BTEC

# Pearson BTEC International Level 2 Engineering

## Specification

Pearson BTEC International Level 2 Certificate in Engineering (19327)

Pearson BTEC International Level 2 Extended Certificate in Engineering (19328)

Pearson BTEC International Level 2 Diploma in Engineering (19329)

Pearson BTEC International Level 2 Diploma in Engineering (Maintenance) (19330)

Pearson BTEC International Level 2 Diploma in Engineering (Manufacturing) (19331)

Pearson BTEC International Level 2 Diploma in Engineering (Electronics) (19332)

**For first teaching in September 2014**

**Issue 2**

ALWAYS LEARNING

PEARSON

# Pearson BTEC International Level 2 Qualifications Engineering

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## Edexcel, BTEC and LCCI qualifications

Edexcel, BTEC and LCCI qualifications are awarded by Pearson, the UK's largest awarding body offering academic and vocational qualifications that are globally recognised and benchmarked. For further information, please visit our qualification websites at www.edexcel.com, www.btec.co.uk or www.lcci.org.uk. Alternatively, you can get in touch with us using the details on our contact us page at qualifications.pearson.com/contactus

## About Pearson

Pearson is the world's leading learning company, with 40,000 employees in more than 70 countries working to help people of all ages to make measureable progress in their lives through learning. We put the learner at the centre of everything we do, because wherever learning flourishes, so do people. Find out more about how we can help you and your learners at qualifications.pearson.com

## Pearson's Self-regulated Framework qualifications

These qualifications have been approved by Pearson as meeting the criteria for Pearson's Self-regulated Framework.

Pearson's Self-regulated Framework is designed for qualifications that have been customised to meet the needs of a particular range of learners and stakeholders. These qualifications are not accredited or regulated by any UK regulatory body. For further information please see Pearson's Self-regulated Framework policy on our website.

This specification is Issue 2. Key changes are sidelined. We will inform centres of any changes to this issue. The latest issue can be found on our website qualifications.pearson.com

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

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# Contents

# 1 Purpose of this specification

Pearson BTEC International Level 2 Certificate, Extended Certificate and Diploma qualifications in Engineering are designed for international schools and colleges. They are part of an international suite of BTEC Firsts qualifications offered by Pearson. These qualifications are not available to centres in the United Kingdom, the Channel Islands, the Isle of Man or British Armed Forces schools based overseas.

The purpose of this specification is to set out:

- the aim/objective of the qualifications
- the structure and rules of combination of these qualifications
- the resources required by the centre to offer these qualifications
- the knowledge, skills and understanding which will be assessed as part of these qualifications
- the method of assessment and any associated requirements relating to it
- the criteria against which learners' level of attainment will be measured (for example assessment criteria).

If you need guidance or support for Pearson BTEC International Level 2 qualifications please contact your Pearson representative.

## Pearson BTEC International Level 2 qualification titles covered by this specification

The following qualifications have been approved by Pearson Education Limited as meeting the criteria for Pearson's Self-regulated Framework. These qualifications are not accredited or regulated by any UK regulatory body.

**Pearson BTEC International Level 2 Certificate in Engineering**
**Pearson BTEC International Level 2 Extended Certificate in Engineering**
**Pearson BTEC International Level 2 Diploma in Engineering**
**Pearson BTEC International Level 2 Diploma in Engineering (Maintenance)**
**Pearson BTEC International Level 2 Diploma in Engineering (Manufacturing)**
**Pearson BTEC International Level 2 Diploma in Engineering (Electronics)**

The 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 Pearson.

This specification must be used for delivery and teaching in your centres. For international centres this replaces the following QCF qualifications:

| | |
|---|---|
| Pearson BTEC Level 2 Certificate in Engineering (QCF) | 500/7578/0 |
| Pearson BTEC Level 2 Extended Certificate in Engineering (QCF) | 500/7577/9 |
| Pearson BTEC Level 2 Diploma in Engineering (QCF) | 500/7576/7 |

## Pearson’s international suite of BTEC First qualifications

Pearson BTEC International Level 2 qualifications make up our international suite of BTEC Firsts provision. These qualifications are designed in a range of sectors for learners who wish to explore a work-related vocational qualification or specific industry area. They offer learners the knowledge, understanding and skills that they need to prepare for employment.

On successful completion of a Pearson BTEC International Level 2 qualification, learners can progress to continued study in the same or related vocational area and/or within employment.

### Pearson BTEC International Level 2 Certificate

The Pearson BTEC International Level 2 Certificate offers a work-related vocational qualification that focuses on particular aspects of employment in the appropriate vocational sector. The Pearson BTEC International Level 2 Certificate is a qualification that can be part of a learner’s programme of study and provide a vocational learning experience. Potentially the qualification could prepare learners for progression to an appropriate Level 3 programme in the same or related vocational area.

### Pearson BTEC International Level 2 Extended Certificate

The Pearson BTEC International Level 2 Extended Certificate extends the work-related focus from the Pearson BTEC International Level 2 Certificate and covers the key knowledge and practical skills that are required in the appropriate vocational sector. The Pearson BTEC International Level 2 Extended Certificate offers flexibility and a choice of emphasis through the optional units, providing an engaging programme for those who are clear about the vocational area they wish to explore through further study or who wish to enter employment. Potentially the qualification could prepare learners for progression to an appropriate Level 3 programme in the same or related vocational area.

### Pearson BTEC International Level 2 Diploma

The Pearson BTEC International Level 2 Diploma extends the work-related focus from the Pearson BTEC International Level 2 Extended Certificate, with broader coverage of knowledge and practical skills required for the vocational sector.

Potentially the qualification could prepare learners for progression to an appropriate Level 3 programme in the same or related vocational area or, for those who have decided that they wish to enter a particular area of work, for progression to employment in the appropriate vocational sector.

Other learners may want to use this qualification to extend the specialism they studied on the Pearson BTEC International Level 2 Certificate or the Pearson BTEC International Level 2 Extended Certificate programme.

# 2 Qualification summaries

## Key information

| Pearson BTEC International Level 2 Certificate in Engineering | |
|---|---|
| Total Notional Learning Hours (NLH) | 150<br>(including 90 Guided Learning Hours (GLH)) |
| Qualification value (NLH/10) | 15 |
| Assessment | This qualification is internally assessed |
| Unit grading information | Pass/Merit/Distinction |
| Overall qualification grading information | Pass/Merit/Distinction/Distinction* |

| Pearson BTEC International Level 2 Extended Certificate in Engineering | |
|---|---|
| Total Notional Learning Hours (NLH) | 300<br>(including 180 Guided Learning Hours (GLH)) |
| Qualification value (NLH/10) | 30 |
| Assessment | This qualification is internally assessed |
| Unit grading information | Pass/Merit/Distinction |
| Overall qualification grading information | Pass/Merit/Distinction/Distinction* |

| Pearson BTEC International Level 2 Diploma in Engineering | |
|---|---|
| Total Notional Learning Hours (NLH) | 600<br>(including 360 Guided Learning Hours (GLH)) |
| Qualification value (NLH/10) | 60 |
| Assessment | This qualification is internally assessed |
| Unit grading information | Pass/Merit/Distinction |
| Overall qualification grading information | Pass/Merit/Distinction/Distinction* |

| Pearson BTEC International Level 2 Diploma in Engineering (Maintenance) | |
|---|---|
| Total Notional Learning Hours (NLH) | 600<br>(including 360 Guided Learning Hours (GLH)) |
| Qualification value (NLH/10) | 60 |
| Assessment | This qualification is internally assessed |
| Unit grading information | Pass/Merit/Distinction |
| Overall qualification grading information | Pass/Merit/Distinction/Distinction* |

| Pearson BTEC International Level 2 Diploma in Engineering (Manufacturing) | |
|---|---|
| Total Notional Learning Hours (NLH) | 600<br>(including 360 Guided Learning Hours (GLH)) |
| Qualification value (NLH/10) | 60 |
| Assessment | This qualification is internally assessed |
| Unit grading information | Pass/Merit/Distinction |
| Overall qualification grading information | Pass/Merit/Distinction/Distinction* |

| Pearson BTEC International Level 2 Diploma in Engineering (Electronics) | |
|---|---|
| Total Notional Learning Hours (NLH) | 600<br>(including 360 Guided Learning Hours (GLH)) |
| Qualification value (NLH/10) | 60 |
| Assessment | This qualification is internally assessed |
| Unit grading information | Pass/Merit/Distinction |
| Overall qualification grading information | Pass/Merit/Distinction/Distinction* |

For further information about Notional Learning Hours and Guided Learning Hours please see *Section 8*: *Programme delivery* and *Section 10*: *Understanding the units*.

## Aim of the Pearson BTEC International Level 2 qualifications in Engineering

The Pearson BTEC International Level 2 Certificate, Extended Certificate and Diploma qualifications in Engineering have been developed in the maintenance, manufacturing, electronic and general engineering sectors to:

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

The engineering sector continues to suffer from a skills gap and needs to keep up with rapidly developing technologies. These Pearson International BTEC Level 2 qualifications 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 qualification structures include a wide range of units to provide opportunities for learners who intend progressing into technician roles and for those who are not yet based in industry and who wish to gain an understanding of engineering.

The Pearson BTEC International Level 2 Certificate and Extended Certificate in Engineering are nested qualifications within the Pearson BTEC International Level 2 Diploma in Engineering qualification and contribute to increasing the vocational focus in schools.

Centres may use the main title Pearson BTEC International Level 2 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 specialist titles.

# 3 Centre resource requirements

As part of the approval process, the centre must make sure that the resource requirements below are in place before offering Pearson BTEC International Level 2 qualifications.

- The centre must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support delivery and assessment.
- Staff involved in the assessment process must have relevant expertise and occupational experience.
- There must be systems in place to make sure that there is continuing professional development for staff delivering the qualifications.
- The centre must have appropriate policies in place relating to the delivery of the qualification.
- The centre must deliver the qualifications in accordance with current equality legislation.
- The centre must have in place any specific unit resource requirements as listed in each unit under the heading *Essential requirements*.

# 4 Qualification structures

## Pearson BTEC International Level 2 Certificate in Engineering

The Pearson BTEC International Level 2 Certificate in Engineering qualification totals 150 Notional Learning Hours (NLH).

Learners must achieve the mandatory unit **and** optional units that provide for a combined total value of 15 to achieve the qualification.

This qualification is **not** designed to allow units to be imported from other Pearson qualifications.

| **Mandatory unit** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 1 | Working Safely and Effectively in Engineering | 2 | 50 | 5 |

| **Optional units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 2 | Interpreting and Using Engineering Information | 2 | 50 | 5 |
| 3 | Mathematics for Engineering Technicians | 2 | 50 | 5 |
| 4 | Applied Electrical and Mechanical Science for Engineering | 2 | 50 | 5 |
| 5 | Engineering Maintenance Procedures | 2 | 50 | 5 |
| 6 | Preparing and Controlling Engineering Manufacturing Operations | 2 | 50 | 5 |
| 7 | Electronic Devices and Communication Applications | 2 | 100 | 10 |
| 8 | Selecting Engineering Materials | 2 | 50 | 5 |
| 10 | Using Computer Aided Drawing Techniques in Engineering | 2 | 100 | 10 |
| 11 | Operation and Maintenance of Mechanical Systems and Components | 2 | 100 | 10 |
| 12 | Operation and Maintenance of Electrical Systems and Components | 2 | 100 | 10 |
| 13 | Operation and Maintenance of Electronic Systems and Components | 2 | 100 | 10 |
| 14 | Secondary Machining Techniques | 2 | 100 | 10 |
| 15 | Part Programming CNC Machines | 2 | 100 | 10 |
| 16 | Application of Welding Processes | 2 | 100 | 10 |

| Optional units (continued) | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 17 | Fabrication Techniques and Sheet Metal Work | 2 | 100 | 10 |
| 18 | Engineering Marking Out | 2 | 50 | 5 |
| 19 | Electronic Circuit Construction | 2 | 100 | 10 |
| 21 | Production Planning for Engineering | 2 | 50 | 5 |
| 24 | Operation and Maintenance of Fluid Power Systems and Components | 2 | 100 | 10 |

## Pearson BTEC International Level 2 Extended Certificate in Engineering

The Pearson BTEC International Level 2 Extended Certificate in Engineering qualification totals 300 Notional Learning Hours (NLH).

Learners must achieve both mandatory units **and** optional units that provide for a combined total value of 30 to achieve the qualification.

This qualification is **not** designed to allow units to be imported from other Pearson qualifications.

| **Mandatory units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 1 | Working Safely and Effectively in Engineering | 2 | 50 | 5 |
| 2 | Interpreting and Using Engineering Information | 2 | 50 | 5 |

| **Optional units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 3 | Mathematics for Engineering Technicians | 2 | 50 | 5 |
| 4 | Applied Electrical and Mechanical Science for Engineering | 2 | 50 | 5 |
| 5 | Engineering Maintenance Procedures | 2 | 50 | 5 |
| 6 | Preparing and Controlling Engineering Manufacturing Operations | 2 | 50 | 5 |
| 7 | Electronic Devices and Communication Applications | 2 | 100 | 10 |
| 8 | Selecting Engineering Materials | 2 | 50 | 5 |
| 10 | Using Computer Aided Drawing Techniques in Engineering | 2 | 100 | 10 |
| 11 | Operation and Maintenance of Mechanical Systems and Components | 2 | 100 | 10 |
| 12 | Operation and Maintenance of Electrical Systems and Components | 2 | 100 | 10 |
| 13 | Operation and Maintenance of Electronic Systems and Components | 2 | 100 | 10 |
| 14 | Secondary Machining Techniques | 2 | 100 | 10 |
| 15 | Part Programming CNC Machines | 2 | 100 | 10 |
| 16 | Application of Welding Processes | 2 | 100 | 10 |

| Optional units (continued) | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 17 | Fabrication Techniques and Sheet Metal Work | 2 | 100 | 10 |
| 18 | Engineering Marking Out | 2 | 50 | 5 |
| 19 | Electronic Circuit Construction | 2 | 100 | 10 |
| 21 | Production Planning for Engineering | 2 | 50 | 5 |
| 24 | Operation and Maintenance of Fluid Power Systems and Components | 2 | 100 | 10 |

## Pearson BTEC International Level 2 Diploma in Engineering

The Pearson BTEC International Level 2 Diploma in Engineering qualification totals 600 Notional Learning Hours (NLH).

Learners must achieve three mandatory units **and** optional units that provide for a combined total value of 60 to achieve the qualification.

This qualification is **not** designed to allow units to be imported from other Pearson qualifications.

| **Mandatory units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 1 | Working Safely and Effectively in Engineering | 2 | 50 | 5 |
| 2 | Interpreting and Using Engineering Information | 2 | 50 | 5 |
| 3 | Mathematics for Engineering Technicians | 2 | 50 | 5 |

| **Optional units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 4 | Applied Electrical and Mechanical Science for Engineering | 2 | 50 | 5 |
| 5 | Engineering Maintenance Procedures | 2 | 50 | 5 |
| 6 | Preparing and Controlling Engineering Manufacturing Operations | 2 | 50 | 5 |
| 7 | Electronic Devices and Communication Applications | 2 | 100 | 10 |
| 8 | Selecting Engineering Materials | 2 | 50 | 5 |
| 9 | Engineering Assembly Methods and Techniques | 2 | 50 | 5 |
| 10 | Using Computer Aided Drawing Techniques in Engineering | 2 | 100 | 10 |
| 11 | Operation and Maintenance of Mechanical Systems and Components | 2 | 100 | 10 |
| 12 | Operation and Maintenance of Electrical Systems and Components | 2 | 100 | 10 |
| 13 | Operation and Maintenance of Electronic Systems and Components | 2 | 100 | 10 |
| 14 | Secondary Machining Techniques | 2 | 100 | 10 |
| 15 | Part Programming CNC Machines | 2 | 100 | 10 |
| 16 | Application of Welding Processes | 2 | 100 | 10 |

| Optional units (continued) | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 17 | Fabrication Techniques and Sheet Metal Work | 2 | 100 | 10 |
| 18 | Engineering Marking Out | 2 | 50 | 5 |
| 19 | Electronic Circuit Construction | 2 | 100 | 10 |
| 20 | Using Specialist Secondary Machining Techniques | 2 | 50 | 5 |
| 21 | Production Planning for Engineering | 2 | 50 | 5 |
| 22 | Application of Quality Control and Measurement in Engineering | 2 | 100 | 10 |
| 23 | Casting and Moulding Engineering Components | 2 | 100 | 10 |
| 24 | Operation and Maintenance of Fluid Power Systems and Components | 2 | 100 | 10 |
| 25 | Applying Continuous Improvement and Problem-solving Techniques | 2 | 100 | 10 |
| 26 | Workplace Organisation and Standard Operating Procedures | 2 | 100 | 10 |
| 27 | PC Hardware and Software Installation and Configuration | 2 | 100 | 10 |
| 28 | Mobile Communications Technology in Engineering | 2 | 50 | 5 |

## Pearson BTEC International Level 2 Diploma in Engineering (Maintenance)

The Pearson BTEC International Level 2 Diploma in Engineering (Maintenance) qualification totals 600 Notional Learning Hours (NLH).

Learners must achieve three mandatory units **and** optional units that provide for a combined total value of 60 to achieve the qualification. Units to the minimum value of 20 must be taken from *Optional units – Group A*.

This qualification is **not** designed to allow units to be imported from other Pearson qualifications.

| **Mandatory units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 1 | Working Safely and Effectively in Engineering | 2 | 50 | 5 |
| 2 | Interpreting and Using Engineering Information | 2 | 50 | 5 |
| 3 | Mathematics for Engineering Technicians | 2 | 50 | 5 |

| **Optional units – Group A**<br>**Select units to a minimum value of 20** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 4 | Applied Electrical and Mechanical Science for Engineering | 2 | 50 | 5 |
| 5 | Engineering Maintenance Procedures | 2 | 50 | 5 |
| 9 | Engineering Assembly Methods and Techniques | 2 | 50 | 5 |
| 11 | Operation and Maintenance of Mechanical Systems and Components | 2 | 100 | 10 |
| 12 | Operation and Maintenance of Electrical Systems and Components | 2 | 100 | 10 |
| 13 | Operation and Maintenance of Electronic Systems and Components | 2 | 100 | 10 |
| 24 | Operation and Maintenance of Fluid Power Systems and Components | 2 | 100 | 10 |

| Optional units – Group B | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 8 | Selecting Engineering Materials | 2 | 50 | 5 |
| 10 | Using Computer Aided Drawing Techniques in Engineering | 2 | 100 | 10 |
| 16 | Application of Welding Processes | 2 | 100 | 10 |
| 18 | Engineering Marking Out | 2 | 50 | 5 |
| 19 | Electronic Circuit Construction | 2 | 100 | 10 |

## Pearson BTEC International Level 2 Diploma in Engineering (Manufacturing)

The Pearson BTEC International Level 2 Diploma in Engineering (Maintenance) qualification totals 600 Notional Learning Hours (NLH).

Learners must achieve three mandatory units **and** optional units that provide for a combined total value of 60 to achieve the qualification. Units to the minimum value of 20 must be taken from *Optional units – Group A*.

This qualification is **not** designed to allow units to be imported from other Pearson qualifications.

| **Mandatory units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value** (NLH/10) |
| 1 | Working Safely and Effectively in Engineering | 2 | 50 | 5 |
| 2 | Interpreting and Using Engineering Information | 2 | 50 | 5 |
| 3 | Mathematics for Engineering Technicians | 2 | 50 | 5 |

| **Optional units – Group A**<br>**Select units to a minimum value of 20** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value** (NLH/10) |
| 4 | Applied Electrical and Mechanical Science for Engineering | 2 | 50 | 5 |
| 6 | Preparing and Controlling Engineering Manufacturing Operations | 2 | 50 | 5 |
| 8 | Selecting Engineering Materials | 2 | 50 | 5 |
| 10 | Using Computer Aided Drawing Techniques in Engineering | 2 | 100 | 10 |
| 14 | Secondary Machining Techniques | 2 | 100 | 10 |
| 15 | Part Programming CNC Machines | 2 | 100 | 10 |
| 20 | Using Specialist Secondary Machining Techniques | 2 | 50 | 5 |
| 21 | Production Planning for Engineering | 2 | 50 | 5 |
| 25 | Applying Continuous Improvement and Problem-solving Techniques | 2 | 100 | 10 |
| 26 | Workplace Organisation and Standard Operating Procedures | 2 | 100 | 10 |

| Optional units – Group B | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 9 | Engineering Assembly Methods and Techniques | 2 | 50 | 5 |
| 16 | Application of Welding Processes | 2 | 100 | 10 |
| 17 | Fabrication Techniques and Sheet Metal Work | 2 | 100 | 10 |
| 18 | Engineering Marking Out | 2 | 50 | 5 |
| 19 | Electronic Circuit Construction | 2 | 100 | 10 |
| 23 | Casting and Moulding Engineering Components | 2 | 100 | 10 |

## Pearson BTEC International Level 2 Diploma in Engineering (Electronics)

The Pearson BTEC International Level 2 Diploma in Engineering (Electronics) qualification totals 600 Notional Learning Hours (NLH).

Learners must achieve three mandatory units **and** optional units that provide for a combined total value of 60 to achieve the qualification. Units to the minimum value of 20 must be taken from *Optional units – Group A*.

