level 2

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	Unit 11	Unit 12	Unit 13	Unit 14	Unit 15	Unit 16	Unit 17	Unit 18	Unit 19	Unit 20
Spiritual																				
Moral and ethical	✓				✓				✓											
Social and cultural	✓				✓				✓											
Citizenship issues	✓				✓				✓		✓	✓	✓							
Environmental issues	✓				✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓		✓	
European developments	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Health and safety considerations	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Equal opportunities issues	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

	Unit 21	Unit 22	Unit 23	Unit 24	Unit 25	Unit 26	Unit 27	Unit 28	Unit 15	Unit 16	Unit 17	Unit 18	Unit 19	Unit 20	Unit 21	Unit 22	Unit 23	Unit 24	Unit 25	Unit 26	Unit 27	Unit 28
Spiritual																						
Moral and ethical					✓	✓		✓											✓	✓		✓
Social and cultural					✓	✓		✓											✓	✓		✓
Citizenship issues		✓		✓	✓	✓		✓								✓		✓	✓	✓		✓
Environmental issues	✓		✓	✓	✓	✓	✓	✓		✓	✓		✓		✓		✓	✓	✓	✓	✓	✓
European developments	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Health and safety considerations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Equal opportunities issues	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Annexe E

National Occupational Standards/mapping with NVQs

The grid below maps the knowledge covered in the Edexcel BTEC Level 2 Certificate, Extended Certificate and Diploma in Engineering against the underpinning knowledge of the Level 2 NVQ in Mechanical Manufacturing Engineering, Level 2 NVQ in Engineering Maintenance and Installation, Level 2 NVQ in Materials Processing and Finishing, Level 2 NVQ in Business Improvement Techniques, Level 2 NVQ in Performing Engineering Operations, Level 2 NVQ in Performing Manufacturing Operations and Level 2 NVQ in Engineering Technical Support SEMTA SSC National Occupational Standards.

KEY

Relevant NVQ units are listed where the BTEC unit provides partial coverage of the underpinning knowledge and understanding

A blank space indicates no coverage of the underpinning knowledge.

Units	1	2	3	4	5	6	7	8	9	10
Level 2 NVQ in Mechanical Manufacturing Engineering	Units 1, 3	Unit 2							Units 27, 28, 29, 30	
Level 2 NVQ in Engineering Maintenance and Installation	Units 1, 3	Unit 2			Unit 4					
Level 2 NVQ in Materials Processing and Finishing	Units 1, 3	Unit 2								
Level 2 NVQ in Business Improvement Techniques	Unit 1									
Level 2 NVQ in Fabrication and Welding Engineering	Units 1, 3	Unit 2								
Level 2 NVQ in Performing Engineering Operations	Unit 1	Unit 3			Units 19, 21, 37, 38		Units 33, 36			Units 3, 4, 32, 61, 63
Level 2 NVQ in Performing Manufacturing Operations	Unit 1					Units 4, 18				
Level 2 NVQ in Engineering Technical Support	Units 1, 3									

Units	11	12	13	14	15	16	17	18	19	20
Level 2 NVQ in Mechanical Manufacturing Engineering				Units 4, 5, 6, 7, 8, 9, 10	Units 19, 20, 21, 26					Units 11, 12, 13, 14, 15, 16
Level 2 NVQ in Engineering Maintenance and Installation	Units 4, 5, 6, 7, 8	Units 4, 9, 10, 11, 12	Units 4, 13, 14, 15							
Level 2 NVQ in Fabrication and Welding Engineering						Units 4, 5, 6, 7, 8	Units 21, 22, 23, 24, 29	Unit 21		
Level 2 NVQ in Performing Engineering Operations	Unit 19	Unit 37	Unit 38	Units 1, 2, 11, 12, 13	Unit 14	Units 27, 28, 29, 30	Unit 22	Unit 22	Unit 36	

Units	21	22	23	24	25	26	27	28		
Level 2 NVQ in Mechanical Manufacturing Engineering										
Level 2 NVQ in Engineering Maintenance and Installation				Units 4, 16, 17, 18						
Level 2 NVQ in Materials Processing and Finishing			Units 4, 5, 6, 7, 10, 13, 14, 15, 18, 19, 20, 23, 50, 53							
Level 2 NVQ in Business Improvement Techniques					Units 5, 13	Units 4, 9				
Level 2 NVQ in Fabrication and Welding										
Level 2 NVQ in Performing Engineering Operations	Unit 62		Units 43, 48, 50	Unit 21						
Level 2 NVQ in Performing Manufacturing Operations										
Level 2 NVQ in Engineering Technical Support										

Annexe F

Unit mapping overview

BTEC First in Engineering legacy (specification end date 31/08/2010)/new QCF versions of the BTEC First qualifications in Engineering (specification start date 01/09/2010) – the BTEC Level 2 Certificate in Engineering, BTEC Level 2 Extended Certificate in Engineering and the BTEC Level 2 Diploma in Engineering.