This qualification is **not** designed to allow units to be imported from other Pearson qualifications.

| **Mandatory units** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 1 | Working Safely and Effectively in Engineering | 2 | 50 | 5 |
| 2 | Interpreting and Using Engineering Information | 2 | 50 | 5 |
| 3 | Mathematics for Engineering Technicians | 2 | 50 | 5 |

| **Optional units – Group A**<br>**Select units to a minimum value of 20** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 4 | Applied Electrical and Mechanical Science for Engineering | 2 | 50 | 5 |
| 7 | Electronic Devices and Communication Applications | 2 | 100 | 10 |
| 13 | Operation and Maintenance of Electronic Systems and Components | 2 | 100 | 10 |
| 19 | Electronic Circuit Construction | 2 | 100 | 10 |
| 27 | PC Hardware and Software Installation and Configuration | 2 | 100 | 10 |
| 28 | Mobile Communications Technology in Engineering | 2 | 50 | 5 |

| **Optional units – Group B** | | | | |
|---|---|---|---|---|
| **Unit** | **Unit title** | **Level** | **Notional Learning Hours** | **Unit value (NLH/10)** |
| 8 | Selecting Engineering Materials | 2 | 50 | 5 |
| 9 | Engineering Assembly Methods and Techniques | 2 | 50 | 5 |
| 10 | Using Computer Aided Drawing Techniques in Engineering | 2 | 100 | 10 |
| 12 | Operation and Maintenance of Electrical Systems and Components | 2 | 100 | 10 |

# 5 Assessment and grading

The assessment of Pearson BTEC International Level 2 qualifications is criterion-referenced and the centre is required to assess learners' evidence against published outcomes of learning and assessment criteria.

Each unit within the qualification has specified assessment and 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 assessment criteria
- to achieve a 'merit' a learner must additionally have satisfied **all** the merit grading criteria
- to achieve a 'distinction' a learner must additionally have satisfied **all** the distinction grading criteria.

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

## BTEC internal assessment

All units in the Pearson BTEC International Level 2 qualifications are assessed through internal assessment, which means that the centre can deliver the programme in a way that suits its learners and relates to local need. The way in which the centre delivers the programme must also ensure that assessment is fair and that standards are consistent over time. To achieve this, it is important that centres:

- plan the assessment of units to fit with delivery, allowing for the linkages between units
- write suitable assessments (for example assignments, projects or case studies) or select assessments from available resources, adapting them as necessary
- plan the assessment for each unit in terms of when it will be authorised by the Internal Verifier, when it will be used and assessed, how long it will take, and how you will determine that learners are ready to begin an assessment
- ensure each assessment is fit for purpose, valid, will deliver reliable assessment outcomes across assessors, and is authorised before use
- provide all the preparation, feedback and support that learners need to undertake an assessment before they begin producing their evidence
- make careful and consistent assessment decisions based only on the defined assessment criteria and unit requirements
- validate and record assessment decisions carefully and completely
- work closely with Pearson to ensure that the implementation, delivery and assessment is consistent with BTEC quality standards.

**Internal Verifiers** must oversee all assessment activity to make sure that individual assessors do not misinterpret the specification or undertake assessment that is not consistent with the BTEC quality standards in respect of level, content or duration of assessment. The process for ensuring that assessment is being conducted correctly is called internal verification. Normally, a programme team will work together with individuals being both assessors and Internal Verifiers. Internal Verifiers must make sure that assessment is fully validated within the centre by:

- checking every assessment instrument carefully and endorsing it before it is used
- ensuring that each learner is assessed carefully and thoroughly using only the relevant assessment criteria and associated guidance within the specification
- ensuring the decisions of every assessor for each unit at all grades and for all learners are in line with BTEC quality standards.

**Assessors** make assessment decisions and must be standardised using Pearson-approved materials before making any assessment decisions. They are usually the teachers within the school or college, but the term 'assessor' refers to the specific responsibility for carrying out assessment and making sure that it is done in a way that is correct and consistent with BTEC quality standards. Assessors may also draft or adapt internal assessment instruments. Centres are required to keep records of assessment and have assessment authorised by Pearson. The main records are:

- the overall plan of delivery and assessment, showing the duration of assessment and the timeline for internal verification
- assessment instruments, which are authorised through an Internal Verifier
- assessment records, which contain the assessment decisions for each learner for each unit
- an internal verification sampling plan, which shows how assessment decisions are checked, and that must include across the sample all assessors, unit assessment locations and learners
- internal verification records, which show the outcomes of sampling activity as set out in the sampling plan.

## Learner preparation

As Pearson BTEC International Level 2 qualifications are all internally assessed, it is important that learners are prepared for assessment. Learners:

- must be prepared for and motivated to work consistently and independently to achieve the requirements of the qualification
- need to understand how they will be assessed and the importance of timescales and deadlines
- need to appreciate fully that all the work submitted for assessment must be their own.

Centres will need to provide learners with an induction and a guide or handbook to cover:

- the purpose of the assessment briefs for learning and assessment
- the relationship between the tasks given for assessment and the grading criteria
- the concept of vocational and work-related learning
- how learners can develop responsibility for their own work and build their vocational and employability skills
- how learners should use and reference source materials, including what would constitute plagiarism.

The centre must communicate assessment grading rules to all learners at the beginning of the programme.

For full guidance on all of the rules surrounding internal assessment for BTEC qualifications please see the *Guide to Internal Assessment for BTEC Firsts and Nationals* which can be located in the key documents section of our website: www.btec.co.uk/keydocuments

## Final assessment decisions

Final assessment is the culmination of the learning and assessment process. Learners should be given a full opportunity to show how they have achieved the outcomes of learning covered by a final assessment. This is achieved by ensuring that learners have received all necessary learning, preparation and feedback on their performance and then confirming that they understand the requirements of an assessment, before any assessed activities begin.

There will then be a clear assessment outcome based on the defined assessment criteria. Centres must devise an assessment plan that will set a clear timeline for assessment decisions to be reached. Once an assessment has begun, learners must not be given feedback on progress towards criteria. After the final assignment is submitted, an assessment decision must be given.

An assessment decision:

- must be made with reference to the assessment criteria
- should record how it has been reached, indicating how or where criteria have been achieved
- may indicate why attainment against criteria has not been demonstrated
- must not provide feedback on how to improve evidence to meet higher criteria.

Centres' Internal Verifiers and assessors must work together to ensure that assessment decisions are reached promptly and validated before they are given to the learner.

## Late submission

Centres must encourage learners to understand the importance of deadlines and of handing work in on time. For assessment purposes, it is important that learners are assessed fairly and consistently according to the assessment plan that the Internal Verifier has authorised and that some learners are not advantaged by having additional time to complete assignments. Centres are not required to accept assessment work that was not completed by the date in the assessment plan. Learners may be given authorised extensions for legitimate reasons, such as illness at the time of submission. If a late completion by a learner is accepted, the evidence should be assessed normally, unless it is judged to not meet the requirements for authenticity. It is not appropriate to give automatic downgrades on assessment decisions as 'punishment' for late submission.

## Resubmission of improved evidence

Once an assessment decision is given to a learner it is final in all cases, except where the Internal Verifier approves **one** opportunity to resubmit improved evidence. The criteria used by the Internal Verifier to authorise a resubmission opportunity are always:

- initial deadlines or agreed extensions have been met
- the teacher considers that the learner will be able to provide improved evidence without further guidance
- the evidence submitted for assessment has been authenticated by the learner and the assessor
- the original assessment can remain valid
- the original evidence can be extended and re-authenticated.

Centres will need to provide a specific re-submission opportunity that is authorised by the Internal Verifier. Any resubmission opportunity must have a deadline that is **within 10 days** of the assessment decision being given to the learner, and within the same academic year.

Centres should make arrangements for resubmitting the evidence for assessment in such a way that it does not adversely affect other assessments and does not give the learner an unfair advantage over other learners. Centres must consider how the further assessment opportunity ensures that assessment remains fit for purpose and in line with the original requirements. For example, the centre may opt for learners to improve their evidence under supervised conditions, even if this was not necessary for the original assessment, to ensure that plagiarism cannot take place. How centres provide opportunities to improve and resubmit evidence for assessments needs to be fair to all learners.

Care must be taken when setting assignments and at the point of final assessment to ensure that the original evidence for assessment can remain valid and can be extended. The learner must not have further guidance and support in producing further evidence. The Standards Verifier is likely to want to include evidence that has been resubmitted as part of the sample they will review.

## Retaking assessment

Pearson BTEC International Level 2 qualifications do not allow for compensation – this means that learners must achieve every pass criterion in order to successfully achieve the qualification.

### Conditions for retaking a new assignment

If a learner has met all of the conditions set out above for *Resubmission of improved evidence*, but has still not achieved the targeted pass criteria following the resubmission of the assignment, the Internal Verifier may authorise **one** retake opportunity to meet the required pass criteria. The Internal Verifier must only authorise a retake in exceptional circumstances where they believe it is necessary, appropriate and fair to do so.

The criteria used by the Internal Verifier to authorise a resubmission opportunity are always:

- the retake must be a new task or assignment targeted only to the pass criteria which were not achieved in the original assignment – an assessor cannot award a merit or distinction grade for a retake
- the assessor must agree and record a clear deadline before the learner starts the retake
- the learner and assessor must sign declarations of authentication as they both did for previous submissions

Standards Verifiers will require the centre to include evidence of any retakes in sampling. Retakes should not be required as a matter of course. Centres should keep a record of the number of retakes required on any programme to support the centres' own quality monitoring.

## Calculation of the qualification grade

### Pass qualification grade

Learners who achieve the minimum eligible value specified by the rule of combination will achieve the qualification at pass grade (see *Section 4: Qualification structures)*.

### Qualification grades above pass grade

Learners will be awarded a merit, 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 value of the unit (as shown in the table overleaf).

## Points available per unit value at specified unit grades and levels

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

| Unit level | Points per unit value | | |
|---|---|---|---|
| | **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 (or combinations of these grades appropriate to the qualification).

## Qualification grade

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

*Annexe A: Calculation of the qualification grade* gives examples of how qualification grades above a pass are calculated.

# 6 Centre and qualification approval

The centre must be approved by Pearson before delivering and assessing Pearson BTEC International Level 2 qualifications on Pearson's Self-regulated Framework. Centres that have not previously been approved will need to apply for, and be granted, centre recognition as part of the process for approval to offer these qualifications.

Before you offer these qualifications you must meet both centre and qualification approval requirements.

### Approvals agreement

All centres are required to enter into an approval agreement that is a formal commitment by the head or principal of a centre to meet all requirements. If the centre does not comply with the agreement this could result in the suspension of certification or withdrawal of approval.

# 7 Quality assurance

Quality assurance is at the heart of Pearson BTEC International Level 2 qualifications on Pearson's Self-regulated Framework. The centre internally assesses these qualifications and is responsible for making sure that all assessors and Internal Verifiers adhere to their internal verification processes, to ensure consistency and validity of the assessment process.

Pearson uses quality assurance to check that all centres are working to the agreed standard. It gives us the opportunity to identify and provide support, if needed, to safeguard certification.

For guidance, please refer to the *Pearson's Self-regulated Framework (SRF) Quality Assurance Handbook* on our website.

# 8 Programme delivery

Pearson BTEC International Level 2 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 Pearson BTEC International Level 2 qualifications each unit shows both the Guided Learning Hours and the Notional 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 outcome of learning being studied on a programme. This definition includes lectures, tutorials and supervised study, for example in 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.

Guided learning hours form part of the Notional Learning Hours for a unit. Notional Learning Hours are defined as the total amount of time a learner is expected to take, on average, to complete the unit to the required standard, including teaching, study and assessment time.

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

## Mode of delivery

Pearson does not define the mode of study for Pearson BTEC International Level 2 qualifications. Centres are free to offer the qualifications using any mode of delivery that meets their learners' needs. Please refer to the policy pages on our website at: www.edexcel.com/policies

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. Centres must have due regard to Pearson's policies that may apply to different modes of delivery.

## Resources

Physical resources need to support the delivery of the programme and the proper assessment of the outcomes of learning 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 Pearson.

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

## Delivery approach

It is important that centres develop an approach to teaching and learning that supports the specialist vocational nature of Pearson BTEC International Level 2 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. Delivery staff 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 of planning the delivery and assessment of the unit. The outline learning plan can be used in conjunction with the programme of suggested assignments.

## Support and training

Pearson offers an extensive package of training to support all aspects of BTEC delivery, including:

- **Teaching and published resources** – we provide an extensive selection of published materials along with our innovative range of digital teaching tools. In addition, we offer guides to support planning and delivery and to help students study. For more information please visit our website: www.edexcel.com/international/iama/teacher/
- **Subject Advisors** – our subject experts are on hand to answer any questions centres may have on delivering the qualification and assessment. For more information visit our website: www.edexcel.com/Aboutus/contact-us/teachers-hods
- **Training** – many of our training events form part of the added value service offered by Pearson. As well as standard events, we can create bespoke training programmes to meet centres' specific needs. These can be delivered face-to-face or online so that centres can choose where, when and how training takes place. For more information please visit our website: www.edexcel.com/training/ or email us at: internationaltfp@pearson.com

If you would like further information please contact your local Pearson representative – to find out how visit:
www.edexcel.com/Aboutus/contact-us/international-customers/

# 9 Access and recruitment

Pearson is committed to providing qualifications with no artificial barriers. A full statement, included in our *Equality Policy*, can be found on our website.

Equality and fairness are central to our work. We are committed to making sure that qualifications do not discriminate and all learners achieve the recognition they deserve from undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

## Restrictions on learner entry

These qualifications are suitable for learners aged 14 and above. Centres must give due regard to Pearson's policies that apply to the fair and equal recruitment of learners to all Pearson qualifications.

Centres are required to recruit learners to Pearson BTEC International Level 2 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 learner'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 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/International 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.

## Recognition of Prior Learning

Recognition of Prior Learning (RPL) is a method of assessment 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.

Pearson 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.

# 10 Understanding the units

All units in these qualifications have the following sections.

## Title

The title is a short description of the content of the unit. This form of words will appear on the learner's Notification of Performance (NOP).

## Level

The level of the unit indicates the complexity and demand expected to achieve it. The level places the unit on a framework of comparability with other units and qualifications at that level.

## Notional Learning Hours (NLH)

Notional Learning Hours (NLH) are the total amount of time a learner is expected to take, on average, to complete the unit to the required standard, including teaching, study and assessment time.

## Guided Learning Hours (GLH)

The Guided Learning Hours (GLH) are defined as all the times when a tutor, trainer or facilitator is present to give specific guidance towards the outcome of learning 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.

## Unit value

The unit value is calculated by dividing the Notional Learning Hours (NLH) by 10.

## SRF unit code

The unique approval code for the unit.

## Unit aim

Says what the aims of the unit are in terms of what is covered and what the unit will enable learners to do.

## Unit introduction

The introduction gives a short description of the unit, and details the key knowledge, skills and understanding the learner will gain through studying the unit. The introduction highlights the focus of the unit and how it links to the vocational sector to which the qualification relates.

## Outcomes of learning

Outcomes of learning state what a learner can be expected to know, understand or be able to do as a result of completing a programme of learning for the unit.

## Assessment and grading grid

The assessment and grading grid gives the criteria used to determine the evidence that each learner must produce in order to achieve 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.

## Unit content

In the unit content section topics are listed as bullets to provide detail on what is required to design and deliver a programme of learning. Not all topics have to be covered to be able to meet the assessment criteria. Centres are able to select the topics they deliver, ensuring that learners produce evidence of sufficient depth and breadth to meet the assessment criteria.

## Information for delivery staff

This section gives delivery staff information on delivery and assessment. It contains the following subsections.

Essential requirements – identifies any specialist resources needed to allow learners to generate the evidence required for the unit. The centre will need to ensure that any requirements are in place when it seeks approval to offer the qualification.

Employer engagement and vocational contexts – gives examples of agencies, networks and other useful contacts for employer engagement and for sources of vocational contexts.

Delivery guidance – explains the content's relationship to the outcomes of learning and offers guidance on possible approaches to delivery of the unit. This section includes an example outline learning plan which demonstrates one way of planning the delivery and assessment of the unit. The delivery guidance section is based on the more usual delivery modes but is not intended to rule out alternative approaches.

Assessment guidance – gives information about the evidence that learners must produce, together with any additional guidance if appropriate. This section should be read in conjunction with the assessment criteria and grading criteria. It also includes a programme of suggested assignments which demonstrates how assignments match and cover the assessment and grading criteria. This is provided for guidance only and it is recommended that centres either write their own assignments or adapt any suggested assignments to meet local needs and resources.

Suggested resources – indicates resource materials that can be used to support the teaching of the unit, for example books, journals and websites.

# Units

# Unit 1: Working Safely and Effectively in Engineering

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20657G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge and practical application of statutory regulations and organisational safety requirements to enable them to work safely, efficiently and effectively in engineering.

## Unit introduction

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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | M1 Carry out a risk assessment on an engineering workplace, making 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 | M3 Describe 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 | | |

| 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:** |
| P6 Maintain good working relationships with colleagues and other relevant people when carrying out an engineering work activity | | |

## Unit content

**1 Be able to apply statutory regulations and organisational safety requirements**

Materials and equipment handling:

- own and others' roles and responsibilities, e.g. 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, e.g. defined by classification, packaging and labelling of dangerous substances regulations
- sources of information and guidance within an organisation
- using equipment safely, e.g. mechanical, electrical, fluid power equipment
- lifting and carrying techniques
- housekeeping, e.g. tidy workspace, protecting others from harm, as a result of work being carried out by self or others

Personal protective equipment (PPE):

- appropriate to task undertaken, e.g. overalls, protective footwear, eye protection, masks/respirators

Hazards and risks:

- working environment, e.g. 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, e.g. first aider, fire warden
- actions in the event of an accident or emergency, e.g. use of fire extinguishers (types and applications), types and sounding/initiating emergency alarm, evacuation procedure and escape routes
- reporting routines, e.g. 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, e.g. commissioning/installing equipment or systems, machining/ manufacturing a product or component, servicing/maintenance of plant or equipment, construction/testing of circuits
- prepare work environment, e.g. area free from hazards, safety procedures implemented, PPE and tools obtained and checked (safe and usable condition)
- prepare for activity, e.g. all necessary drawings, specifications, job instructions, materials/components obtained, storage arrangements for work, authorisation to carry out work
- complete work activity, e.g. 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, e.g. improvements in work practices/methods, quality, safety, customer service, internal communications, teamwork
- dealing with problems affecting engineering processes, e.g. access to materials/tools/equipment/drawings/job specifications, quality, people
- working with others, e.g. colleagues (familiar and unfamiliar), management/supervisor, external (customers/suppliers/contractors)

## Information for delivery staff

### Essential requirements

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 to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning 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, e.g. 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 (e.g. 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 'e.g.' 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 'e.g.' 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.

<table>
<tr><th>Topic and suggested assignments/activities/assessment</th></tr>
<tr><td>Whole-class teaching:<br>● health and safety induction, college tour including workshops<br>● to introduce the Health and Safety at Work Act 1974 and other current and relevant legislation to include management of health and safety at work regulations, workplace health and safety and welfare regulations<br>● explain the responsibilities, under the Health and Safety at Work Act 1974 and other current and relevant legislation, of employees and employers.<br>Group activity:<br>● investigate the Health and Safety at Work Act 1974 and identify duties under sections 2, 3 and 7.<br>Whole-class teaching:<br>● explain the importance of adherence to approved working practices, personal hygiene and reporting of injuries.</td></tr>
<tr><td>Whole-class teaching:<br>● introduction to materials and equipment handling<br>● explain sources of safety information and guidance within an organisation, consider manual handling regulations and demonstrate lifting and carrying techniques.<br>Group activity:<br>● examine COSHH regulations and identify warning signs for the seven main groups of hazardous substances.<br>Practical workshop activity/tutor demonstration:<br>● safe use of equipment and importance of good housekeeping<br>● materials and equipment handling techniques<br>● positions and use of electrical isolation switches and cut-outs.</td></tr>
</table>

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>● introduction to personal protective equipment (PPE)<br>● explain the requirements of the PPE at work regulations and consider personal and protective equipment appropriate to a range of engineering tasks.<br>Practical workshop activity/tutor demonstration:<br>● use of PPE to include overalls, protective footwear, eye protection, masks/respirators<br>● learners select most appropriate PPE for given engineering tasks.<br>Whole-class teaching:<br>● 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.<br>Practical workshop activity:<br>● learners carry out a hazard identification and risk assessment.<br>Whole-class teaching:<br>● explain the dangers of not working to laid down procedures. |
| Whole-class teaching:<br>● 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.<br>Practical workshop activity/tutor demonstration:<br>● identification and safe operation of fire fighting equipment<br>● alarms and evacuation procedures<br>● identification and location of warning signs and notices. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, P3, P5, M1, M3, D1)** |
| Whole-class teaching:<br>● explain the importance of preparation for work activities, including:<br>● environment, relevant safety procedures and equipment requirements<br>● preparation requirements and documentation for work activity<br>● authorisation, drawings, specifications, job instructions<br>● materials and components.<br>Practical workshop activity:<br>● obtain all necessary drawings and equipment to carry out selected work activity. |
| Whole-class teaching:<br>● explain how working relationships contribute to improvements in work practices, quality and safety<br>● describe the importance of good working relationships, communication and team work<br>● explain the importance of maintaining good customer relationships and internal communications.<br>Group activity:<br>● identify problems affecting engineering process and suggest solutions. |

| Topic and suggested assignments/activities/assessment |
|---|
| Practical workshop activity:<br>● learners to have access to workshops and machinery to carry out engineering work activities (continued).<br>Tutor demonstration:<br>● quality inspection methods.<br>Group activity:<br>● discussion on work practice improvements. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P4, P6, M2, D2)** |
| Feedback on assessment, unit evaluation and close. |

## Assessment guidance

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 (e.g. 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 (e.g. 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 (e.g. 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 (e.g. 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 describe how it could be improved (M3).

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 suggested 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.<br>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.<br>Tutor observation record of the preparation for and completed task.<br>A report of the risk assessment undertaken and identification of how work activity can be improved.<br>A safety policy for the engineering work area with references back to relevant legislation. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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.<br>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.<br>A report making recommendations for improvements in an emergency procedure.<br>A written report evaluating working relationships and identifying factors that lead to and maintain good working relationships. |

## Suggested resources

### Books

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

# Unit 2: Interpreting and Using Engineering Information

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20658G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' knowledge and skills to use engineering information such as drawings and working instructions to carry out manufacturing or engineering 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. In order to be useful, engineering drawings and related documentation must be stored, reviewed and approved, distributed 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 they undertake.

The first outcome of learning 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 outcome of learning 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 outcome of learning 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.

## Outcomes of learning

On completion of this unit a learner should:

1 Understand how to interpret drawings and related documentation

2 Be able to use information from drawings and related documentation

3 Be able to produce production documentation.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 suitable information from engineering drawings and related documentation to enable a given task to be carried out | M1 Explain 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 Use appropriate drawings and related documentation to complete a given engineering task | M2 Specify the care and control procedures for the drawings and related documentation used when carrying out and checking own work output | D2 Justify improvements in the care and control procedures used for drawings and related documentation |
| P3 Select other information sources to support and check engineering drawings and related documentation | | |
| P4 Complete all necessary production documentation for a given engineering task | | |

## Unit content

**1 Understand how to interpret drawings and related documentation**

Information:

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

Engineering drawings:

- working and machine drawings, e.g. component, general assembly and sub-assembly, fabrication, welding, repair and modification,
- schematic and network drawings: fluid power, installation, wiring and circuit diagrams
- graphical representations, e.g. sketches, other schematic diagrams, flow charts, physical layout diagrams, illustrations from manufacturers' manuals

Related documentation:

- working instructions, e.g. operation sheets and job cards, test schedules, manufacturers' manuals for assembly/test/installation, weld procedure specifications
- quality control information, e.g. national, international and organisational standards, reference tables and charts

Tasks:

- those assistive of manufacturing or engineering process operations, e.g. product manufacture or modification, equipment installation or repair, system or service planning

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

Production documentation:

- for manufacturing or process operation, e.g. job cards, test reports, quality control documentation

Evaluating documents:

- evaluating procedures

Other information:

- sources relevant to task, e.g. 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 and also bonding and finishing materials

**3 Be able to produce production documentation**

Work output/engineering task:

- manufacturing or engineering process operation, e.g. product design, manufacture and assembly
- maintenance, planning and procedures

Gaps/deficiencies in information:

- scaling artefacts
- misinterpretation of drawings
- variants and equivalent types of national and international standard symbols
- role of colour and hachure in spatial representation
- on-drawing identification standards
- identifying discontinuities of line and area

Drawing and document care and control:

- location and security, e.g. storage conditions, access points and return procedures, reporting discrepancies in data and documents
- physical handling, e.g. damage and effects from graffiti, cleanliness, folding methods
- document control, e.g. issue and amendment dates, part/ pattern numbers, reporting of loss or damage

Evaluating documents:

- Request for Information (RFI) strategies and procedures

## Information for delivery staff

### Essential requirements

Learners will need access to sources of information (e.g. 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 and 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 and electronic components and assemblies as well as hydraulic or pneumatic components and systems. In addition, both outcomes of learning 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 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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning. 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 and manufacturing, 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 (e.g. *Unit 5*: *Engineering Maintenance Procedures*, *Unit 9*: *Engineering Assembly Methods and Techniques*, *Unit 19*: *Electronic Circuit Construction*). The practical activities undertaken in these units could then provide a focus for the 'interpretation' required by outcome of learning 1 and the context for the learner's own work on given engineering tasks for outcomes of learning 2 and 3.

Note that the use of 'e.g.' 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 'e.g.' 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 themes** |
|---|
| Whole-class teaching:<br>● introduction to the unit content, method of working and assessment<br>● introduction to the use of engineering drawings and related documentation<br>● explain the methods and range of use of engineering drawings and related documentation in manufacturing and process operations.<br>Group work:<br>● activities to examine examples of different types of engineering drawing and related documentation. |
| Whole-class teaching:<br>● introduction to interpretation of engineering drawings<br>● consider the style and presentation of drawings and graphical representations and the information that they convey.<br>Group work:<br>● activities to investigate given engineering drawings and present findings. |
| Whole-class teaching:<br>● introduction to engineering documentation<br>● consider the documentation used for working instructions and quality control information.<br>Group work:<br>● activities to investigate the documentation used to support and control given manufacturing and engineering process operations. |
| Preparation for and carry out assignment.<br>**Assignment 1 (P1, P3, M1, M2, D1)** |
| Whole-class teaching:<br>● introduction to the use of drawings and related documentation to carry out and check own work<br>● whole-class teaching – use of production drawings and associated documentation.<br>Group work:<br>● investigation of manufacturing case study. Presentation of findings to the group.<br>Industry visit or guest speaker:<br>● to gain first-hand experience of production drawings and associated documentation in use. |
| Whole-class teaching:<br>● 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. |

| Topic and suggested assignments, activities and assessment themes |
| --- |
| Group work:<br>● investigation of drawing and document control case studies. Presentation of findings to the group.<br>Industry visit or guest teacher:<br>● gain first-hand experience of drawing and document control.<br>Group work:<br>● carry out simple engineering tasks using drawings and related documentation and following document control procedures. |
| Preparation for and carry out assignment.<br>**Assignment 2 (P2, P4, D2)** |
| Feedback on assessment, unit evaluation and close. |

## Assessment guidance

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 outcome of learning 1 (covering P1, P3, M1, M2 and D1). The assignment would involve the extraction of suitable 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 interview to capture this evidence of the use of other information sources to ensure authenticity.

The second assignment, covering P2, P4 and D2, could be based around a specified task that enables the learner to use information from drawings and related documentation to carry out a simple engineering task. 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 specify the care and control procedures for the drawings and related documentation (M2) and explain gaps or deficiencies in the information obtained and which need to be resolved to enable a given task to be carried out (M1). 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 evaluation and justification. 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 or poor quality or superscription-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 learners will need to demonstrate the ability to justify valid solutions to meet identified gaps or deficiencies with the information obtained (D1) and suggest improvements in the care and control procedures used for drawings and related documentation (D2). 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 information required. Such information might consist of a library of drawings and other diagrams, specifications, manuals, job cards and other production documentation. Computer-based information sources and a technical library should be made available to learners as well as standards available from competent Authorities.

**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 assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P3, M1, M2, 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.<br>Tutor observation record of the learner's use of sources.<br>Report to include specific mention of any gaps or deficiencies in the information clearly indicating how these problems were resolved. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P2, P4, D2 | 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 about the manufacturing or engineering process operation undertaken together with all necessary production documentation.<br>A further report justifying any improvements that could be made to the procedures. |

## Suggested resources

### Books

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

| | |
|---|---|
| www.standardsuk.com | British Standards and associated publications |
| www.theiet.org | The Institution of Engineering and Technology |
| www.asee.org | The American Society for Engineering Education |
| http://mscweb.gsfc.nasa.gov/543web/files/GSFC-X-673-64-1F.pdf | NASA Engineering Drawing Standards Manual (American 1994 Edition ) |
| http://www.engineering.com/Ask@/qactid/2/qaqid/4581.aspx | Engineering Drawing Chat Forum |
| http://www.fep.up.pt/disciplinas/PGI914/Ref_topico1/Indicators_of_Design_Deficiency.pdf | Design Deficiency |

# Unit 3: Mathematics for Engineering Technicians

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20659G** |

**This unit is internally assessed**

## Unit aim

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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | M1 Transpose and evaluate complex formulae | D1 Transpose and evaluate combined formulae |
| P2 Use algebraic methods to transpose and evaluate simple formulae | 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 | | |
| P6 Solve right-angled triangles for angles and lengths of sides using basic Pythagoras' theorem, sine, cosine and tangent functions | | |

## 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, e.g. scales of drawings and maps
- proportion, e.g. stress/strain
- percentage, e.g. 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, e.g. $5.6 \times 10^5$, $12 \times 10^3$W and 12kW
- ensure answers to numerical problems are reasonable, e.g. approximations, significant figures, decimal places

Algebraic methods:

- transpose and evaluate simple equations including bracketed terms, roots and powers, e.g. $V = IR$, $P = VI$, $p\mathrm{V} = c$, $v = u + at$, $s = ½(u + v)t$, $\mathrm{P} = \mathrm{I}^2\mathrm{R}$
- complex formulae, e.g. $s = ut + ½a\mathrm{t}^2$, $v^2 = u^2 + 2\mathrm{as}$, $V{=}V_0\,Sin^2\pi\,ft$, $X_\mathrm{c} = 1/(2\pi fC)$
- combining formulae, e.g. $½mv^2 = mgh$ find v, $½QV = ½CV^2$ find V

Graphical methods:

- plot linear relationships, e.g. determining gradient, intercept, distance travelled, linear acceleration, work done
- plot and use non-linear relationships, e.g. 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, e.g. squares, rectangles, triangles, circles
- area of compound shapes, e.g. L-shapes, parallelograms

Volume:

- regular solid bodies, e.g. right rectangular prisms, cylinders, cones, spheres
- compound solid bodies, e.g. truncated prisms, cylinders with spherical ends

Trigonometry:

- Pythagoras' theorem
- acute angle ratios
- sine, cosine, tangent ratios
- Sin$\theta$/Cos$\theta$ = Tan$\theta$ relationship to solve right angle triangle problems, triangles within a compound area or volume
- complex shapes, e.g. a combined rectangle and triangle or pyramid
- use trigonometry to solve unknown dimensions

## Information for delivery staff

### Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning but it may be necessary to integrate components to coincide with theoretical concepts being considered in subsequent work. 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 to find 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, e.g. 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, e.g. $5.6 \times 10^5$, $12 \times 10^3$W 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 'e.g.' 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 'e.g.' 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/assessment |
|---|
| Whole-class teaching:<br>● introduction to the unit content, scheme of work and assessment strategy<br>● tutor-led revision of manual procedures for addition, subtraction, multiplication, division and calculation of ratio, proportion and percentage<br>● explain and apply BODMAS rule.<br>Individual learner activity:<br>● exercises in arithmetical calculation<br>● exercises in use of electronic scientific calculator. |
| Whole-class teaching:<br>● 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<br>● explain approximating answers and expressing numbers of significant figures/decimal places<br>● tutor demonstration of use of electronic scientific calculator for basic functions and special function keys, e.g. EXP and ENG<br>● explain direct proportional and linear relationships followed by how to choose suitable scales and plot graphs from given data<br>● 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<br>● tutor demonstration of the calculation of the area under a graph and its significance in practical applications, e.g. velocity-time graph, voltage-current graph.<br>Individual learner activity:<br>● exercises in plotting linear graphs.<br>Whole-class teaching:<br>● describe and discuss typical inversely proportional relationships<br>● explain exponential growth and decay, its occurrence and lead learners in choosing suitable scales and plotting graphs from given data.<br>Individual learner activity:<br>● exercises in plotting non-linear graphs. |

| Topic and suggested assignments/activities/assessment |
|---|
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P3)** |
| Whole-class teaching:<br>● explain application of transposition and evaluation of simple formulae.<br>Individual learner activity:<br>● exercises in transposition and evaluation of simple formulae.<br>Whole-class teaching:<br>● explain and discuss transposition rules and procedures for more complex formulae<br>● tutor demonstration of transposition and evaluation of complex and combined formulae involving powers and roots.<br>Individual learner activity:<br>● exercises in transposition and evaluation of formulae. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P2, M1, D1, D2)** |
| Whole-class teaching:<br>● explain and demonstrate the use of standard formulae; for calculation of area of squares, rectangles, and triangles<br>● explain and demonstrate the use of standard formulae in terms of radius and diameter for the calculation of area of circles<br>● explain and demonstrate calculation of area of compound shapes.<br>Individual learner activity:<br>● exercise in calculation of areas.<br>Whole-class teaching:<br>● explain and demonstrate the use of standard formulae for calculation of volume.<br>Individual learner activity:<br>● exercises in calculation of volumes.<br>Whole-class teaching:<br>● explain and demonstrate the use of standard formulae for calculation of volume of compound solid bodies.<br>Individual learner activity:<br>● exercises in calculation of volumes of compound solid bodies. |

| Topic and suggested assignments / activities / assessment |
|---|
| Prepare for and carry out assignment.<br>**Assignment 3 (P4, P5, M2, M3)** |
| Whole-class teaching:<br>● 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<br>● 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.<br>Individual learner activity:<br>● exercises involving solution of right angle triangles.<br>Whole-class teaching:<br>● 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 an appropriate trigonometrical ratio and Pythagoras' theorem.<br>Individual learner activity:<br>● exercises involving solution of right angle triangles.<br>Whole-class teaching:<br>● prove the relationship $Sin\theta/Cos\theta = Tan\theta$ and demonstrate calculation of dimensions within complex shapes containing right angle triangles.<br>Individual learner activity:<br>● exercises involving calculation of dimensions. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P6, M4)** |
| Feedback on all assessment tasks, guidance on remedial action if necessary. |
| Unit evaluation and close. |

## Assessment guidance

The assessment strategy applied will need to cover all the outcomes of learning and associated pass criteria but not necessarily all the example 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 (e.g. find the value for $V$ given values for $I$ and $R$ for the equation $V=IR$) and transpose and evaluate formulae (e.g. 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 (e.g. 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 (e.g. 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 (e.g. find the length of the hypotenuse given the length of the other two sides) and the sine, cosine and tangent relationships (e.g. 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 (e.g. find a value for $a$, given values for $s$, $u$ and $t$ and the formula $s = ut + ½at^2$).

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 (e.g. 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 (e.g. 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 suggested 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, M1, 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.<br>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, M4 | 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. |

## Suggested resources

### Books

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

### Websites

| | |
|---|---|
| www.freestudy.co.uk | Engineering Council open learning tutorials |

# Unit 4: Applied Electrical and Mechanical Science for Engineering

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20660G** |

**This unit is internally assessed**

## Unit aim

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 much scope for experimentation and a practical approach to elements of the outcomes of learning.

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

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | M2 Describe the correct 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 | | |
| P5 Determine the uniform acceleration/ retardation of a body from given data | | |
| P6 Determine the pressure at depth in a fluid from given data | | |

## 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 electromagnetic coils, e.g. 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

# Information for delivery staff

## Essential requirements

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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcomes of learning and tutors will have their own preferences with regards to the best point to start. The order of delivery of the outcomes of learning 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 outcome of learning – 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, learner must gain a sufficient understanding of the scientific 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>• introduction to the relevance of science to engineering, unit content, the scheme of work and assessment strategy<br>• consider the definitions of common quantities and SI units.<br>Group work:<br>• explore and compare calculator types, review common functions and carry out calculator use exercises.<br>Individual learner activity:<br>• complete worksheet on common quantities and SI units. |
| Whole-class teaching:<br>• explain the terminology used to describe the parameters of direct current and their associated symbols and units<br>• tutor demonstration of an electrical circuit using components or computer simulation<br>• develop practical circuits to show series and parallel connection of resistors<br>• explain the formulae used for Ohms law and resistors in series and parallel followed by individual learner<br>• activity involving calculations using formulae<br>• explain the terminology used to describe the parameters of magnetic fields and their associated symbols and units, current-carrying conductors and solenoids<br>• tutor demonstration of magnetic fields and solenoids<br>• define flux, flux density and state formula for calculation of force on a current carrying conductor in a magnetic field<br>• 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.<br>Individual learner activity:<br>• exercises on solution of circuit problems involving force on a conductor.<br>Whole-class teaching:<br>• describe and discuss the principle of operation and practical applications of relays, contactors and solenoids, basic dc motors and transformers<br>• tutor demonstration of the calculation of output emf for no load condition.<br>Individual learner activity:<br>• tutor-led revision exercises on dc circuits and force on a conductor. |

| **Topic and suggested assignments/activities/assessment** |
| --- |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1, D1)** |
| Whole-class teaching:<br>● consider mass, weight, concurrent and non-concurrent coplanar forces and the moment of a force and conditions required for static equilibrium<br>● tutor demonstrate of the construction of parallelogram, triangle and polygon of forces.<br>Individual learner activity:<br>● exercises on graphical solution of concurrent coplanar force systems.<br>Whole-class teaching:<br>● 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.<br>Individual learner activity:<br>● exercises on solution of non-concurrent coplanar force systems.<br>Whole-class teaching:<br>● 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<br>● practical activity to determine coefficient of friction<br>● consider – density and relative density, common – units of pressure, absolute and gauge pressure, pressure at depth below the free surface of a liquid.<br>Individual learner activity:<br>● exercises on pressure calculation and measurement. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P6)** |
| Whole-class teaching:<br>● consider – displacement, velocity and acceleration, displacement-time and velocity-time graphs, formulae for motion with uniform acceleration<br>● tutor demonstration of calculations to solve problems relating to linear motion from given data.<br>Individual learner activity:<br>● exercises on motion with uniform acceleration.<br>Whole-class teaching:<br>● consider Newton’s laws of motion and inertia, develop formula for calculation of inertial resistance from Newton’s 2nd law of motion, work and power<br>● tutor demonstration of calculations using Newton’s laws of motion and inertia.<br>Individual learner activity:<br>● exercises on motion with uniform acceleration involving work and power. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P3, P4, P5, M2, D2)** |
| Feedback on assessment, unit evaluation and close. |

## Assessment guidance

Evidence of achievement of the outcomes of learning 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 (e.g. $1.2 \times 10^4$ or $12 \times 10^3$). 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 and 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 cover the criteria and related content sufficiently. 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 to 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 suggested 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. |

## Suggested resources

### Books

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 | Explains thousands of topics, from engines to lock-picking to ESP. |

# Unit 5: Engineering Maintenance Procedures

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20661G** |

**This unit is internally assessed**

## Unit aim

This unit gives learners the opportunity to explore safely 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.

## Outcomes of learning

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

3 Be able to follow health and safety procedures in the workshop.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 four failures of engineering equipment | M2 Explain the health and safety precautions and procedures for a given maintenance activity | D2 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 resource considerations for engineering maintenance operations | | |
| P6 Identify the resources required for a given maintenance activity | | |
| P7 Use appropriate documentation to plan a given maintenance activity on a non-complex engineering system | | |

| 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 a maintenance activity using appropriate documentation | | |
| P9 Demonstrate correct health and safety procedures in the workshop when carrying out engineering maintenance activities | | |

## Unit content

### 1 Know about engineering maintenance purposes, procedures and resources

Causes and effects:

- causes of equipment failure, e.g. age, wear, vibration, corrosion, fouling, environment, lack of maintenance, malicious damage
- effects, e.g. importance of downtime, increased cost, equipment and component life

Types of maintenance procedures:

- planned maintenance, e.g. routine maintenance, preventative maintenance, condition monitoring, front-line maintenance; and when and where they are used; servicing
- unplanned maintenance, e.g. breakdown, front-line maintenance and when and where they are used, repair, equipment failure, run to failure

Resources for maintenance operations:

- human (roles and responsibilities), e.g. managers, maintenance personnel, operators
- tools, materials and equipment – for specific maintenance functions, e.g. 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, e.g. pump, valve, compressor, heating, lighting, fluid power, manufacturing or test equipment

Identification of resources:

- availability of maintenance and production staff
- appropriate documentation, e.g. permit-to-work, maintenance check lists, production schedules, machine or process records, hand-over documents, equipment manuals
- fault-finding aids
- appropriate spares, materials and consumables
- appropriate test equipment and tools

Maintenance planning:

- frequency of maintenance
- reasons for selecting different frequency rates for specific maintenance, e.g. on shift, daily, weekly, monthly, or yearly routines
- identification of planned repairs and replacements
- health and safety issues
- environmental issues
- estimation of costs

Maintenance documentation:

- information, e.g. manufacturers’ manuals, drawings charts and diagrams, planning sheets, instructions, schedules
- recording, e.g. maintenance logs, other records
- hand-over documents
- fault-finding aids

**3 Be able to follow health and safety procedures in the workshop**

Health and safety procedures:

- assess and record workshop risks
- update risk assessments due to asset or organisational changes
- monitor and review preventative and protective measures
- provide health surveillance in regard to fluid, radioactive, atmospheric and other ambient hazards
- legally-accountable health and safety officers
- role of trade unions or other employee health and safety groups
- adequate hazard signage
- protocols for dealing with imminent dangers such as fires, spillages and kinetic injuries
- communication with emergency services
- adequate and accessible telephonic and equipment stoppage facilities
- summoning help, warning, and reacting to fire, spillage, injuries and other hazards or crises

## Information for delivery staff

### Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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.

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 noncomplex 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 outcomes of learning 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.

Note that the use of 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● introduction to the unit, delivery and assessment model, glossary of terms and terminology<br>● introduction to engineering maintenance, its purpose, procedures and resources<br>● outline applicable health and safety legislation, regulations and codes of practice and explain the need for maintenance and maintenance considerations.<br>Individual learner activity:<br>● investigate the maintenance operations in various organisations and the health and safety requirements and environmental considerations relating to maintenance in a given organisation/industry. |
| Whole-class teaching:<br>● explain the causes of equipment failure and the effect of poor maintenance on downtime, costs, equipment and component life.<br>Group activity:<br>● identify the need for maintenance within particular organisations. |
| Whole-class teaching:<br>● explain principles and procedures of planned and unplanned types of maintenance and examples of their application in industry.<br>Individual learner activities:<br>● identify types of maintenance in given situations<br>● review of the factors affecting given maintenance type and evaluate types of maintenance. |
| Whole-class teaching:<br>● explain the roles of personnel applicable to the maintenance process<br>● explain the impact of using less well trained staff, in-house, contract, specialist<br>● explain the tools materials and equipment requirements for maintenance functions also the cost implications of keeping spares and consumables<br>● explain the health and safety precautions for maintenance functions.<br>Industry visit:<br>● to local company to see types of maintenance used. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, P3, P4, P5, M1, M2)** |

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>● introduction to planning and carrying out a maintenance activity<br>● consider maintenance planning, documentation and discuss the possible environmental and health and safety issues.<br>Individual learner activity:<br>● identify and obtain maintenance planning documentation, produce written maintenance plans and carry out cost estimate for given task.<br>Practical workshop activity:<br>● tutor demonstration of a maintenance activity on a non-complex engineering system<br>● learners plan and carry out maintenance activities on non-complex engineering systems. |
| Whole-class teaching:<br>● explain maintenance resource requirements and examine further examples of maintenance information, documentation requirements, recording methods and charts.<br>Practical workshop activity:<br>● 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.<br>**Assignment 2 (P6, P7, P8, P9, D1, D2)** |
| Feedback on assessment, unit evaluation and close. |

## Assessment guidance

Outcome of learning 1 and the associated criteria (P1, P2, P3, P4, P5, M1 and M2) could be covered through an assignment that requires the learner to respond to pre-set 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 (e.g. human, tools, materials and equipment).