New units \ Old units	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10
Unit 1	F									
Unit 2		F								
Unit 3				F						
Unit 4			F							
Unit 5					F					
Unit 6						F				
Unit 7							F			
Unit 8								F		
Unit 9									F	
Unit 10										F

New units \ Old units	Unit 11	Unit 12	Unit 13	Unit 14	Unit 15	Unit 16	Unit 17	Unit 18	Unit 19	Unit 20
Unit 11	F									
Unit 12		F								
Unit 13			F							
Unit 14				F						
Unit 15					F					
Unit 16						X				
Unit 17							F			
Unit 18								F		
Unit 19									P	
Unit 20										F

Old units / New units	Unit 21	Unit 22	Unit 23	Unit 24	Unit 25	Unit 26	Unit 27	Unit 28	Unit 29	Unit 30	Unit 31
Unit 21					F						
Unit 22								F			
Unit 23		F									
Unit 24						F					
Unit 25										F	
Unit 26											F
Unit 27				F							
Unit 28									F		

KEY

P – Partial mapping (some topics from the old unit appear in the new unit)

F – Full mapping (topics in old unit match new unit exactly or almost exactly)

X – Full mapping + new (all the topics from the old unit appear in the new unit, but new unit also contains new topic(s))

Unit mapping in depth

BTEC First in Engineering legacy (specification end date 31/08/2010)/new QCF versions of the BTEC First qualifications in Engineering (specification start date 01/09/2010) – the BTEC Level 2 Certificate in Engineering, BTEC Level 2 Extended Certificate in Engineering and the BTEC Level 2 Diploma in Engineering

New units		Old units		Mapping/comments (new topics in italics)
Number	**Name**	**Number**	**Name**	
Unit 1	Working Safely and Effectively in Engineering	**Unit 1**	Working Practices in Engineering	Full coverage.
Unit 2	Interpreting and Using Engineering Information	**Unit 2**	Using and Interpreting Engineering Information	Full coverage.
Unit 3	Mathematics for Engineering Technicians	**Unit 4**	Mathematics for Engineering Technicians	All topics in learning outcome 1 are covered but now split over two outcomes with emphasis on engineering applications. Content of old learning outcome 2, use of a scientific calculator, now implicit throughout.
Unit 4	Applied Electrical and Mechanical Science for Engineering	**Unit 3**	Applied Electrical and Mechanical Science for Technicians	Full coverage.
Unit 5	Engineering Maintenance Procedures	**Unit 5**	Engineering Maintenance Procedures and Planning	Full coverage.
Unit 6	Preparing and Controlling Engineering Manufacturing Operations	**Unit 6**	Preparing and Controlling Engineering Manufacturing Operations	Full coverage.
Unit 7	Electronic Devices and Communication Applications	**Unit 7**	Electronic Devices and Communication Applications	Full coverage.
Unit 8	Selecting Engineering Materials	**Unit 8**	Selecting Engineering Materials	Full coverage of old unit content plus addition of *smart materials*.
Unit 9	Engineering Assembly Methods and Techniques	**Unit 9**	Engineering Assembly Techniques	Full coverage.
Unit 10	Using Computer Aided Drawing Techniques in Engineering	**Unit 10**	Using Computer Aided Drawing Techniques in Engineering	Full coverage.
Unit 11	Operation and Maintenance of Mechanical Systems and Components	**Unit 11**	Mechanical Maintenance Fundamentals	Full coverage.

New units		Old units		Mapping/comments (new topics in italics)
Number	**Name**	**Number**	**Name**	
Unit 12	Operation and Maintenance of Electrical Systems and Components	**Unit 12**	Electrical Maintenance Fundamentals	Full coverage.
Unit 13	Operation and Maintenance of Electronic Systems and Components	**Unit 13**	Electronic Maintenance Fundamentals	Full coverage.
Unit 14	Selecting and Using Secondary Machining Techniques to Remove Material	**Unit 14**	Selecting and Using Secondary Machining Techniques to Remove Material	Full coverage.
Unit 15	Part Programming CNC Machines	**Unit 15**	Programming CNC Machines	Full coverage.
Unit 16	Application of Welding Processes	**Unit 16**	Application of Welding Processes	Full coverage of learning outcomes 1, 3 and 4. LO2 now focused on *preparing for work in the welding environment* rather than selecting and using information sources, tools and equipment.
Unit 17	Fabrication Techniques and Sheet Metal Work	**Unit 17**	Fabrication Techniques and Sheet Metal Work	Full coverage, although content now more detailed and unit size increased.
Unit 18	Engineering Marking Out	**Unit 18**	Engineering Marking Out	Full coverage.
Unit 19	Electronic Circuit Construction	**Unit 19**	Electronic Circuit Construction and Testing	Unit now focuses only on circuit construction.
Unit 20	Using Specialist Secondary Machining Techniques	**Unit 23**	Using Specialist Secondary Machining Techniques	Full coverage.
Unit 21	Production Planning for Engineering	**Unit 25**	Production Planning Techniques	Full coverage.
Unit 22	Application of Quality Control and Measurement in Engineering	**Unit 28**	Application of Quality Control and Measurement in Engineering	Full coverage.
Unit 23	Casting and Moulding Engineering Components	**Unit 22**	Casting and Moulding Processes	Full coverage.
Unit 24	Operation and Maintenance of Fluid Power Systems and Components	**Unit 26**	Fluid Power Maintenance Fundamentals	Full coverage.
Unit 25	Applying Continuous Improvement and Problem-solving Techniques	**Unit 30**	Applying Continuous Improvement and Problem-solving Techniques	Full coverage.