Outcome of learning 2 and its associated criteria (P6, P7, P8, P9, D1 and D2) 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, e.g. pumps, valves, compressors, heating, lighting, fluid power and manufacturing or test equipment. Tutor observation will be necessary during the activity to capture the correct use of maintenance documentation and to ensure appropriate health and safety measures are being followed. 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 distinction grade criterion D2, 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 (e.g. frequency, replacement parts, health, safety and environmental issues) and when carrying out the maintenance activity (e.g. 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 outcomes of learning 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, P3, P4, P5, M1, M2 | 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:<br>● the different causes and effects of equipment failure<br>● planned and unplanned maintenance procedures<br>● the benefits and limitations of a planned maintenance activity<br>● the health and safety precautions<br>● the resources needed for engineering operations. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P6, P7, P8, P9, M2, D1, D2 | 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.<br>Tutor observation of the planning and implementation of the given maintenance activity.<br>A report justifying the resources and methods used when carrying out the given maintenance activity.<br>A report evaluating the maintenance documentation used. |

## Suggested resources

### Books

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

### Websites

| | |
|---|---|
| www.pwemag.co.uk/news/readable_sitemap.php | Plant and Works Magazine Sitemap |
| www.maintenanceonline.co.uk/home.asp | General UK-oriented Maintenance Website |

# Unit 6: Preparing and Controlling Engineering Manufacturing Operations

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20662G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' skills to prepare and control a manufacturing operation using defined procedures safely and effectively.

## 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 prepared properly 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 enable manufacturing operations to start and continue safely. 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 appropriately 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 different problems in preparation | 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 | | |
| P4 Control a manufacturing operation in a safe manner by identifying a problem and making adjustments | | |
| P5 Use operating procedures when controlling a manufacturing operation | | |

## 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, e.g. machinery, process plant, tools, material handling arrangements, equipment specific to the operation
- reporting to appropriate person, e.g. team leader, supervisor, maintenance personnel, quality control

Problems in preparation:

- areas where problems occur, e.g. 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, e.g. hand manufacturing operations, manually operated machine operations, fully automated machine operations, combined manufacturing operation

Data:

- collected on the condition of operation, e.g. 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:

- e.g. trends, variation from specification, discrepancies

Adjustments:

- process effectiveness, e.g. operational sequence, production time
- process characteristics, e.g. quality, accuracy
- material utilisation, e.g. in production, consumables
- manufacturing programme changes
- operational safety

Operating procedures:

- job instructions
- equipment/tool operating instructions, e.g. machinery, process plant, hand held and portable tools, material handling arrangements, equipment specific to the operation
- making adjustments from data

# Information for delivery staff

## Essential requirements

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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcomes of learning 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>• introduction to unit, scheme of work and assessment<br>• explain relevant aspects of health and safety legislation and discuss importance of maintaining work area<br>• explain and discuss health and safety requirements (PPE, safe disposal of materials etc)<br>• explain procedures for cleaning and storing tools and equipment.<br>Practical workshop exercise:<br>• preparing the work area. |
| Whole-class teaching:<br>• explain the roles of maintenance and quality control personnel and procedures for reporting to appropriate person<br>• identify and explain job instruction documents<br>• identify and explain equipment/tool operating instructions<br>• discuss consequences of failure to follow instructions<br>• describe and discuss problems that might arise (with documentation, materials, work area etc). |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1, D1)** |
| Whole-class teaching:<br>• describe and discuss the range of production methods in relation to scales of production and different engineering activities<br>• describe and discuss safe working practices associated with the range of production methods. |
| Industrial visit to local manufacturing company. |
| Whole-class teaching:<br>• explain the purpose of process plans/specifications and the information that they contain<br>• explain the use of engineering drawings<br>• describe typical documentation and recording procedures<br>• explain the procedures for checking the condition of machinery and tools<br>• explain the purpose of production programmes/schedules and ways in which output is monitored and recorded. |

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>● describe procedures for reporting material faults, machine or equipment malfunction<br>● describe typical quality control inspection and recording procedures<br>● describe the tendency and reasons for a process to drift from specification. |
| Whole-class teaching and practical demonstration:<br>● describe procedures for setting up machinery and process plant in readiness for production<br>● describe and demonstrate typical start-up, operating and shut-down procedures<br>● describe and demonstrate typical material handling procedures and safe use of equipment. |
| Whole-class teaching and practical demonstration:<br>● describe and demonstrate the use of process monitoring techniques<br>● describe and demonstrate quality control procedures<br>● describe how changes to the manufacturing programme are typically accommodated. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, P5, M2, D2)** |
| Review of unit. |

## Assessment guidance

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 (e.g. *Unit 14: Secondary Machining Techniques*). 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 outcomes of learning. 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, e.g. 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 of learning 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, M1, 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.<br>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, D2 | 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.<br>A written description of how the collection of data can help control manufacturing operations. |

## Suggested resource

**Book**

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

# Unit 7: Electronic Devices and Communication Applications

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20663G** |

**This unit is internally assessed**

## Unit aim

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. Learners must follow appropriate health and safety procedures to protect themselves, others and equipment.

## Unit introduction

Electronics drive the modern world and have given us a wide range of electronically controlled products from digitally controlled home appliances to heart pacemakers. It has spawned the computer revolution, the internet and all modern navigation and communication systems such as the global mobile phone network. 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.

## Outcomes of learning

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 using safe practises

4 Understand electronic communication systems and data transmission.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 and operation of repeaters and regenerators for communication over longer distances | D2 Describe the advantages of given electronic communication systems |
| P3 Identify BS symbols and the physical forms of given electronic components and devices | M3 Explain how electronic communication systems successfully transfer data | |
| P4 Construct a passive circuit correctly, using different methods of construction | | |
| P5 Construct and test the operation of an analogue electronic circuit, correctly | | |
| P6 Construct and test the operation of a digital electronic circuit, correctly | | |
| P7 Describe safe working practices when working with electronic devices | | |

| 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 Describe how electronic communication is achieved | | |
| P9 Describe how electronic data is transmitted | | |

## Unit content

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

Signals:

- digital and analogue signals, e.g. light intensity, temperature, voltage, frequency
- DC and alternating signals, e.g. sinusoidal, pulse, square/rectangular, triangular, sawtooth
- waveform measurements, e.g. amplitude, peak to peak, pulse duration, mark to 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, e.g. 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, e.g. light dependant resistor (LDR), photodiode, thermistor, thermocouple, microphone, strain gauge
- indicators and output devices, e.g. lamp, LED, buzzer, speaker, relay, motor, solenoid, heater
- operational amplifiers, e.g. inverting and non-inverting amplifiers, comparators
- timers and multivibrators, e.g. astable, bistable and monostable
- two input logic gates, e.g. AND, OR, NOT, NAND, NOR, XOR

**3 Be able to construct and test analogue and digital electronic circuits using safe practices**

Simple passive circuits:

- combinations of series and parallel resistor components, e.g. potential divider circuits
- series and parallel combinations of two capacitors
- time-delay effect of capacitor, e.g. time constant T = CR, charge and energy storing

Analogue circuits:

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

Digital circuits:

- simple combinational logic circuits and truth tables, e.g. 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, e.g. multimeter, logic probe, oscilloscope, signal and pulse generators

Health and safety requirements:

- personal safety, e.g. appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators, electrical testing safety
- procedures, e.g. 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, e.g. permit to work, use of danger tags, warning notices, safety barriers, cones and tapes, isolation of equipment, proof marking, recording of maintenance operations

### 4 Understand electronic communication systems and data transmission

Electronic communication systems:

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

Data transmission:

- representation of digital signals and data, e.g. digital logic levels, binary numbers, coding methods, binary, BCD, ASCII, audio tones
- protocols, e.g. handshaking, flow control, error checking
- simplex, half and full duplex working

## Information for delivery staff

### Essential requirements

Delivery should be based in an adequately-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, as well as to adequate hardware and software resources.

### Employer engagement and vocational contexts

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning involve a large amount of practical investigative work. Outcomes of learning 2 and 3 have the most practical content whilst outcome of learning 1 provides the supporting knowledge of signals and units of measurement used in electronic systems. Outcome of learning 4 covers the requirements for electronic communication systems and data transfer.

To support outcome of learning 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 outcome of learning 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 outcome of learning 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 outcome of learning 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● introduction to unit, scheme of work and methods of assessment<br>● explain digital, analogue, DC and alternating signals<br>● explain waveform measurements and speech waveforms<br>● explain and demonstrate use of units of measurement for voltage, current, frequency and bits per second. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1)** |
| Whole-class teaching:<br>● introduce and explain the function and use of different types of components<br>● explain and demonstrate the use of British Standards<br>● explain the function and use of electronic devices.<br>Practical learner activity:<br>● 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.<br>**Assignment 2 (P2, P3)** |

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>• explain combinations of series and parallel resistor components, combinations of two capacitors and time delay<br>• effect of capacitor in passive circuits<br>• explain use of diode as a one-way device, and bipolar and unipolar transistor circuits<br>• describe purpose and function of linear integrated circuit<br>• explain function of simple combinational logic circuits and truth tables<br>• demonstrate electronic circuit construction and testing techniques.<br>Practical learner activity:<br>• practise use of protoboard, veroboard and PCBs for analogue and digital circuit construction<br>• practise use of correct equipment for testing of electronic circuits. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P4, P5, P6, M1, D1)** |
| Whole-class teaching:<br>• explain the function and operation of transmitter sub-systems, channel/link and receivers<br>• explain the use of repeaters/regenerators for long distance communications<br>• explain and demonstrate representation of digital signals and data. Explain the use of protocols<br>• explain the operation of different duplex communication systems.<br>Employer visit:<br>• visit to local employer to view electronic communication systems in industrial setting. |
| Prepare for and carry out assignments.<br>**Assignment 4 (P7) and Assignment 5 (P8, P9, M2, M3, D2)** |
| Unit evaluation, feedback and close. |

## Assessment guidance

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 outcomes of learning 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 (P7) could involve a learner producing a poster outlining the relevant health and safety checks to consider when working with electronic devices.

The final assignment could involve a written task, to describe how electronic communication is achieved, and how data is transmitted (P8, P9). For M3 learners should explain how communication systems successfully transfer data. Further tasks could ask the learner to explain the function and operation of repeaters and regenerators for communication over longer distances (M2) and to 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 suggested 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, P3 | Electronic Devices and Components | Learners write a short report 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, M1, 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 | The Safeguarding of Personnel and Equipment | Learners describe suitable checks and installed precautions in a systematic but non-ritualised manner. | Learners produce an assignment poster checklist of relevant precautions. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P8, P9, M2, M3, D2 | Electronic Communication Systems | Learners produce a report to explain electronic communication. | A written assignment with several tasks requiring learners to explain how electronic communication is achieved and how communication systems successfully transfer data. |

## Suggested resources

### Books

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

### Websites

| | |
|---|---|
| http://phet.colorado.edu/en/simulation/circuit-construction-kit-ac-virtual-lab | University of Colorado Virtual Laboratory |
| http://freecircuitdiagrams4u.blogspot.co.uk/ | Example Circuit Diagrams for Various Devices |

# Unit 8: Selecting Engineering Materials

Level: **2**
Notional Learning Hours: **50 (including 30 GLH)**
Unit value (NLH/10): **5**
SRF unit code: **20664G**

**This unit is internally assessed**

## Unit aim

This unit will develop learners' understanding of common engineering materials and their properties and know how engineering materials are selected.

## 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.

## Outcomes of learning

On completion of this unit a learner should:

1. Understand the properties of common engineering materials
2. Know how engineering materials are identified
3. Be able to select engineering materials.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 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 Justify the selection of a material for a given application |
| P2 Describe the properties of a given ferrous metal and a given non-ferrous metal | M2 Explain an appropriate form of supply for a given material requirement | |
| P3 Describe the properties of a given organic material, a given thermoplastic, a given thermosetting polymer and a given smart material | | |
| P4 Identify symbols and abbreviations used on given engineering documentation | | |
| P5 Identify the forms of supply available for a given engineering material | | |
| P6 Select an appropriate material in terms of form and size, for a given application | | |

## Unit content

### 1 Understand the properties of common engineering materials

Properties:

- mechanical, e.g. tensile strength, hardness, toughness/brittleness, malleability and ductility
- electromagnetic, e.g. electrical conductivity, ferromagnetism
- chemical and durability, e.g. resistance to corrosion, solvents, environmental degradation, wear

Common engineering materials:

- ferrous material, e.g. cast iron, low and high carbon steel, stainless steel
- non-ferrous material, e.g. aluminium, brass, bronze, copper, lead
- organic materials, e.g. hard and soft woods, wood composites
- thermoplastics, e.g. PVC, nylon, PTFE, polythene, Perspex
- thermosetting polymer, e.g. Bakelite, Formica, melamine, Kevlar epoxy resin, polyester resin, reinforcing material (glass fibres, carbon fibres, wood flour)
- smart materials, e.g. 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, e.g. bright drawn mild steel bar, copper-coated circuit board, solid diameters, pipe and tube diameters, wire gauges
- documentation, e.g. engineering drawings and related specifications

### 3 Be able to select engineering materials

Form of supply:

- form, e.g. bar stock, sheet materials, pipe or tube, wire, rolled steel sections, castings, forgings, mouldings, extrusions, powders and fluids
- surface finish, e.g. bright drawn, cold drawn, plated, painted, plastic coated
- size, e.g. diameter(s), thickness, gauge
- identification coding, e.g. International Organisation for Standardisation (ISO) and British Standards Institution (BSI) materials coding systems, suppliers and organisation’s colour codes

# Information for delivery staff

## Essential requirements

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. Outcome of learning 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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 and density, appearance (colour and 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 outcomes of learning 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 or employers.

Note that the use of 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● introduction to unit content<br>● define mechanical properties, electromagnetic properties and properties of durability and resistance to chemical attack<br>● describe and discuss typical components and applications where knowledge of these properties is essential to good design. |
| Whole-class teaching:<br>● describe composition, appearance and properties of the range of ferrous materials, and discuss applications, view and handle specimen components<br>● describe composition, appearance and properties of the range of non-ferrous materials, and discuss applications, view and handle specimen components<br>● describe composition, appearance and properties of the range of polymer materials, and discuss applications, view and handle specimen components<br>● describe composition, appearance and properties of the range of organic and smart materials, and discuss applications, view and handle specimens.<br>Individual or small-group activity:<br>● carry out investigation involving visual and tactile recognition of materials and informal property tests. |
| Preparing for and carrying out assignment.<br>**Assignment 1 (P1, P2, M1)** |

| Topic and suggested assignments/activities/assessment |
| --- |
| Whole-class teaching:<br>● explain abbreviations used for items on engineering drawings and documents.<br>Individual or small-group activity:<br>● interpret material specifications on given drawings and documents.<br>Whole-class teaching:<br>● describe and discuss surface finishes resulting from cold and hot forming processes<br>● describe and discuss paints commonly used for surface protection<br>● describe and discuss plating techniques commonly used for surface protection.<br>Individual or small-group activity:<br>● carry out investigation involving visual and tactile recognition of the range of surface finish and surface protection.<br>Whole-class teaching:<br>● describe commonly available range of barstock, pipe, tube, wire and extruded sections<br>● describe commonly available range of rolled sheet, plate and structural sections<br>● describe procurement of castings, forgings and mouldings.<br>Individual or small-group activity:<br>● carry out investigation to identify the suppliers and costs of given materials. |
| Whole-class teaching:<br>● describe and discuss ISO and BSI identification codes for common engineering materials<br>● describe and discuss typical in-house colour coding systems used for barstock and other materials<br>● describe and discuss typical in-house systems used by engineering firms to identify and locate materials in stock.<br>Individual or small-group activity:<br>● carry out exercise to identify material types and properties from coded information. |
| Preparing for and carrying out assignment.<br>**Assignment 2 (P3, P4, P5, P6, M2, D1)** |

## Assessment guidance

Evidence of achievement of the outcomes of learning 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 outcomes of learning, 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 outcomes of learning, the criterion P1 could be met through a short, written task in which learners are required to describe the properties of common engineering materials such as mechanical, electromagnetic, chemical, durability. It may be more appropriate however, to link it with the criteria P2, P3 and M1 in an assignment that asks the learner to investigate a material's properties in order to explain the choice for its use as an engineering component. 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, P6, M2 and D1 in an assignment that requires the learner to identify forms of supply available for a given engineering material and select the most appropriate for the specification. For M2 learners will explain an appropriate form of supply for a given material requirement. For D1, learners should examine the properties of a material to justify its selection for a given application. This could be achieved by reference to a material database, BS or 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 suggested 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 describe behavioural properties of engineering materials. Also to describe the properties of given materials and explain the reasons for choosing one of them in a given application. | A report containing written responses to the set tasks. |
| P4, P5, P6, M2, D1 | Identifying Engineering Materials | Learners to identify material specifications from given documents, identify available forms of supply and explain the most appropriate for the specification. Also to justify the selection of a material for the given application. | A report containing written responses to the set tasks. |

## Suggested resources

### Books

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

### Websites

| | |
|---|---|
| http://www-materials.eng.cam.ac.uk/mpsite/interactive_charts/ | Materials Selection Charts |
| http://oregonstate.edu/instruct/me480/Lecture/W11/PDF_Files_W11/WeekOneToFive11.pdf | Oregon State University Lecture Notes with Equations and Recommended Books |

# Unit 9: Engineering Assembly Methods and Techniques

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20677G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' skills and knowledge 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 develop learners' skills and knowledge to carry out a range of relevant assembly methods and techniques on engineering equipment. For example, the assembly or sub-assembly and fitting of mechanical, electrical and 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. 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 laid correctly 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | 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 to propose improvements |
| P2 Use appropriate tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment | M2 Demonstrate appropriate fault fixing techniques during assembly | |
| P3 Connect or fit components to engineering equipment correctly | | |
| P4 Carry out an assembly task safely, using given tools, assembly methods and techniques | | |

## Unit content

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

Tools, equipment and measuring instruments:

- hand tools, e.g. hacksaws, files, spanners, wrenches, sockets, screwdrivers, crimping tools
- power tools, e.g. drills, air tools, soldering irons
- equipment, e.g. for lifting and moving, jigs, fixtures, supports, wiring looms
- measuring instruments, e.g. ruler, tape measures, micrometers, gauges, multimeters

Fit for service:

- appropriate to assembly task, e.g. following the guidance of drawings, job instructions, assembly procedures
- health and safety considerations, e.g. 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, e.g. torque, safe working load, voltage and current ranges

Quality checks:

- completeness
- alignment
- positional accuracy
- component security
- damage or foreign objects
- specific component checks, e.g.:
  - pipework (correct direction and flow, component quality such as pipes free from ripple, creases)
  - electrical and electronic (correct inputs and 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 and working clearances, bearing end float)

Engineering equipment:

- any relevant assembly or sub-assembly with a range of components, e.g. mechanical, electrical/electronic, pipework, fluid power equipment

**2 Be able to assemble components to engineering equipment**

Connect and fit components:

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

## Information for delivery staff

### Essential requirements

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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

Delivery of this unit might 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 and 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 outcomes of learning 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 practice. 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 of their own and 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 and learning phases 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 except for summative assessment exercises, where tool-sharing may delay individual learners, thus vitiating their achievements.

### 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:<br>● introduction to unit, scheme of work and method of assessment<br>● explain workshop layout and health and safety requirements relevant to assembly processes<br>● explain importance of using PPE and guards<br>● explain and discuss how fully to observe COSHH regulations<br>● view a range of hand-tools, equipment and measuring instruments, explaining their safe use and storage<br>● explain importance or working to job instructions and assembly drawings. |
| Whole-class teaching and practical workshop exercise:<br>● introduce and explain the requirements of inspection<br>● carry out inspection on selected systems and components. |
| Whole-class teaching and practical workshop exercise:<br>● explain importance of working to set times<br>● introduce and explain the requirements of assembly, fitting and joining exercises<br>● tutor demonstration and group practical of assembly, fitting and joining techniques. |
| Whole-class teaching and practical workshop exercise:<br>● explain importance of working to set times<br>● introduce and explain the requirements of assembly, fitting and joining exercises<br>● tutor demonstration and group practical of assembly, fitting and joining techniques. |
| Individual learner activities:<br>● carry out risk assessment of practical activities and prepare for, and carry out assembly, fitting and joining exercises, including component removal and refitting, equipment strip and rebuild.<br>Prepare for and carry out assignment.<br>**Assignment 1 (P1, P3, P4, M2, D1)** |

| Topic and suggested assignments, activities and assessment |
| --- |
| Whole-class teaching:<br>● explain the importance of quality checks<br>● tutor demonstration of correct and safe procedures for carrying out quality checks.<br>Individual learner activities:<br>● prepare for, and carry out quality checking exercises. |
| Whole-class teaching:<br>● explain specific system quality requirements<br>● explain importance of customer feedback and co-ordinating with line managers and quality control teams.<br>Group activity:<br>● discuss impact of quality and accuracy on production or maintenance of final product. |
| Individual learner activity:<br>● investigate and carry out quality checks during and on completion of assembly tasks. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P1, P2, M1)** |
| Unit review, feedback and evaluation. |

## Assessment guidance

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 and equipment defect reports and relevant photographs that have been annotated to explain procedures or difficulties. Such supporting product evidence would then support the tutor or witness observation or oral questioning records.

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 outcomes of learning 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 and 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 P2. This may mean that these two criteria (P1 and P2) 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 also 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 and 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 to propose improvements (D1). There is a direct link between the criteria P4 and D1, and centres may choose to make this opportunity explicit in the task and 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 i.e. 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 suggested 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, 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. |

## Suggested resources

### Book

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

### Websites

| | |
|---|---|
| http://www.bps-group.net/download/CILT_Seminar_in_Singapore_4_Nov_09.pdf | Singaporean Seminar Notes on IE Flow Modelling |
| http://nraoiekc.blogspot.co.uk/2012/03/industrial-engineering-principles.html | Industrial Engineering UK blogspot with Topic Index |

# Unit 10: Using Computer Aided Drawing Techniques in Engineering

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20665G** |

**This unit is internally assessed**

## Unit aim

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 and 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 or plotting of drawings.

## Outcomes of learning

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 and plotting.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 appropriate manner | M1 Describe different 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 an accurate CAD drawing using an orthographic projection method | M2 Describe the drawing commands used across the range of drawing types | D2 Produce detailed and accurate drawings independently and within agreed timescales |
| P3 Produce an accurate CAD drawing using an isometric projection method | M3 Describe different methods used to create relevant folder and file names and maintain directories to aid efficient recovery of data | |
| P4 Produce an accurate circuit diagram using CAD | | |
| P5 Use CAD commands correctly, to modify a given orthographic and isometric drawing | | |
| P6 Use CAD commands correctly, to modify different given circuit diagram types | | |

| 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 Set up a suitable electronic folder for the storage and retrieval of information | | |
| P8 Store, retrieve, print and plot CAD drawings correctly | | |

# Unit content

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

Start up:

- system configuration, e.g. digitiser, printer or plotter
- power up and execute software in correct order
- set up the environment, e.g. 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, e.g. pneumatic, hydraulic, electrical, electronic
- use of standards, e.g. BS8888, BS3939, BS2917

Drawing commands:

- co-ordinates, e.g. absolute, relative and polar entry systems
- features, e.g. types of line, grids, snaps, circle, text, hatching, dimensioning
- viewing, e.g. 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:

- e.g. array and pattern, copy and duplicate, move, rotate and revolve, erase, stretch, trim, scale, chamfer and fillet, change layers or levels, colours and types of line

**4 Be able to store and retrieve engineering drawings for printing or 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 or plot drawings in a range of sizes

# Information for delivery staff

## Essential requirements

Centres will need to have access to a suitably equipped computing room with printing and 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 and ISO 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 and CAM, and other relevant applications.

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 the third assignment. Although CAD software can be used to construct circuit diagrams other proprietary software with suitable circuit symbols may be used to develop this element as appropriate.

Note that the use of 'e.g.' 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 'e.g.' 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 assessments** |
|---|
| Whole-class teaching:<br>● introduction to CAD system<br>● exercise on using the operating system to identify and activate CAD software.<br>Tutor demonstration or alternatively individual practical activities:<br>● introduction to system configuration and setting up the drawing environment including the use of relevant toolbars and menus<br>● exiting and closing down the CAD system.<br>Whole-class teaching:<br>● use of appropriate standards used in creating drawings, e.g. BS 8888, BS 3939, BS 2917. |
| Whole-class teaching:<br>● 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.<br>Individual learner activities:<br>● exercises developing CAD skills and using relevant use of navigation commands, e.g. absolute, relative and polar entry systems<br>● exercises developing CAD skills and using relevant use of drawing commands, e.g. types of line, grids, snaps, circle, text, hatching, dimensioning<br>● exercises to produce, store, retrieve and modify CAD-generated drawings. |
| Tutor demonstration or individual practical activities:<br>● printing and plotting drawings using appropriate scale and paper size in order to produce hard copies of CAD generated drawings of components and assemblies in both 1st and 3rd angle orthographic projection<br>● using editing and modification commands, e.g. array, copy, move, rotate, erase, stretch, trim, scale, chamfer and fillet, change layers, colours and line types. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, P7, P8, D2 – partial – 1st drawing)** |

| Topic and suggested assignments, activities and assessments |
|---|
| Individual learner activities:<br>● exercises on using isometric tools and techniques to produce CAD-generated drawings<br>● exercises on using scale and paper size in order to produce hard copies of isometric drawings. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P5, M1, M3, D2 – partial – 2nd drawing)** |
| Individual learner activities:<br>● exercises on using appropriate tools and techniques to produce CAD-generated drawings of components, symbols and associated hardware used in circuit diagrams, e.g. hydraulic, electronic, electrical, pneumatic<br>● exercises on using text annotation to correctly label circuit components<br>● 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.<br>**Assignment 3 (P4, P6, M2, D1, D2 – partial – 3rd drawing)** |
| Unit review, feedback and evaluation. |

## Assessment guidance

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 and 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, printing and 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 producing detailed and accurate drawings within agreed timescales (D2).

Assignment 2 will involve producing an isometric drawing (P3) and modifying 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). It would also address the second drawing required by D2.

Assignment 3 will involve producing a circuit diagram (P4) and modifying two different types of circuit diagrams (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 drawing commands 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 to demonstrate competence in producing detailed and 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, P7, P8, D2 (in part – 1st drawing) | CAD Drawing Using an Orthographic Projection Method | Learners produce a CAD drawing using orthographic projection from a given diagram or exhibited component. | 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 or printed hard copy. Witness statements demonstrating time taken and competence in setting up and closing down CAD hardware and software. Setting up and using electronic folders for the storage and retrieval of CAD drawings. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P3, P5, M1, M3, 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.<br>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.<br>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, 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.<br>Screen dumps can be used to show an annotated range of commands used and time taken. |

## Suggested resources

### Books


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

**Websites**

| | |
|---|---|
| http://www.autodesk.co.uk/suites/product-design-suite/overview | AUTODESK website with free trial software and route to AUTOCAD |
| http://en.wikipedia.org/wiki/Computer-aided_design | Wikipedia article with plentiful reference links |
| http://www.freecadweb.org/ | Website for free CAD software resources (FreeCAD) |
| http://sourceforge.net/directory/science-engineering/os:windows/freshness:recently-updated/ | General resource site for free and approval software with many science and engineering offerings including some CAD softwares |

# Unit 11: Operation and Maintenance of Mechanical Systems and Components

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20666G** |

**This unit is internally assessed**

## Unit aim

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

## Unit introduction

Mechanical engineering equipment, systems, processes and service operations all need to be maintained in order 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 for a given mechanical maintenance operation | M1 Carry out a suitable risk assessment for a mechanical work area and report on findings | D1 Analyse a given mechanical system for ease of safe maintenance |
| P2 Describe, with the aid of block diagrams, the operation of a given mechanical system | M2 Explain the relationship between component faults and the malfunction of a mechanical system | D2 Compare and contrast different fault-finding techniques when carrying out maintenance work on a mechanical system |
| P3 Select appropriate mechanical system components using manufacturers' databases or parts catalogues | M3 Explain the reasons for following correct procedures and carrying out post rectification tests when undertaking corrective maintenance on mechanical systems | |
| P4 Describe the function and operation of different mechanical system components | M4 Explain the benefits of carrying out routine maintenance on a mechanical component or system | |
| P5 Use appropriate fault-finding aids or techniques to identify a given problem in a mechanical system and report findings | | |

| 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:** |
| 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 | | |
| P7 Carry out a routine maintenance operation on a mechanical component or system, using the correct documentation and record actions | | |

## Unit content

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

Workplace hazards:

- e.g. 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, e.g. appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators
- personal health, e.g. appropriate use of barrier creams, personal cleanliness, consumption of food, prompt attention to injuries
- procedures, e.g. response to alarms, use of safety equipment, reporting of accidents, reporting of hazardous items of plant or equipment
- safe working practices, e.g. 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
- 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:

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

Dismantling and assembly:

- aids, e.g. use of manufacturers' service manuals, parts lists and drawings, approved working procedures, spare parts catalogues, maintenance manuals
- systems, e.g. power transmission, rotary equipment, lifting and handling

Component removal or fit and replacement:

- components, e.g. fasteners, seals, gaskets, bearings, transmission components
- use of appropriate tools, equipment and documentation, e.g. 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, e.g. leak detection, wear, chafing, fouling, security of attachment, overheat, corrosion, lubrication, replenishments, adjustments, replacements, repair
- reports and documentation, e.g. 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

# Information for delivery staff

## Essential requirements

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 or alternatively databases, flow charts and system diagrams
- British or 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 outcome of learning 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 organisations that may be able to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcomes of learning 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 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 maintain mechanical components and systems in most industrial settings.

Learners must be made aware of, and have access to, relevant UK and local 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 outcomes of learning are ordered logically and it would be reasonable to deliver them sequentially throughout the unit.

All the outcomes of learning 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 practice. 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.

Outcome of learning 4 has a high reliance on understanding developed from the other three outcomes of learning.

As such, teaching and learning needs to focus on the development of this knowledge so that it may be applied to outcome of learning 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:<br>● introduction to unit content, overview of activities and assessment methods, issue of scheme of work and assessment plan<br>● introduction to types of mechanical systems and components. Identify hazards associated with the mechanical workplace/workshop environment.<br>Practical exercise:<br>● learners identify potential hazards in the workshop or workplace and how the risk from these hazards has been minimised using good practice. |
| Whole-class teaching and workshop demonstration and practise:<br>● health and safety requirements for a mechanical workshop environment –personal safety, personal health, procedures, safe working practices.<br>Individual learner exercise:<br>● using safety documents and physical walk round, learners to familiarise themselves with centre workshop and workplace local safety rules, placards and procedures. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1)** |

| Topic and suggested assignments, activities and assessment |
|---|
| Workshop teaching and demonstration:<br>● demonstration and explanation of appropriate system function and operation, using actual mechanical system.<br>Explanation of associated operational and isolation safety of the particular system<br>● demonstration and explanation of mechanical components and consumables, e.g. bearings, seals, gaskets, lubricating devices, fasteners and mechanical hardware<br>● demonstrate use of associated manuals, parts catalogues and manufacturers databases, used for information on component selection, function and where appropriate, operation<br>● using actual mechanical system, demonstrate and explain the function and basic operation of major components.<br>Learner exercise:<br>● 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<br>● 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:<br>● given the appropriate maintenance and parts manuals or database, together with a range of mechanical components and consumables learners identify components, state their function, detail common faults and where appropriate describe their operation. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, P5)** |
| Workshop or workplace whole-class teaching and demonstration:<br>● fault-finding theory, related safety and use of aids and instruments<br>● application of fault-finding theory to relevant system/s<br>● system dismantling, assembly and functional testing techniques, related safety precautions and use of manufacturers and other maintenance documentation<br>● system component removal and fit or replacement and system functional test.<br>Practical learner exercises:<br>● fault-finding using a range of aids, instruments, techniques and appropriate maintenance documentation and manuals<br>● system dismantling, assembly and test<br>● system component removal or fitting, or alternatively 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. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P6, M2, M3, D1, D2)** |

| Topic and suggested assignments, activities and assessment |
|---|
| Workshop teaching and demonstration:<br>● routine maintenance theory, benefits and activities (such as rivet or other fastener replacement, bearing replacement or re-grease, minor repairs, system and component lubrication, replenishments, examination and adjustments), completion of maintenance documentation, and related safety issues.<br>Practical learner exercises:<br>● undertake a range of routine maintenance activities, following best safe practice and completing maintenance documents. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P7, M4)** |
| Unit review. |

## Assessment guidance

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 outcome of learning 1 could come from a written assignment, requiring learners to describe the hazards and health and safety requirements related to a mechanical maintenance activity (P1). In order to identify and recognise the significance of workplace hazards and meet M1, learners will need to carry out a risk assessment of their own workshop or workplace environment and produce a written report on their findings.

Outcomes of learning 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, which should be selected by the tutor based on the specialist needs of the learner.

Outcome of Learning 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 or 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 or fault on a given mechanical system using four fault-finding aids or 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 or 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 explain 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 explaining 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 suggested 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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. |
| P5, P6, M2, M3, D1, D2 | System Fault-Finding, Dismantling together with Assembly and Testing | A multi-stage practical and theoretical activity, requiring learners to fault-find, dismantle, reinstate 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 vivavoce and tutor observations together with learners' response to written tasks. |

## Suggested resources

### Books

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

**Websites**

| | |
|---|---|
| http://workshop-manuals.com/ | Free workshop manuals for download. Motor trade emphasis |
| http://en.wikipedia.org/wiki/Fault_detection_and_isolation | Wikipedia article |
| learn.yale-wrexham.net/mod/resource/view.php?id=72246 | Downloadable Powerpoint regarding machine diagnosis |

# Unit 12: Operation and Maintenance of Electrical Systems and Components

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20667G** |

**This unit is internally assessed**

## Unit aim

This unit will develop learners' knowledge of the function, operation and maintenance of a variety of electric systems and system components. Learners will develop the skills needed safely to undertake maintenance activities on a range of electrical systems and components used in industry.

## 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 interpret correctly maintenance procedures, safe working practices, and health and safety requirements when carrying out routine maintenance activities.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 for a given electrical maintenance activity | M1 Carry out a suitable 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 Explain the relationship between component faults and the malfunction of a piece of electrical equipment or system | D2 Compare and contrast 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 and checks when undertaking corrective maintenance on electrical systems | |
| P4 Select appropriate electrical equipment or system components using manufacturers' data bases or parts catalogues | M4 Explain the benefits of carrying out routine maintenance on an electrical component, equipment or system | |
| P5 Describe the function and operation of different electrical system components | | |

| 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:** |
| P6 Use appropriate fault-finding aids or techniques to identify the problem in an electrical system and report findings | | |
| 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 | | |
| P8 Carry out routine maintenance activities on an electrical component or system, using the correct documentation and record actions | | |

## Unit content

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

Workplace hazards:

- e.g. 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, e.g. appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators, electrical testing safety
- personal health, e.g. appropriate use of barrier creams, personal cleanliness, consumption of food, prompt attention to injuries
- procedures, e.g. 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, e.g. 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, e.g. switchgear and distribution panels, electrical plant, wiring enclosures, portable appliances, motors and starters, luminaires, control systems, small fans, pumps, compressors, alarm and safety systems

Electrical circuits:

- wiring diagram representation
- circuit, e.g. 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, e.g. cables and connectors, batteries, transformers, rectifiers, contactors
- circuit components, e.g. capacitors, circuit boards, switches, solenoids, thermistors, thermocouples
- devices, e.g. 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, e.g. intermittent operation, partial failure or out-of specification output, complete breakdowns
- aids, e.g. functional charts, diagrams, troubleshooting 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, e.g. six point (collect the evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system), half split, input and output, unit substitution, emergent sequence, visual examination, unit substitution
- documentation, e.g. operation and maintenance manuals, fault and repair reports, final test handover procedures

Dismantling and assembly:

- aids, e.g. use of manufacturers' service manuals, parts lists and drawings, approved working procedures, spare parts catalogues, maintenance manuals
- systems and equipment, e.g. switchgear and distribution panels, electrical plant, wiring enclosures, portable appliances, motors and starters, luminaires, control systems, fans, pumps, compressors, alarm and safety systems

Component and equipment removal and replacement:

- components, e.g. damaged wires and cables, electrical units or components, termination and connection, soldering and de-soldering
- use of appropriate tools, equipment and documentation, e.g. 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, e.g. as wear, chafing, fouling, security of attachment, missing or loose fittings, adjustments, replacements
- reports and documentation, e.g. BS, ISO and BSEN standards, scheduled maintenance reports, corrective maintenance reports, other company-specific reports, job cards, maintenance logs, recording of condition, use of maintenance manuals and parts catalogues

## Information for delivery staff

### Essential requirements

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 or alternatively databases, flow charts, electrical circuit and system diagrams
- British and 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 outcome of learning 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 organisations that may be able to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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

All the outcomes of learning 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 practice. 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.

Outcome of learning 4 has a high reliance on understanding developed from the other three outcomes of learning.

As such, teaching and learning needs also to focus on the development of this knowledge in order that it may be applied to outcome of learning 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 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:<br>● introduction to unit content, overview of activities and assessment methods, issue of scheme of work and assessment plan<br>● introduction to different types of electrical systems, equipment and components; identify hazards associated with the workplace and workshop environment.<br>Practical exercise:<br>● learners identify potential hazards in the workshop or workplace and how the risk from these hazards has been minimised using good practice. |
| Whole-class teaching and workshop demonstration and practise:<br>● health and safety requirements for an electrical workshop environment – personal safety, personal health, procedures, safe working practices.<br>Individual learner exercise:<br>● using safety documents and physical walk round, learners to familiarise themselves with centre workshop or workplace local safety rules, placards and procedures. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, M1)** |

| **Topic and suggested assignments, activities and assessment** |
|---|
| Workshop teaching and demonstration:<br>● 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<br>● explain the operation of electrical system components (electrical supply, circuit components, devices)<br>● demonstrate the use of associated manuals, parts catalogues and manufacturers' databases, used for information on component/ or device selection, function and where appropriate, operation.<br>Learner exercises:<br>● 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<br>● 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:<br>● given the appropriate maintenance and parts manuals or database, together with a range of electric system components or devices, learners identify components and devices, state their function, detail common faults and where appropriate describe their operation. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P2, P3, P4, P5)** |
| Workshop or workplace whole-class teaching and practical demonstration:<br>● explain fault-finding theory, related safety and use of aids and instruments<br>● application of fault-finding theory to relevant systems and circuits<br>● system and equipment dismantling, assembly and functional check and test techniques, related safety precautions and use of manufacturers' and other maintenance documentation<br>● system component removal and fit or replacement and system functional test.<br>Practical learner exercises:<br>● fault-finding using a range of aids, instruments, techniques and appropriate maintenance documentation and manuals<br>● equipment dismantling, assembly and testing<br>● removal and fitting and or alternatively replacement of identified faulty components and post assembly functional checking and testing. |
| Industrial visit:<br>● visit regional electrical maintenance or electrical component assembly and testing company.<br>Learner exercise:<br>● completion of a pre-designed questionnaire relating to workplace safety, fault-finding and associated electrical maintenance activities. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P6, P7, M2, M3, D1, D2)** |

| Topic and suggested assignments, activities and assessment |
| --- |
| Workshop teaching and demonstration:<br>● routine maintenance theory, benefits and activities, completion of maintenance documentation, related safety issues.<br>Practical learner exercises:<br>● undertake a range of routine maintenance activities, following best safe practice and completing maintenance documents. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P8, M4)** |

## Assessment guidance

Evidence of achieving the outcomes of learning 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 outcome of learning 1 could come from a written assignment, requiring learners to describe the hazards and safe working practices related to an electrical maintenance activity (P1). In order to identify and recognise the significance of workplace hazards and meet M1, learners will need to carry out a risk assessment of their own workshop or workplace environment and produce a written report on their findings.

Outcomes of learning 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 describe, with the aid of diagrams a given electrical circuit. 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 or devices. These should be selected by tutors based on the specialist needs of the learner.

Outcome of learning 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 or 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 or fault on a given electrical system using four fault-finding aids or 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 or part identified as causing the problem, reassemble the system and carry out a simple test or 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 explain 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 explaining 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 suggested 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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 written tasks that have been set. |
| P6, P7, M2, M3, D1, D2 | System Fault-finding, Dismantling and Assembly and Testing | A multi-stage practical and theoretical activity, requiring learners to fault-find, dismantle, remantle 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 vivavoce and tutor observations together with the learner's response to written tasks. |

## Suggested resources

### Books

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

**Websites**

| | |
|---|---|
| http://www05.abb.com/global/scot/scot252.nsf/veritydisplay/dff84c4ff41d7a47852573fa007aa61f/$file/1zcl000002eg%20users%20manual.pdf | ABB transformer maintenance manual |
| https://www1.eere.energy.gov/femp/pdfs/OM_9.pdf | Maintenance guide manual for thermal power installations (US practice) |
| http://accessengineeringlibrary.com/browse/electrical-equipment-handbook-troubleshooting-and-maintenance | Access engineering library on-line hyperlinked manual |

# Unit 13: Operation and Maintenance of Electronic Systems and Components

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20668G** |

**This unit is internally assessed**

## Unit aim

This unit will develop learners' knowledge of the function, operation and maintenance of a variety of electronic systems and system components. Learners will develop the skills needed safely to undertake maintenance activities on a range of electronic systems and components used in industry.

## Unit introduction

Electronic engineering equipment, circuits, systems, processes and services, all need to be maintained to ensure their 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 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 electronic engineering.