New units		Old units		Mapping/comments (new topics in italics)
Number	**Name**	**Number**	**Name**	
Unit 26	Workplace Organisation and Standard Operating Procedures	**Unit 31**	Workplace Organisation and Standard Operating Procedures	Full coverage.
Unit 27	PC Hardware and Software Installation and Configuration	**Unit 24**	Personal Computer Hardware and Software Installation	Full coverage.
Unit 28	Mobile Communications Technology	**Unit 29**	Mobile Communications Technology	Full coverage.
		Unit 20	Telecommunications Technology	No new unit.
		Unit 21	Application of Digital Networks	No new unit.
		Unit 27	Installing and Maintaining Home Entertainment Systems	No new unit.

Annexe G

Examples of calculation of qualification grade above pass grade

Edexcel will automatically calculate the qualification grade for your learners when your learner unit grades are submitted.

The generic examples below demonstrate how the qualification grade above pass is calculated using the following two tables which are also shown in the section earlier on in the specification *Calculation of the qualification grades above pass grade*.

Points available for credits achieved at different QCF levels and unit grades

The table below shows the **number of points scored per credit** at the unit level and grade.

Unit QCF level	Points per credit		
	Pass	Merit	Distinction
Level 1	3	4	5
Level 2	**5**	**6**	**7**
Level 3	7	8	9

Learners who achieve the correct number of points within the ranges shown in the 'qualification grade' table below will achieve the qualification merit or distinction or distinction* grade.

Qualification	Points range above pass grade		
	Merit	Distinction	Distinction*
BTEC Level 2 Certificate	85–94	95–99	100 and above
BTEC Level 2 Extended Certificate	170–189	190–199	200 and above
BTEC Level 2 Diploma	340–379	380–399	400 and above

Example 1

Achievement of pass qualification grade

A learner completing a 15-credit Edexcel BTEC Level 2 Certificate achieves the credit required to gain a pass qualification grade and does not achieve the points to gain a merit grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit 1	2	5	Pass	5	$5 \times 5 =$ 25
Unit 2	2	5	Pass	5	$5 \times 5 =$ 25
Unit 3	2	5	Merit	6	$5 \times 6 =$ 30
Qualification grade totals		**15**	**Pass**		**80**

Example 2

Achievement of merit qualification grade

A learner completing a 15-credit Edexcel BTEC Level 2 Certificate achieves the points required to gain a merit qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit 1	2	5	Pass	5	$5 \times 5 =$ 25
Unit 2	2	5	Merit	6	$5 \times 6 =$ 30
Unit 3	2	5	Merit	6	$5 \times 6 =$ 30
Qualification grade totals		**15**	**Merit**		**85**

Example 3

Achievement of distinction qualification grade

A learner completing a 15-credit Edexcel BTEC Level 2 Certificate achieves the points required to gain a distinction qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit 1	2	5	Merit	6	$5 \times 6 =$ 30
Unit 2	2	5	Merit	6	$5 \times 6 =$ 30
Unit 3	2	5	Distinction	7	$5 \times 7 =$ 35
Qualification grade totals		**15**	**Distinction**		**95**

Example 4

Achievement of merit qualification grade

A learner completing a 30-credit Edexcel BTEC Level 2 Extended Certificate achieves the points required to gain a merit qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit 1	2	5	Merit	6	$5 \times 6 =$ 30
Unit 2	2	5	Pass	5	$5 \times 5 =$ 25
Unit 3	2	5	Distinction	7	$5 \times 7 =$ 35
Unit 6	2	10	Pass	5	$10 \times 5 =$ 50
Unit 8	3	5	Pass	7	$5 \times 7 =$ 35
Qualification grade totals		**30**	**Merit**		**175**

Example 5

Achievement of merit qualification grade

A learner completing a 60-credit Edexcel BTEC Level 2 Diploma achieves the points required to gain a merit qualification grade.

	Level	Credit	Grade	Grade points	Points per unit = credit x grade
Unit 1	2	5	Merit	6	$5 \times 6 =$ 30
Unit 2	2	5	Pass	5	$5 \times 5 =$ 25
Unit 3	2	5	Distinction	7	$5 \times 7 =$ 35
Unit 6	2	10	Merit	6	$10 \times 6 =$ 60
Unit 9	1	5	Merit	4	$5 \times 4 =$ 20
Unit 10	2	10	Distinction	7	$10 \times 7 =$ 70
Unit 11	2	10	Merit	6	$10 \times 6 =$ 60
Unit 14	2	10	Merit	6	$10 \times 6 =$ 60
Qualification grade totals		**60**	**Merit**		**360**

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