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. 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 for specific electronic maintenance activities | M1 Carry out a suitable 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 Explain the relationship between component faults and the malfunction of a piece of electronic equipment or system | D2 Compare and contrast 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 and checks when undertaking corrective maintenance on electronic systems | |
| P4 Select appropriate electronic equipment or system components using manufacturers' databases or parts catalogues | M4 Detail the benefits of carrying out routine maintenance on an electronic component, equipment or system | |
| P5 Explain the function and operation of different electronic system components | | |

| 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:** |
| P6 Use appropriate fault-finding aids or techniques to identify the problem in an electrical system and report findings | | |
| 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 | | |
| P8 Carry routine maintenance on an electronic component, equipment or system, using the correct documentation and record actions | | |

## Unit content

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

Workplace hazards:

- e.g. 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, e.g. appropriate dress, protective clothing, appropriate or protective headgear, protective gloves and footwear, eye protection, face masks and respirators, electronic testing safety
- personal health, e.g. appropriate use of barrier creams, personal cleanliness, consumption of food, prompt attention to injuries
- procedures, e.g. 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, e.g. 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 and equipment, e.g. 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 and data network systems

Electronic circuits:

- wiring and schematic diagram representation
- circuits, e.g. sensor and 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, e.g. cables and connectors, batteries, transformers, rectifiers, contactors
- circuit components, e.g. capacitors, fixed resistors, variable resistors, thermistors, transistors, diodes
- devices, e.g. 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, e.g. intermittent operation, partial failure or out-of specification output, complete breakdowns
- aids, e.g. functional charts, wiring diagrams, schematic diagrams, troubleshooting 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, e.g. 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, e.g. operation and maintenance manuals, fault/repair reports, final test handover procedures

Dismantling and assembly:

- aids, e.g. use of manufacturers' service manuals, parts lists and drawings, approved working procedures, spare parts catalogues, maintenance manuals
- systems and equipment, e.g. sensor and actuator, alarm or protection, transmission, data network, ADC/DAC circuits, circuit boards, motor control circuits

Component or equipment removal and replacement:

- e.g. wiring and cables, terminations and connections, servo controllers, sensors, integrated circuits, protection devices, inverters, use of appropriate tools, equipment and documentation, e.g. 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, e.g. wear, chafing, fouling, security of attachment, missing or loose fittings, adjustments, performance, continuity, input/output, replacements
- reports and documentation, e.g. BS, ISO and also 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

# Information for delivery staff

## Essential requirements

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 alternatively databases, flow charts, electronic circuit and system diagrams
- British and 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 outcome of learning 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 organisations that may be able to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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

All the outcomes of learning 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.

Outcome of learning 4 has a high reliance on understanding developed from the other three outcomes of learning.

As such, teaching and learning needs to focus on the development of this knowledge in order that it may be applied to outcome of learning 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:<br>● introduction to unit content, overview of activities and assessment methods, issue of scheme of work and assessment plan<br>● ensure learners have correct personal safety equipment for their working environment<br>● introduction to the types of systems, equipment and components found in an electronic maintenance, working environment<br>● identify hazards associated with the workshop environment.<br>Visit to centre workshop and learners workplace:<br>● 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.<br>Practical exercise:<br>● learners identify potential hazards in the workshop or workplace and how the risk from these hazards has been minimised using good practice. |
| Whole-class teaching and workshop demonstration and practise:<br>● health and safety requirements for an electronic workshop environment – personal safety, personal health, procedures, safe working practices.<br>Individual learner exercise:<br>● using safety documents and physical walk round, learners to familiarise themselves with centre workshop and workplace local safety rules, placards and procedures. |

| Topic and suggested assignments, activities and assessment |
|---|
| Prepare and carry out assignment.<br>**Assignment 1 (P1, M1)** |
| Whole-class workshop teaching:<br>● function and operation of electronic system components and devices<br>● demonstrate use of associated manuals, parts catalogues and manufacturers databases, used for information on component and device selection, function and where appropriate, operation.<br>Learner exercise:<br>● given the appropriate maintenance and parts manuals and database, together with a range of electronic system components or devices, learners identify components and devices, state their function, detail common faults and where appropriate describe their operation. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P2, P3, P4, P5)** |
| Workshop teaching and demonstration:<br>● describe the different electronic systems and circuits; electronic circuits and symbols<br>● explain appropriate system function and operation, using live system and circuit set-up<br>● explanation of associated operational and isolation safety of the particular system<br>● workshop teaching at an electronic system/equipment – system major components function and basic operation given. |
| Learner exercise:<br>● 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 and actuator or alarm or protection circuit and describe the purpose of the components, within the circuit<br>● 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:<br>● fault-finding theory, related safety and use of aids and instruments.<br>Workshop teaching and demonstration:<br>● demonstration of application of fault-finding theory to relevant systems and circuits<br>● system and equipment dismantling, assembly and functional check and test techniques, related safety precautions and use of manufacturers and other maintenance documentation<br>● system and circuit component removal and fitting and replacement and system and circuit functional test.<br>Practical learner exercises:<br>● fault-finding using a range of aids, instruments, techniques and appropriate maintenance documentation and manuals<br>● system and equipment dismantling, assembly and test<br>● given system and circuit component removal and fitting and or alternatively replacement of identified faulty components and post assembly functional checking and testing. |

| Topic and suggested assignments, activities and assessment |
|---|
| Industrial visit:<br>● visit to regional electronic maintenance or electronic component assembly and testing company.<br>Learner exercise:<br>● completion of a pre-designed questionnaire relating to workplace safety, fault-finding and associated electronic maintenance activities. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P6, P7, M2, M3, D1, D2)** |
| Workshop teaching and demonstration:<br>● routine maintenance theory, benefits and activities, e.g. inspection and checking of electronic wiring, cabling, fixtures, fittings, terminations, soldered joints, (such as wear, chaffing, fouling, security of attachment, mechanical damage, fire damage), adjustments, component, equipment and system tests for correct operation, completion of maintenance documentation, and related safety issues.<br>Practical learner exercises:<br>● undertake a range of routine maintenance activities, following best safe practice and completing maintenance documents. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P8, M4)** |

## Assessment guidance

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 outcome of learning 1 could come from a written assignment, requiring learners to describe the hazards and health and safety requirements related to an electronic maintenance activity (P1). In order to identify and recognise the significance of workplace hazards and meet M1, learners will need to carry out a risk assessment of their own workshop or workplace environment and produce a written report on their findings.

Outcomes of learning 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 describe, with the aid of diagrams a given electronic circuit. 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 explain the function and operation of six electronic system components or devices. These should be selected by tutors based on the specialist needs of the learner.

Outcome of learning 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 and 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 or 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 or part identified as causing the problem, reassemble the system and carry out a simple test or 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 explain 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 complete successfully 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 electronic 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 suggested 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, and assembly and Testing | A multi-stage practical and theoretical activity, requiring learners to fault-find, dismantle and remantle 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. |

## Suggested resources

### Books

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

Sinclair I and Lewis G – *Electronic and Electrical Servicing* (Newnes, 2002) ISBN 0750654236

### Websites

| | |
|---|---|
| http://www.usbr.gov/power/data/fist/fist4_1b/fist4_1b.pdf | Maintenance scheduling of electrical equipment managed by The Bureau of Land Reclamation (US) |
| http://www05.abb.com/global/scot/scot252.nsf/veritydisplay/dff84c4ff41d7a47852573fa007aa61f/$file/1zcl000002eg%20users%20manual.pdf | ABB transformer maintenance manual |
| https://www1.eere.energy.gov/femp/pdfs/OM_9.pdf | Maintenance guide manual for thermal power installations (US practice) |
| http://accessengineeringlibrary.com/browse/electrical-equipment-handbook-troubleshooting-and-maintenance | Access engineering library on-line hyperlinked manual |

# Unit 14: Secondary Machining Techniques

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20669G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge and skills of exploring, selecting and using appropriate secondary machining techniques.

## Unit introduction

This unit will provide learners with knowledge of the manufacturing processes mainly associated with generating and forming shapes through machining techniques. The unit introduces the learner to secondary machining techniques, focusing on the traditional techniques of turning, milling, drilling and grinding, primarily giving a deeper understanding of the practical processes involved.

Learners will develop skills in and knowledge of 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 operational and safety requirements of these techniques.

In this unit learners will also 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.

## Outcomes of learning

On completion of this unit a learner should:

1 Know how a range of secondary machining techniques are used

2 Know how workholding 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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 secondary machining techniques are used to produce components | 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 correct use of workholding devices for different machining techniques | M2 Explain the importance of using the correct tooling and having machine parameters set correctly when machining a workpiece | D2 Compare and contrast different secondary machining techniques for accuracy and safety of operation |
| P3 Describe the correct use of workholding tools for different machining techniques | | |
| P4 Carry out machining procedures, monitoring and adjusting machining parameters to produce the features as defined by the workpiece | | |
| P5 Carry out machining procedures adhering to safe working practices  Machine a given workpiece safely and carry out necessary checks for accuracy | | |

| 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:** |
| P6 Carry out appropriate checks for accuracy, on a given workpiece | | |
| P7 Describe different methods of reducing risk when carrying out secondary machining techniques | | |

## Unit content

### 1 Know how a range of secondary machining techniques are used

Secondary machining techniques:

- a range of secondary machining techniques, e.g.:
  - for turning: generation of shapes; forming of shapes, e.g. centre lathe, capstan, turret, automatic
  - for milling: generation of shapes; forming of shapes, up-cut, down-cut, e.g. horizontal, vertical
  - for drilling: e.g. pedestal, bench, radial
  - for grinding: e.g. surface, cylindrical, centreless, profile grinding, thread grinding

### 2 Know how workholding devices and tools are used

Workholding devices:

- workholding devices for secondary machining techniques, e.g.:
  - for turning: e.g. 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: e.g. 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: e.g. clamping direct to machine table, machine vice, angle plate, vee block and clamps, fixtures
  - for grinding: e.g. 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, e.g. solid high speed steel, brazed tungsten carbide, indexible tips, composite wheels
- tools for specific secondary machining techniques, e.g.:
  - for turning: e.g. turning tools, facing tools, form tools, parting off tools, thread chaser, single point threading, boring bars, recessing tools, centre drills, twist and core drills, solid reamers, expanding reamers, taps, dies, knurling tool
  - for milling: e.g. face mills, slab mills and cylindrical cutters, side and face cutters, slotting cutters, slitting saws, profile cutters, twist drills, boring tools, end mills, slot drills
  - for drilling: e.g. drill bit, flat bottomed drill, counter-boring tool, countersinking tool, centre drill, spot facing tool, reamer, tap
  - for grinding: e.g. 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 and safety mechanisms
- parameters for different secondary machining techniques, e.g.:
  - for turning: e.g. threading, profile, and taper mechanisms, workpiece revolutions per minute, linear feed rate, depth of cut for roughing and finishing
  - for milling: e.g. linear and table feed rate, milling cutter revs per minute, depth of cut for roughing and finishing
  - for drilling: e.g. tooling revs per minute, linear feed rate, swarf clearance
  - for grinding: e.g. linear/table feed rate, depth of cut for roughing and finishing, cross feed, dressing of wheels

Features of the workpiece:

- producing features, e.g.:
  - for turning: e.g. 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: e.g. flat faces, square faces, parallel faces, angular faces, steps and shoulders, open ended slots, enclosed slots, recesses, tee slots, drilled holes, bored holes, profile forms, serrations, indexed or rotated forms, special forms
  - for drilling: e.g. blind holes, through holes, flat bottomed holes, counter-bored holes, countersinking, spot facing, reaming, tapping
  - for grinding: e.g. flat faces, vertical faces, parallel faces, faces square to each other, shoulders and faces, slots, parallel diameters, tapered diameters, counter-bores, 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, e.g.:
  - for turning: e.g. 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: e.g. 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: e.g. 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: e.g. 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, e.g. risk assessment, avoidance of dangerous conditions

Working safely:

- moving parts
- machine guards
- handling cutting fluids
- insecure components
- emergency stop and machine isolation
- wearing appropriate protective clothing and equipment
- clean and tidy work area
- safe working relevant to specific secondary machining techniques, e.g.:
  - for turning: e.g. handling turning tools, airborne particles, tool breakage, swarf disposal
  - for milling: e.g. handling milling cutters, cutter breakage, swarf disposal, backlash in machine slides
  - for drilling: e.g. handling drills, taps and reamers, tool breakage, swarf disposal
  - for grinding: e.g. handling grinding wheels, sparks and airborne particles, bursting wheels

# Information for delivery staff

## Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcome of learning 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 and/or local 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 'e.g.' 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 'e.g.' needs to be taught or assessed. The content guidance is normative and not prescriptive.

**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:<br>● introduction to engineering workshop<br>● class exercise on identifying different machine tools<br>● health and safety briefing, legislation and assessment of risk<br>● class exercise on risk assessments.<br>Practical workshop activity:<br>● identify safety devices and equipment. |
| Whole-class teaching:<br>● explain the principles of turning, milling, drilling and grinding.<br>Workshop activity:<br>● identifying individual component parts and features of machines and safety precautions. |
| Workshop activities:<br>● identify key features of a range of components<br>● use of measurement tools, techniques and gauges to determine appropriate levels of accuracy. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, M1)** |
| Small-group activities:<br>● demonstration of the use of work holding devices for different manufacturing techniques.<br>Individual learner exercise:<br>● use of work holding devices. |
| Small-group activities:<br>● workshop demonstration of the use of different tools<br>● demonstration of the use of different tools for different applications. |

| Topic and suggested assignments, activities and assessment |
|---|
| Prepare for and carry out assignment.<br>**Assignment 2 (P2, P3)** |
| Workshop activity:<br>● workshop demonstration on the use of a manufacturing technique and the use of guards and safety devices, lubricants etc. |
| Workshop activity:<br>● closely supervised small-group machining activity. |
| Individual learner exercise:<br>● using appropriate techniques to manufacture a component to a given standard. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P4, P5, P6, P7, M2, D1, D2)** |
| Review of unit delivery and assessment. |

## Assessment guidance

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 cover techniques, use of work-holding devices and tools and describing methods of reducing risk when machining workpieces. 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 explain the importance of monitoring the features of the workpiece 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 monitoring certain features for accuracy 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 P7) and the second merit criteria (M2) rely on practical activities in the workshop, in addition describing methods of reducing risk and the importance of using the correct machine parameters and tooling 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 suggested 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, P7, M2, D1, D2 | Using Secondary Machining Techniques Safely | An activity requiring learners to machine a given workpiece using a secondary machining technique and observing the accuracy, health and safety, use of tooling and method used. | A practical demonstration supported by witness statements and observation records and annotated photographs. A report evaluating the suitability of the chosen secondary machining techniques with reference to two other methods 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. |

## Suggested resources

### Books

Meyers A and Slattery J – *Basic Machining Reference Handbook* (International Press Inc, 2001) ISBN 0831131209

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

### Websites

| | |
|---|---|
| http://en.wikipedia.org/wiki/Machining | Wikipedia article on basic machining with the usual references and links |
| http://www.thomasnet.com/articles/custom-manufacturing-fabricating/types-machining | An American portal to the more modern machining techniques |
| http://www.egr.msu.edu/~pkwon/me478/operations.pdf | Powerpoint PDF about basic machining and its formulae and equations |
| http://www3.nd.edu/~manufact/MPEM_pdf_files/Ch08.pdf | Well-illustrated, mathematical PDF issued by Pearson Publishing in 2008 |

# Unit 15: Part Programming CNC Machines

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20670G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' skills in planning, part programming and using 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. 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 the final execution of the program.

## Outcomes of learning

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 proof reading procedure for a CNC program and check conformity to specification.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | 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 | M2 Describe the methods used to store, retrieve, transfer, load and run a CNC program | D2 Compare two different methods of proof reading used to check a given part program |
| P3 Load, store, retrieve and transfer a CNC program | M3 Explain the proof reading methods used to check a program conforms to specification | |
| P4 Run a part program to operate a CNC machine safely | | |
| P5 Use proof reading methods to check a program | | |
| P6 Use equipment to check conformity to the 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:

- e.g. 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, e.g. 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)
- downloading
- storing and retrieving programs, e.g. tapes, disks or CDs
- downloading via computer interface
- program edit facilities

Run part programs on CNC machines:

- e.g. 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:

- e.g. simulation/graphing software
- single block program run
- dry run
- over-ride controls
- adjustments for tool or probe compensation

Conformity to specification:

- features, e.g. unilateral and bilateral tolerances, direct measurement
- equipment, e.g. rulers, callipers, micrometers, slip gauges

# Information for delivery staff

## Essential requirements

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 speakers 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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcomes of learning 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 outcomes of learning 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● introduction to unit content, assessment strategy and method of working<br>● introduction to product specifications, including consideration of materials to be machined, cutting tools required, speeds and feeds of cutting processes and product tolerances.<br>Group work:<br>● examination of a range of product specifications to extract relevant information.<br>Whole-class teaching:<br>● examination of CNC machine types (e.g. turning, milling, EDM, etc) and their applications.<br>Group work:<br>● match CNC machines to required machining methods for given product specifications. |
| Whole-class teaching:<br>● 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.<br>Group work:<br>● preparing a plan for the manufacture of a product, using a CNC machines, from the product specification.<br>Group presentation:<br>● present plans for given CNC machines and products. Invite feedback from the group and discuss possible enhancements to the plan. |

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>● examine datum points, co-ordinate systems and relationship with machine axes.<br>Group work:<br>● setting datum and co-ordinates for a given product.<br>Whole-class teaching:<br>● tutor demonstration of writing a part program for a given product and CNC machine; examination of safety issues associated with machining processes.<br>Group work:<br>● writing a part program for the manufacture of a product from a CNC machining plan. |
| Group presentations:<br>● present part program including identified risks; invite feedback from the group and discuss possible enhancements to the program. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2)** |
| Whole-class teaching:<br>● tutor demonstration of how to safely load and store a part program.<br>Group work:<br>● writing, loading and storing part programs. |
| Whole-class teaching:<br>● tutor demonstration of how to safely retrieve and transfer a part program.<br>Group work:<br>● retrieving and transferring part programs. |
| Whole-class teaching:<br>● tutor demonstration of how to safely run a part program on a CNC machine.<br>Group work:<br>● summative activities to write, load, store and run part programs on CNC machines. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, M1, M2, D1)** |
| Whole-class teaching:<br>● introduction to proofreading a CNC part program and checking for conformity to specification<br>● discussion and tutor demonstrations of proofreading and conformity check techniques.<br>Group work:<br>● 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.<br>**Assignment 3 (P5, P6, M3, D2)** |
| Unit review, feedback and evaluation. |

## Assessment guidance

Evidence of learners' achievement of the outcomes of learning 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 (e.g. 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 proof reading methods to check a part program and equipment to ensure 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 suggested 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:<br>• the part program used<br>• tutor observation records of practical tasks<br>• printout records<br>• photographic records of processes<br>• 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:<br>• annotated and amended part program<br>• records of test runs<br>• records of equipment used and results of tests<br>• tutor observation records<br>• written explanation/comparison of proofreading methods. |

## Suggested resources

### Books

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

# Unit 16: Application of Welding Processes

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20671G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' knowledge and skills to carry out a range of welding techniques safely and effectively 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 practice.

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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 causes of weld defects, suggesting remedies for different defects that can be found in a welded joint |
| P2 Select the appropriate tools, equipment and information needed when materials are to be joined by welding | 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 correct procedures used during a destructive or non-destructive test | |
| P4 Produce two joints safely and to a required quality standard using different welding positions | | |
| P5 Produce two joints safely and to a required quality standard using different types of joint | | |
| P6 Perform two destructive and two non-destructive tests and record the test outcomes | | |

## Unit content

**1 Know about health and safety legislation and safe working practices when welding**

Legislation:

- aspects relevant to welding, e.g. Health and Safety at Work Act 1974, 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, e.g. materials, safe handling of gas cylinders
- checking conditions, e.g. 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, e.g. within the learning environment, workplace
- common hazards associated with welding, e.g. fumes, burns, radiation, electric shock

**2 Be able to prepare for work in a welding environment**

Tools and equipment:

- equipment availability, e.g. cables, hoses, torches/electrode holders, gas pressure regulators, flow meters
- assembling welding equipment, e.g. cables, weld return clamps, electrode holders, gas supplies, safety devices
- setting and adjusting welding conditions, e.g. gas pressures/flow rates, voltage, amperage
- connecting the weld return lead

Information sources:

- safety instructions
- job instructions
- engineering drawings
- quality control documentation, e.g. weld procedure specification, record/reporting sheet

Welding:

- processes, e.g. 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, e.g.:
  - for MMA: e.g. rutile, basic, nickel alloy, cellulosic, stainless steel, other electrodes
  - for MIG, MAG and cored wire: e.g. two wire types from different groups, two different shielding gases where applicable
  - for TIG, plasma-arc: e.g. one size of electrode, two types of filler wire from different material groups
  - for gas welding: oxygen; acetylene; filler wire, e.g. 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, e.g. 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, e.g. flat (PA), horizontal vertical (PB), horizontal (PC), vertical upwards (PF), vertical downwards (PG)
- welding technique, e.g. torch and filler angles for various positions

Joints:

- producing joints using welding processes, e.g.:
  - 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, e.g. carbon steel, stainless steel, aluminium
- forms, e.g. 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, e.g. 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, e.g. visual, dye penetrant, fluorescent particle, magnetic particle
- destructive, e.g. macroscopic examination, nick break (fracture) tests, bend tests
- non-thermal specimen removal processes, e.g. hand saws, power saws, abrasive discs
- specimen preparation processes, e.g. 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

## Information for delivery staff

### Essential requirements

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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning 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 the 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● introduction to welding producing permanent joints<br>● specific processes applicable to welding<br>● health and safety related to welding and safe working practices. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, M1)** |
| Whole-class teaching:<br>● sources of information required and used when welding<br>● selection of welding processes<br>● theory of welding practice<br>● tools and equipment required and used during welding. |
| Workshop practical session:<br>● process selection<br>● introduction to welding equipment used<br>● preparation for use, shutdown procedures and storage of equipment. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P2, P3)** |
| Whole-class teaching:<br>● welding theory: techniques, joints, materials, positions<br>● weld quality standards<br>● visual inspection of welds and common defects and irregularities. |
| Workshop demonstrations followed by individual learner practice:<br>● safety in welding workshops<br>● welding basics – process specific<br>● techniques in welding different joints<br>● techniques in welding different materials<br>● techniques in welding different positions<br>● weld quality and visual inspection. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P4, M2, D1)** |

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>● weld testing theory: visual, destructive and non-destructive<br>● test standards<br>● test procedures<br>● methods of reporting. |
| Workshop practical followed by individual learner practice:<br>● preparation of joints for testing<br>● testing of welded joints<br>● reporting results of weld tests. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P5, P6, M3, D2)** |

## Assessment guidance

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' knowledge of health and safety legislation and safe working practices; however a written description would produce best evidence against this criterion (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 describe 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, e.g. 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 causes 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 perform the related tasks at P6 and M3 satisfactorily.

**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 suggested 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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.<br>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.<br>A quality report recording the type of test and the test results, including photographs or diagrams and supported by witness statements. |

## Suggested resources

### Books

Jeffus L – *Welding Principles and Applications* (Delmar Learning, 2007) ISBN 1418052752

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

# Unit 17: Fabrication Techniques and Sheet Metal Work

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20672G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' knowledge and skills to measure, mark out, cut, form and assemble fabricated structures using sheet metal effectively and safely.

## 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 the 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 to understand the safety precautions required when working with fabrication tools and machinery.

## Outcomes of learning

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 assemble fabricated structures accurately.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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, identifying 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 | M2 Explain the cutting action of machines and hand tools that 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 different sheet metal fabrications | | |
| P4 Use a given quality standard to join and assemble materials accurately to produce a fabricated structure | | |

## 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, e.g. 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, e.g. 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, e.g. 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, e.g. rule, tape rule, protractor, height gauge
- marking out tools, e.g. scriber, centre punch, chalk line, square, trammel, dividers, templates, surface plate, chalk, blueing or paint
- features, e.g. 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, e.g. single ‘one off’ components and batch production

Material types:

- forms of supply
- sheet, plate or section materials, e.g. hot-rolled black, cold-rolled
- thickness up to and including 3 mm
- range of material types appropriate to assembly, e.g. 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), e.g. mild steel, tinned steel, galvanised steel, aluminium, stainless steel, brass, copper
- non-metallic, e.g. plastics and rubbers, common forms, e.g. sheet, extrusions and mouldings, uses in fabricated assemblies, e.g. seals, gaskets, trims, panels and screens

**3 Be able to cut and form materials safely in a sheet metal fabrication environment**

Cutting:

- hand tools, e.g. tin snips, hacksaw, files
- hand power tools, e.g. drill, nibbler
- machine tools, e.g. bench shears, guillotine, band saw, pillar drill, punching and cropping machines
- operations, e.g. straight cuts, external curved contours, round holes
- cutting action of hand tools and machinery, e.g. shear and material removal (filing and drilling)

Forming:

- tools and equipment, e.g. hammers, mallets, stakes and formers, hand or powered bending machines, hand or powered rolling machine
- safety checks on tools and equipment, e.g. hammer shafts are secure, striking faces on stakes and formers are free from defects and damage, machine guards and safety devices, forming tools
- operations, e.g. bends, folds, curved panels, cylindrical sections, ducting or trunking

**4 Be able to join and assemble fabricated structures accurately**

Joining processes:

- permanent and non-permanent joints, thermal, e.g. temporary tack welding, soldering or brazing, resistance spot welding
- mechanical fasteners, e.g. hollow or solid riveting, self-piercing rivets, threaded inserts, structural fasteners, bolts, screws
- adhesives, e.g. structural adhesives, epoxides, acrylics and their toughened variants

Assemblies:

- type of assembly, e.g. 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, e.g. 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, e.g. 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

# Information for delivery staff

## Essential requirements

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 to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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.

Outcome of learning 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, i.e. 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 outcomes of learning 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 outcomes of learning 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 'e.g.' 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 'e.g.' 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/assessment |
|---|
| Whole-class teaching and workshop session:<br>● induction into workshops and general safety and emergency procedures<br>● identify specific processes used in the fabrication and sheet metal work industries. |
| Class taught session:<br>● explain safe working practices<br>● identify health and safety legislation related to fabrication and sheet metal working environments. |
| Prepare and carry out assignment.<br>**Assignment 1 (P1, M1)** |
| Class taught session:<br>● stock material types – sheet, tube, sections, plate<br>● types of material, metallic, non-metallic<br>● tools and equipment required when measuring and marking out. |
| Workshop practical session:<br>● measurement techniques and tools<br>● marking of sheet, tube and sectional materials as used in industry<br>● marking out according to material type and surface form. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P2, D1)** |
| Class taught session:<br>● safety when using cutting tools and machinery<br>● cutting tools types of hand operated, power tools, and machines<br>● tool maintenance<br>● tool set up, consumables and use<br>● cutting action – shear, materials removal. |

| Topic and suggested assignments/activities/assessment |
| --- |
| Workshop practical followed by individual learner practice:<br>● safety in the workshop when using cutting equipment<br>● correct tool set up and maintenance<br>● material characteristics when cutting<br>● cutting external profiles<br>● cutting internal profiles and shapes<br>● cutting of sheets and sections – blanking, cropping. |
| Class taught session:<br>● safety when using forming tools and machinery<br>● bending and folding theory, types of machine<br>● use of rolling machinery<br>● forming with hammers and mallets. |
| Workshop practical followed by individual learner practice:<br>● safety in the workshop when using forming equipment<br>● bending and folding – safety, set up, maintenance, spring-back<br>● rolling – safety, set up, maintenance<br>● hand power tools used for forming operations<br>● manual forming processes – hammers, mallets stakes and formers. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P3, M2)** |
| Class taught session:<br>● safety in the workshop and in industry during assembly<br>● thermal joining processes<br>● mechanical fastening<br>● adhesives<br>● types of assembly and best use of materials<br>● quality standards – dimensional accuracy, tolerances and geometrical tolerances<br>● recording and interpreting accuracy and tolerances. |
| Workshop practical followed by individual learner practice:<br>● preparation of joints for assembly<br>● safe joining and assembly techniques<br>● joining materials – thermal, mechanical and bonding with adhesives<br>● working to specifications and checking assembled components. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P4, D2)** |

## Assessment guidance

To achieve all pass criteria learners will need to demonstrate their skills using all four stages of the fabrication process. Learners will use a given quality standard 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 (M1). Learners will also be able to explain the cutting action of specific tools (M2). 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 comparing the advantages and disadvantages of using permanent and non-permanent joining methods and the alternative methods of marking out (D2). Tutors will need to be satisfied that the learners' work is distinctive based on the written answers to set questions or tasks. For D1, learners will examine a pattern that has been marked out for a specified part and suggest a method for mass producing these parts.

### 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 suggested 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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. |

## Suggested resources

### Books

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

# Unit 18: Engineering Marking Out

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20673G** |

**This unit is internally assessed**

## Unit aim

This unit aims to develop in learners the skills needed to conduct 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 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, allowing them to conduct 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 different applications | 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 different applications |
| P2 Describe the appropriate measuring and marking out equipment used for the 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 different applications | | |
| P4 Mark out different applications to the prepared work plan | | |
| P5 Demonstrate safe working practices and good housekeeping | | |

## 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, e.g. 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, e.g. surface tables/plates, angle plates, v-blocks and clamps
- calibration of measuring and marking out equipment
- marking out mediums, e.g. lacquer, whitewash

Applications:

- square/rectangular, e.g. bar stock, sheet materials
- circular/cylindrical, e.g. bar stock, tubes, turned components, flat disks
- irregular shapes, e.g. 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, e.g. 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, e.g. using squares, dial test indicators, slip gauges, packing pieces, jacks
- marking out to a planned sequence of operations, e.g. 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, e.g. 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

## Information for delivery staff

### Essential requirements

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 to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 (e.g. 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 'e.g.' 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 'e.g.' 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/assessment |
|---|
| Whole-class teaching:<br>● introduction to unit content assessment model, workshops, library and IT resources<br>● explain safe working practices, personal protection, hygiene procedures, appropriate behaviour in the working environment and importance of maintaining a tidy and safe work area<br>● explanation of the engineering drawing terms and abbreviations used in the marking out process.<br>Individual learner exercise:<br>● identify drawing types, terms and abbreviations. |
| Whole-class teaching:<br>● explain importance of work planning prior to marking out operations<br>● explain planning the sequence of marking out operations<br>● identify marking out equipment material requirements.<br>Individual learner activity:<br>● read engineering drawings and plan equipment requirements and marking out operations.<br>Tutor demonstration:<br>● marking out sequence – simple component drawing on paper using drawing equipment.<br>Individual learner activity:<br>● practise using equipment to mark out simple components on drawing paper. |
| Whole-class teaching:<br>● explain marking out work holding methods, equipment requirements, materials and mediums used<br>● explain how to use, calibrate, and care for marking out equipment and tools.<br>Tutor demonstration:<br>● demonstrate use of work holding equipment and marking out methods.<br>Workshop activity:<br>● learners practise using measuring and marking out tools and equipment<br>● mark out a simple component using equipment. |
| Whole-class teaching:<br>● explain procedures, equipment requirements and marking out applications for square round and irregular shapes.<br>Tutor demonstration:<br>● procedures, equipment and marking out techniques used to mark out square round and irregular shapes.<br>Workshop activity:<br>● learners practise using techniques and equipment to mark out square, round and irregular shapes. |

| Topic and suggested assignments/activities/assessment |
|---|
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, P3, P4, P5, M1, M2)** |
| Whole-class teaching:<br>● explain importance of leaving the work area in a safe and clean condition<br>● explain storage of equipment and documentation requirements. |
| Prepare for and carry out assignment.<br>**Assignment 2 (D1)** |
| Feedback on assessment, unit evaluation and close. |

## Assessment guidance

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 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 outcomes of learning, criteria and unit content with these three activities. However, in the unlikely situation that this cannot be achieved, then more components could be introduced in either practice 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 different applications – square/rectangular, circular/cylindrical and irregular shapes (P1). Learners should then describe the measuring and marking out equipment to be used for these three different applications (P2). Learners must then prepare a work plan for marking out each of the three different applications (P3) and mark them out using the prepared work plan (P4). For each of these tasks to be completed satisfactorily learners should be able to demonstrate safe working practice and good housekeeping at all times (P5).

To achieve a merit grade, learners should be able to recommend corrective action for unsafe or defective marking out equipment (M1); 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 (M2) 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 the 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 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 (D1) 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. 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, P3, P4, P5 | Engineering Marking Out (Task 1) | A practical activity to prepare a work plan to 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 | Engineering Marking Out (Task 2) | 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 | Engineering Marking Out (Task 3) | 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 | 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, identifying problems encountered and suggested improvements. |

## Suggested resources

### Book

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

# Unit 19: Electronic Circuit Construction

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20674G** |

**This unit is internally assessed**

## Unit aim

This unit will develop the ability of 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.

Learners will gain knowledge of how to read simple circuit diagrams and 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 also 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 their knowledge 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.

## Outcomes of learning

On completion of this unit a learner should:

1 Be able to use safe working practices in the electronics laboratory or 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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 different electronic components | D1 Propose a method to construct a given electronic circuit and justify your choice |
| P2 Use safe working practices in the electronics workshop or laboratory | M2 Explain the advantages and disadvantages of the types of electronic circuit board | |
| P3 Describe the purpose of different types of electronic components | | |
| P4 Identify the electronic components in a given circuit diagram | | |
| P5 Describe the manufacture of the types of electronic circuit boards | | |
| P6 Use different methods to construct a given electronic circuit | | |

## Unit content

**1 Be able to use safe working practices in the electronics laboratory or workshop**

Hazards:

- sharp edge hand tools, e.g. cuts and abrasions, swarf from cutting component leads and drills
- soldering irons, e.g. burns, fumes, lead content
- toxic substances, chemical compounds and fumes, e.g. Beryllium oxide, lead, solvents, etching fluid

Safe working practices:

- safe use of hand tools, e.g. drills, soldering irons, wire cutters and strippers, pliers, knives and scalpels, screwdrivers
- use of personal protective equipment (PPE), e.g. safety glasses
- handling and storage of components and test equipment
- use of first aid procedures, e.g. for electrical shock, electrical and acid burns
- procedures for establishing risk
- cable colour coding of mains equipment
- selection and fitting of a fuse or RCD for a device of known power
- checking earth connections
- replacement of a mains plug to a three-core cable
- polarity issues, e.g. power supplies, cells and batteries, electrolytic capacitors, semiconductor devices

**2 Know about electronic components and circuit diagrams**

Component types:

- power sources, e.g. cells, batteries
- transformers
- inductors and chokes, switches, plugs and sockets
- audio and visual indicators, e.g. lamps, LEDs, LCDs, buzzers and sirens
- resistors, e.g. carbon composition, carbon film, metal film, wire wound, variable resistors, light dependent resistors, rheostats, tolerances, colour codes
- capacitors, e.g. ceramic, polyester, polypropylene, metallised paper, mylar, electrolytic, tantalum, polarisation issues, colour codes, values
- semiconductors, e.g. diodes, light emitting diodes (LED), transistors – bipolar and field effect (FET)
- integrated circuit components, e.g. logic gates, operational amplifiers, timers

Circuit diagrams:

- use of block schematic
- component symbols labelling and legends values
- inter connections and linkages
- national and international standards

**3 Know about the manufacture of electronic circuit boards**

Types of circuit boards:

- breadboards and protoboards
- strip and tag boards
- printed circuit boards (PCB)

Circuit board manufacture:

- designing layout
- producing artwork
- etching
- drilling holes
- populating board
- soldering onto printed circuit boards (PCB)

**4 Be able to construct an electronic circuit**

Circuit construction techniques:

- soldering techniques, e.g. avoidance of dry joints, use of heat sinks
- wire-wrapping
- component pin and terminal identification, e.g. labelling
- power supply connections
- noise limitation considerations
- double layer boards
- surface mount technology

Types of circuit:

- e.g. single transistor circuits (amplifier, sensor and switch), combinational logic circuits, alarm circuits, audio and optical circuits

# Information for delivery staff

## Essential requirements

As much of the unit is practically based learners will require access to suitable electronic workshops and 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 organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcomes of learning involve a large amount of practical investigative work. Outcomes of learning 1 and 4 have the most practical content whilst outcomes of learning 2 and 3 provide the supporting knowledge of components and circuit manufacture essential for working in an electronics workshop or laboratory.

In delivering outcome of learning 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 or laboratory. Learners should be instructed on the correct operation and performance on the range of hand tools to be encountered.

For outcome of learning 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.

Outcome of learning 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 outcome of learning 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:<br>● introduction to unit, scheme of work and assessment<br>● introduction to safe working practices and hazards in electronics laboratories and workshops, including PPE handling and storage of components and equipment<br>● explain safety issues relating to power supplies, cells and batteries, electrolytic capacitors and semiconductor devices. |
| Group practical exercise:<br>● identifying hazards specific to learners' own working environment<br>● demonstration and practise of safe use of hand tools<br>● demonstration of how to fit a plug to mains cable selecting an appropriate fuse. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1)** |
| Whole-class teaching:<br>● explain the purpose and function of the different power sources, inductors, switches, plugs and sockets and indicators<br>● introduce and explain the purpose and function of various types of resistor and capacitor<br>● explain the purpose and function of semiconductors and integrated circuit components.<br>Practical class activities:<br>● identifying and sketching various types of components from physical specimens and component catalogues. |
| Whole-class teaching:<br>● explain representation of components on circuit diagrams.<br>Practical class activity:<br>● reading and identifying components from a range of simple circuit diagrams involving a range of components. |

| Topic and suggested assignments, activities and assessment |
|---|
| Whole-class teaching:<br>● describe the different types of circuit boards and explain how to interconnect components<br>● complete circuit formation with the aid of component layout and circuit diagrams, including input and output connections and power supplies<br>● demonstrate the correct use of soldering irons when soldering components on to strip and tag boards<br>● explain and demonstrate construction of electronic circuits using PCB, including designing the layout of the components and interconnection tracks and power supplies<br>● explain the construction of electronic circuits using multi-layer PCBs and the use of surface mounts technology, and other methods of connecting wires.<br>Practical class activities:<br>● constructing simple electronic circuits using breadboard (e.g. protoboards)<br>● constructing the same simple electronic circuits using soldering irons on strip/tag boards. |
| Prepare for and carry out assignments.<br>**Assignment 2 (P3, P4, P5, M1, M2, D1)**<br>**Assignment 3 (P2, P6)** |
| Feedback, unit evaluation and close. |

## Assessment guidance

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, - and other assessable submissions. Such supporting activity evidence would then validate the tutor or witness observation or 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 describe 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 electronic circuit boards (P6). 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 explain the function of further electronic components (M1) and describe the design and manufacture of circuit boards (P5). This section of the assignment could be further extended to cover M2 and D1.

The third assignment should be in the form of a practical activity that 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 suggested 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 describe 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.<br>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 and observation records, physical evidence and annotated photographs. |

## Suggested resources

### Books

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 9780750669238

### Websites

| | |
|---|---|
| http://multisim.en.softonic.com/ | Convenient download of National Instruments MULTISIM beginners' circuit design utility |
| http://www.discovercircuits.com/list.htm | Many schematics, circuits and specifications for different kinds of devices |
| http://www.stanford.edu/class/ee122/Handouts/0%20Intro.pdf | Humorous presentation with useful links, references and ideas |

# Unit 20: Using Specialist Secondary Machining Techniques

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20678G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge and ability to 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.

## Outcomes of learning

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 make a workpiece accurately.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 different specialist secondary machining techniques are used | M1 Explain the importance of checking a workpiece features during machining | D1 Justify the choice of a specialist secondary machining technique for a given workpiece |
| P2 Demonstrate accurate and safe machining for a given workpiece | M2 Explain why the features of a workpiece may be produced inaccurately | |
| P3 Carry out appropriate checks for accuracy on a given workpiece, recording the results | | |
| P4 Describe safe working practices when using specialist secondary machining techniques | | |

## Unit content

### 1 Know how a range of specialist secondary machining techniques are used

Specialist secondary machining techniques:

- honing - machine types, e.g. horizontal, vertical
- lapping - machine types, e.g. rotary disc, reciprocating
- shaping, planning and slotting - machine type, e.g. shaping, planning, slotting, milling machine with slotting attachment
- broaching - machine type, e.g. horizontal, vertical
- electro discharge - machine type, e.g. spark erosion, wire erosion
- gear cutting - machine type, e.g. gear hobbing, gear shaping, bevel gear cutting, gear planing, gear shaving

### 2 Be able to use a specialist secondary machining technique safely to make a workpiece accurately

Features of the workpiece:

- materials, e.g. ferrous, non-ferrous, non-metallic
- workpiece, e.g.:
  - for honing: holes, e.g. through, blind, tapered; operation, e.g. roughing, finishing, polishing
  - for lapping: faces, e.g. flat, parallel, angular; operation, e.g. roughing, finishing, polishing
  - for shaping, planing and slotting: faces, e.g. flat, square to each other, parallel, angular; other features, e.g. steps and shoulders, slots and grooves, keyways, splines, serrations; holes, e.g. square, hexagonal
  - for broaching: holes, e.g. flat sided, square, hexagonal, octagonal; other features, e.g. keyways, splines, serrations, special forms
  - for electro discharge: holes; faces, e.g. flat, square, parallel, angular; forms, e.g. concave, convex, profile,
  - square or rectangular; other features, e.g. threads, engraving, cavities, radii and arcs, slots
  - for gear cutting: machined gears, e.g. 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, e.g.:
  - for honing and lapping, e.g. handling and storing stones, airborne particles
  - for shaping, planing and slotting, e.g. handling and storing tools, effects of backlash in machine slides and screws
  - for broaching, e.g. handling and storing broaches, breakage of broaches, handling cutting oils
  - for electro discharge, e.g. electrical components, handling dielectrics, fumes, handling and storing electrodes and wires
  - for gear cutting, e.g. 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, e.g.:
  - 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 oblation or lobbing
  - for lapping: components to be free from stone or 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, e.g. 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 and 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, e.g. parallelism, angle and 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, e.g. blanks, lead and helix angle, tooth thickness, involute form, composite error rolling test, concentricity

# Information for delivery staff

## Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcome of learning 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 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, and at this level, they must show that they can do this self-reliantly. 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 or other appropriate instruments, and those associated with checking for accuracy against the standards listed.

Learners must be made aware of, and have access to, relevant UK and local 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 'e.g.' 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 'e.g.' 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 assessments** |
|---|
| Whole-class teaching:<br>● introduction to engineering workshop<br>● identifying different specialist machine tools<br>● health and safety briefing, legislation and assessment of risk.<br>Class exercise:<br>● carrying out risk assessments.<br>Workshop activity:<br>● identify safety devices and equipment. |
| Whole-class teaching:<br>● explain the principles of honing, lapping, shaping, broaching, electro-discharge and gear cutting.<br>Workshop activity:<br>● identifying individual component parts and features of machines and safety precautions. |
| Workshop activities:<br>● identify key features of a range of components.<br>Whole-class teaching:<br>● use of measurement tools, techniques and gauges to determine appropriate levels of accuracy.<br>Learner activity:<br>● using tools and techniques to check given components for accuracy. |
| Workshop activity:<br>● workshop demonstration on the use of a manufacturing technique and the use of guards and safety devices, lubricants, and other appropriate resources. |
| Closely supervised small-group machining activity. |
| Learner exercise:<br>● using appropriate techniques to manufacture a component to a given standard. |

| Topic and suggested assignments, activities and assessments |
|---|
| Prepare and carry out assignment.<br>**Assignment 1 (P2, P3)** |
| Whole-class teaching:<br>● investigation of the key features of engineering components and how and why they might be produced inaccurately.<br>Learner activity:<br>● analysing given components in order to investigate the key features and whether inaccuracies have occurred in their manufacture. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P4, M1, M2)** |
| Whole-class teaching:<br>● use of appropriate specialist secondary machining techniques for a range of different applications.<br>Individual learner activity:<br>● analysing given components in order to determine the most appropriate specialist secondary machining technique. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P1, D1)** |
| Review of unit delivery and assessment. |

## Assessment guidance

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 suggest health and safety precautions. 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 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 justify 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 describe safe working practices as required by assessment criteria P4. The last assignment could include a written task to describe three different machining techniques (P1) and a justification of the choice of a particular specialist secondary machining 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 suggested 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 work piece 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 and observation records and annotated photographs to accompany the artefact produced by the learner.<br>Records of measurements taken. |
| P4, M1, M2 | Working Safely in Engineering and Features of a Work Piece | An activity requiring learners to produce a written report showing the safe working practices when using a specialist secondary machining technique and discerning the features of the work piece produced in Assignment 1 and the reasons for inaccuracies. | A report containing written responses describing 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 work piece 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 work piece. | A report containing written responses describing three secondary machining techniques and justifying one for a given work piece. |

## Suggested resources

### Books

Bray S – *Grinding, Honing and Polishing* (Special Interest Model Books, 2009) ISBN 1854862529

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

### Websites

| | |
|---|---|
| http://www.me.utexas.edu/~me302/classnotes/Manufacturing.html | University of Texas checknotes with photographs and machine drawings |
| http://www.veltechuniv.edu.in/ppt%5Cmech%5C4sem%5CMT-II.doc | VelTech University Lesson Notes with worked calculations |

# Unit 21: Production Planning for Engineering

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **50 (including 30 GLH)** |
| Unit value (NLH/10): | **5** |
| SRF unit code: | **20675G** |

**This unit is internally assessed**

## Unit aim

This unit will develop learners' skills in preparing 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 a 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 | | |

## Unit content

### 1 Know about scales of production and the processes and equipment used in manufacturing organisations

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 from a given product specification.

Production plan:

- details required for an engineering activity, e.g. 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, e.g. 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

## Information for delivery staff

### Essential requirements

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 to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● explain the different scales of production and different types of equipment, giving typical examples of each<br>● explain the key stages of production and show how they can be represented in a block diagram<br>● explain typical material and component preparation processes and assembly and finishing processes<br>● explain quality control, packaging and dispatch procedures. |
| Individual learner activity:<br>● investigate the different types of equipment and relate them to scales of production. Investigate the manufacturing process for a given or chosen case study.<br>Prepare for and carry assignment.<br>**Assignment 1 (P1, P2, P3, M1)** |
| Whole-class teaching:<br>● explain the different types of information required for an engineering activity.<br>Individual learner activities:<br>● identify the possible scales and key stages of production from given product details<br>● identify a possible parts list and possible processing methods for given products. |
| Whole-class teaching:<br>● explain and discuss direct and indirect cost of plant, labour, materials and components.<br>Individual learner activity:<br>● estimate total manufacturing unit costs from given data. |
| Whole-class teaching:<br>● describe typical production plan formats<br>● discuss health and safety precautions that might need to be included in a production plan. |
| Whole-class teaching:<br>● explain and demonstrate the calculation of processing time and production costs<br>● explain what changes to the plan are needed if the scale of production is to be increased to repeated batch production. |

| Topic and suggested assignments/activities/assessment |
| --- |
| Individual learner activities:<br>• draw up a block diagram representing the key stages in the production of a given product where only a small quantity is required<br>• draw up a production plan for a product and calculate processing times and production costs. |
| Prepare and carry out assignment.<br>**Assignment 2 (P4, P5, M2, D1)** |
| Review of unit delivery and assessment. |

## Assessment guidance

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 (P1, P2, P3) and the first merit criteria (M1) relate to the first of the two outcomes of learning. 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 outcome of learning 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 (P1, P2 and P3). 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 (M1). Working under guidance to create a production plan from a given product specification would be suitable (P4). It is expected that the given specification will have a materials and parts list to allow the learner to calculate other related data and information (P5).

The product specification needs to have enough 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 (M2).

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 (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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, P3, 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, 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. |

## Suggested resource

### Book

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

# Unit 22: Application of Quality Control and Measurement in Engineering

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20679G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge and skills needed in order to inspect engineered components to ensure their 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 have to be competitively priced and reliable. Engineering companies operate quality assurance programmes to ensure that all parts of their organisation work towards supplying a high 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 develop learners' broad knowledge 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 be able recognise and appreciate the points of inspection required to support quality control.

## Outcomes of learning

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.

## Assessment and grading grid

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

| **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 | 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 the 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 correctly, to inspect a simple engineered product for dimensional and geometric accuracy and surface texture | | |
| P5 Use comparators correctly, to inspect a simple engineered product for dimensional accuracy | | |
| P6 Use gauges correctly, to inspect a simple engineered product for dimensional and geometric accuracy | | |

| 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 Identify the specified fit between assembled components from given tolerance limits | | |

## Unit content

### 1 Know about quality and quality control as applied to manufacturing products

Quality:

- definition of quality, e.g. fitness for purpose, safe to use, meeting the customer's requirements
- quality standard ISO9000
- costs of quality, e.g. 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, e.g. 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, e.g. length, diameter, depth, flatness, parallelism, angle
- geometrical, e.g. 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, e.g. plunger type, lever type
- simple mechanical comparator, e.g. Sigma comparator
- inside caliper
- outside caliper

Use of gauges:

- dimensional accuracy, e.g. slip gauges, length bars
- geometrical accuracy, e.g. radius gauges, profile templates, Go and Not Go gauges (plug gauges, gap gauges, taper plugs, ring gauges)

Simple engineered products:

- e.g. 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, e.g. BS 4500
- types of fit
- clearance, transition, interference

Simple engineered products:

- those suitable for measuring dimensional accuracy
- assembled components
- those suitable for applying tolerances

## Information for delivery staff

### Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

The unit requires practical activities that might be run in parallel with presentations covering the philosophy and administration of quality control. Outcome of learning 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.

Outcomes of learning 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.

Outcome of learning 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 'e.g.' 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 'e.g.' 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 assessments** |
|---|
| Whole-class teaching:<br>● introduction to unit, scheme of work and methods of assessment<br>● define quality and explain quality standards and the costs of quality<br>● explain the role of the quality control department in a manufacturing or engineering context<br>● explain traceability and calibration.<br>Industrial visit:<br>● view real quality control department and the range of documentation used. |
| Individual learner research:<br>● use of case studies to investigate quality and quality control in engineering<br>● preparation for assignment.<br>**Assignment 1 (P1, P2, P3, M1, D1)** |
| Whole-class teaching:<br>● explain and demonstrate the use of a range of measuring equipment to measure dimensional and geometrical attributes of engineered products.<br>Whole-class practical sessions:<br>● practising the use of measuring equipment to check quality of products.<br>Industrial visit:<br>● see use of measuring equipment in industrial setting. |
| Whole-class teaching:<br>● explain and demonstrate the use of a comparator, types of equipment and gauges to measure dimensional and geometrical attributes of engineered products.<br>Whole-class practical sessions:<br>● practising the use comparators and gauges to check quality of products. |
| Individual learner research:<br>● investigating and practising the use of measuring equipment, comparators and gauges to measure a range of engineered products<br>● preparation for assignment.<br>**Assignment 2 (P4, P5, P6, M2, D2)** |
| Whole-class teaching:<br>● explain the concept of tolerances and describe the different systems of limits and fits and types of fit<br>● demonstrate and practise use of ISO and British standards. |
| Individual learner research:<br>● investigation into systems of limits and fits and the use of standards<br>● preparation for assignment.<br>**Assignment 3 (P7, M3)** |
| Feedback, unit evaluation and close. |

## Assessment guidance

This unit could be assessed through the use of three assignments.

The first assignment, covering outcome of learning 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 or portfolio showing evidence of achievement. Witness statements or other observation records will be required to verify achievement. Portfolios should not contain course notes, research or other non-assessable material: therefore, portfolios should exclusively contain materials 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 giving learners an opportunity to achieve M3 by explaining the principle of a hole-based system of limits and fits.

### 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, P3, M1, 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. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P4, P5, P6, M2, 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 and witness statements and a written report or logbook of the tasks undertaken.<br>A further written task explaining and justifying the importance of measurement equipment and techniques. |
| P7, 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. |

## Suggested resources

### Book

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

### Websites

| | |
|---|---|
| http://www.mechanicalengineeringblog.com/tag/total-quality-control-pdf/ | Quality control general blog with some interesting leads |
| http://w3.gazi.edu.tr/~balbasi/581SPC.pdf | Major, highly-mathematical textbook 'Statistical Quality Control' (6th Edition) (downloadable gratis in full ) |

# Unit 23: Casting and Moulding Engineering Components

Level: **2**

Notional Learning Hours: **100 (including 60 GLH)**

Unit value (NLH/10): **10**

SRF unit code: **20680G**

**This unit is internally assessed**

## Unit aim

This unit aims to develop learners' 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 broad knowledge 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 layup 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 health and safety considerations.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | 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 | | |

| 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 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 | | |

## Unit content

### 1 Know about material melting processes and component removal

Methods of melting material:

- scale, e.g. single melt, batch melt, continuous melt, combined methods
- types of furnace, e.g. cupola, induction, rotary, bale out, lift out crucible, tilting crucible, direct or indirect arc, air circulating ovens for thermoplastic melting
- material, e.g. ferrous alloys, non-ferrous alloys, thermoplastics
- measurement of temperature, e.g. pyrometers

Component removal and finishing:

- techniques, e.g. knocking castings out of moulds, removing components from the moulding material or dies, de-coring, removing runner/riser/feeder system
- processes used, e.g. manual, vibratory tables/grids, punch-out mechanisms, chemical leaching
- tooling used, e.g. 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, e.g. 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, e.g. horizontal, vertical
- runners
- risers
- moulding parts, e.g. boxes, boxless
- moulding sand, e.g. oil sand, green sand, chemically bonded gas activated, chemically bonded resin/catalyst, resin bonded heat activated
- mould and core production, e.g. 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, e.g. single waxes, wax assemblies
- mounting of wax patterns, e.g. handles, bars, hangers
- slurry
- producing shells/moulds, e.g. manually, automatically, combined manual and semiautomatic, single, multiple
- curing shells/moulds, e.g. 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, e.g. floor, fixed base, movable base, carousel, conveyor/roller track
- types of die, e.g. 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, e.g. high pressure hot chamber, high pressure cold chamber, squeeze process
- types of die, e.g. 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, e.g. polystyrene, polyethylene, acetal
- equipment, e.g. injection moulding machines, machine tooling

Vacuum forming:

- materials, e.g. polycarbonate, polysulphon, acrylic, polyvinyl chloride and acrylonitrile butadiene styrene (ABS) thermoplastic sheet
- equipment, e.g. vacuum forming machines, machine tooling

Wet lay-up composite moulding:

- materials, e.g. polyester, epoxy, phenolic and vinyl ester resins, glass, carbon, polyethylene and aramid fibres
- moulding techniques, e.g. 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

# Information for delivery staff

## Essential requirements

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 to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

## Delivery guidance

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 outcomes of learning 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 outcome of learning covers moulding processes. The four outcomes of learning 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 'e.g.' 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 'e.g.' 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/assessment** |
|---|
| Whole-class teaching:<br>● introduction to unit, scheme of work and methods of assessment<br>● explain the different scales of melting or casting, the types of furnace used and ways of measuring temperature<br>● describe melting methods used for different materials<br>● explain the ways in which castings are removed and the processes and tooling used<br>● explain blasting methods and ways in which plastic castings are finished. |
| Individual learner research:<br>● investigate melting processes and their applications for different materials and finishing processes. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1)** |
| Whole-class teaching:<br>● explain sand casting processes and describe the use of cores<br>● explain the different moulding parts and use of moulding sand<br>● describe the forms of mould and core production<br>● explain the use and mounting of wax patterns for investment casting<br>● explain the production and curing of shells/moulds.<br>Industrial visit:<br>● 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:<br>● using case studies to investigate sand and investment casting processes and applications. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, D1)** |
| Whole-class teaching:<br>● explain the different locations used for gravity die casting, the different types of die and explain the use of cores<br>● describe the types of pressure die casting, the different types of die used and explain the use of cores.<br>Industrial visit:<br>● visit to local company to view production of components using die casting methods, including melting of materials and component removal. |
| Individual learner research:<br>● using case studies to investigate different die casting processes and applications. |

| Topic and suggested assignments/activities/assessment |
|---|
| Prepare for and carry out assignment.<br>**Assignment 3 (P5, P6, M2, D2)** |
| Whole-class teaching:<br>● describe the different materials for which injection moulding is used and explain the use of moulding machines and equipment<br>● describe the different materials for which vacuum forming is used and explain the use of vacuum forming machines and equipment<br>● describe the different materials for which wet lay-up composite moulding is used and explain the use of moulding techniques.<br>Group/practical activity:<br>● using vacuum forming machines to produce basic components. |
| Individual learner research:<br>● using case studies to investigate different plastic moulding processes and applications. |
| Whole-class teaching:<br>● 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. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P7, P8, M3, D3)** |
| Feedback, unit evaluation and close. |

## Assessment guidance

Evidence for the outcomes of learning 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 outcomes of learning 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 be 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 explain the importance of identifying 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, 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, 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, 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. |
| P7, P8, M3, 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. |

## Suggested resources

### Book

Health and Safety Executive – *Health and Safety in Engineering Workshops* (Health and Safety Executive, 2004) ISBN 0717617173

# Unit 24: Operation and Maintenance of Fluid Power Systems and Components

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20676G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge and understanding of fluid power systems, circuits, and components. Learners will develop the skills needed safely to undertake maintenance activities on a range of pneumatic and hydraulic systems used in industry.

## Unit introduction

In every engineering workshop, processes and service operations need maintenance. 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 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 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 | 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 safe 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 fluid power system | D2 Compare different fault diagnosis techniques when carrying out maintenance work on a fluid power system |
| P3 Identify the symbols used to represent fluid power system components | | |
| P4 Interpret a fluid power circuit diagram, explaining the function of the circuit components shown | | |
| P5 Describe the construction and operation of different fluid power system components | | |

| 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:** |
| P6 Describe the construction, operation and application of a given type of fluid power equipment | | |
| P7 Use appropriate instruments to carry out testing and maintenance routines on a given fluid power system | | |
| P8 Use appropriate fault diagnosis techniques and diagnostic aids to identify a given fluid power system problem and report the findings | | |

## Unit content

**1 Know the health and safety regulations and precautions that need to be observed when working with fluid power systems**

Health and safety regulations:

- for example, the Health and Safety at Work Act 1974, Control of Substances Hazardous to Health (COSHH) regulations, Management of Health and Safety Regulations, Pressure Systems and Transportable Gas Containers Regulations 1989 (SI 1989 No 2169), The Pressure Vessels Directive, and current EU and local Laws and Orders bearing upon Fluid Power control

Safe practices:

- practices to be followed when assembling, testing and maintaining pneumatic equipment and systems, e.g. 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, e.g. pumps, cylinders, compressors, filters, receivers, spools, regulators, actuators, accumulators, valves, bearings, sensors, filters

Diagrams:

- e.g. 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:

- e.g. pumps, directional, flow, pressure and non-return valves, linear and rotary actuators, hydraulic and pneumatic motors, hoses and pipework, fittings, seals, air service units

Equipment:

- construction
- operation
- application
- types, e.g. 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, e.g. pressure indicators, flow indicators, measuring devices, self-diagnostic equipment
- procedures and techniques for carrying out tests

Instruments:

- for example, measuring devices, pressure indicators, flow indicators, self-diagnostic equipment

Maintenance routines:

- regular maintenance activities on fluid power components, devices and systems, e.g. inspection and functional testing, removing and replacing units or 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, e.g. 'symptom', 'fault', 'cause'
- typical faults in pneumatic and hydraulic components and equipment
- symptoms of non-complex faults and their causes

Fault diagnosis techniques:

- for example, 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 and repair reporting
- emergent sequence

Diagnostic aids:

- For example, functional charts, diagrams, flow charts, troubleshooting charts, component data sheets, operation and maintenance manuals, software-based records and data

Problem:

- for example, intermittent, partial failure or out-of-specification output, complete breakdowns

Report findings:

- for example, scheduled maintenance report, corrective maintenance report, other company-specific reports, job cards, maintenance log

## Information for delivery staff

### Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 outcomes of learning and content.

Outcomes of learning 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 the 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 EU, UK and local health and safety legislation and know the importance of the use of appropriate risk assessment. Tutors should ensure that each learner has the correct personal protective equipment (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 has different values to that which real practical experience in a working environment can bring.

The outcomes of learning are ordered appropriately and it would be reasonable to deliver 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 practice.

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 practise 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 and skills, help them to deal with problems affecting the engineering processes manifest, or to support them when they need to work with others more effectively in order to achieve the task.

Note that the use of 'e.g.' 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 'e.g.' needs to be taught or assessed. It is important that learning is flexible, not only across differing industries, but also under changes in legislation and technology.

### 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.

| **Topics and suggested assignments, activities and assessments** |
|---|
| Whole-class teaching:<br>● introduction to unit content, assessment model and method of working<br>● introduction to relevant health and safety legislation and regulations explaining their purpose and the importance of adhering to them<br>● describe the main safe working practices to be followed when working with fluid power systems and equipment.<br>Practical workshop activities:<br>● tour of centre workshops to highlight main areas of risk; demonstrate safe working practices, e.g. use of PPE (personal protective equipment), safe lifting and handling techniques etc. |

| Topics and suggested assignments, activities and assessments |
|---|
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1)** |
| Whole-class teaching and practical demonstration:<br>● explain pneumatic circuits and component symbols including valve symbols, energy transmission symbols, control symbols, compressors, air receivers and pumps, miscellaneous symbols, e.g. reservoir tanks, air service units, filters, pipes and hoses<br>● demonstrate the use and interpretation of different types of fluid power diagram; explain the use of safety related documentation.<br>Learner activity:<br>● using and interpreting diagrams and identifying symbols and components. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4)** |
| Whole-class teaching and practical demonstration:<br>● explain the function, construction, operation and application of pneumatic and hydraulic components.<br>Practical workshop activity:<br>● identify and examine the construction and operation of a range of pneumatic and hydraulic components. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P5, P6)** |
| Whole-class teaching:<br>● explain and demonstrate diagnostic test equipment, fault finding aids, software-based fault diagnostic techniques<br>● explain the importance of preparation for work activities, including:<br>  ▪ relevant safety procedures and equipment requirements<br>  ▪ circuit drawings, specifications, materials and components<br>  ▪ job instructions and documentation for work activity<br>● explain the terminology used and methods of fault diagnosis<br>● introduction to fluid power system fault location, testing, and maintenance.<br>Practical workshop activities:<br>● examine examples of typical faults found in fluid power systems<br>● practise use of fault finding instruments on fluid power systems. |
| Industrial visit:<br>● view practical application of fluid power systems and review the operation and maintenance arrangements in a modern industrial setting. |

| Topics and suggested assignments, activities and assessments |
| --- |
| Whole-class teaching and demonstration:<br>● explain frequencies for maintenance, maintenance routines, and maintenance recording documentation<br>● introduction to the practical work activity<br>● explanation and tutor demonstration of inspection and testing complete systems and components.<br>Practical workshop activities:<br>● learners obtain all necessary drawings and equipment and carry out fault-finding, repair and maintenance of fluid power components and systems. |
| Practical workshop activities:<br>● further practical exercises on fault-finding, repair and maintenance of fluid power components and systems<br>● carry out commissioning test and complete final handover documentation.<br>Whole-class teaching and group work:<br>● discuss possible improvements to working practices. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P7, P8, M2, D1, D2)** |
| Feedback on assessment, unit evaluation and close. |

## Assessment guidance

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, though this generalised activity must never compromise the integrity of assessment for this unit or any other unit in the qualification.

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.

Outcomes of learning 1, 2 and 3 are probably best assessed through the use of written assignments. Outcome of learning 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 outcome of learning 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 correctly interpret a fluid power circuit diagram, explaining the function of six fluid power components.

The third assignment covering P5 and P6 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 covering P7 and P8 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 or 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 different diagnosis techniques when carrying out maintenance work (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 suggested 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 are to identify and explain the function of the components in a given circuit diagram. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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 another. | 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. |
| P7, P8, M2, D1, D2 | Practical Testing and Fault Diagnosis on a Fluid Power System | Learners need to describe their testing and diagnosis of a fluid power system. | A written assignment requiring learners to analyse the system for ease of maintenance and compare diagnostic techniques. |

## Suggested resources

### Books

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

### Websites

| | |
|---|---|
| http://www.sqa.org.uk/files/aq/FP2P04.pdf | Comparable course checklist from The (Scottish) National Occupational Standards |
| http://www.hpmag.co.uk/index.php | 'The Website of Fluid Power Systems and Equipment' with news and links |
| http://www.g-w.com/pdf/sampchap/9781605250816_ch02.pdf | Short but well-illustrated tutorial PDF |
| http://www.workforcedevelopment.com/mechanics/fluid.html | Pennfoster workforce training website with plenty of tutorial links |

# Unit 25: Applying Continuous Improvement and Problem-solving Techniques

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20681G** |

**This unit is internally assessed**

## Unit aim

This unit gives learners the opportunity to investigate and apply continuous improvement and problem-solving techniques for the workplace.

## 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 importantly of all, a competitive price. One way to improve business performance is by empowering the people who constitute the organisation. This means that the top level management, middle management, supervision and all other employees 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 implementing such changes successfully in the manufacturing environment.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 Assess 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 Explain 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 different quality tools to solve a manufacturing problem | | |
| P5 State what is required to implement an improvement activity, describing the implementation issues that may arise | | |
| P6 Use appropriate continuous improvement and problem-solving techniques in a work area | | |

# 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:

- plan, do, check, act (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:

- e.g. 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:

- e.g. 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, e.g. 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

## Information for delivery staff

### Essential requirements

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 to help centres engage and involve local employers in the delivery of this unit, for example:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

The approach to delivery for this unit may be to work in a particular manufacturing sector and work area only, e.g. 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 outcomes of learning 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 functions and limits related to specific situations in the manufacturing environment. It is strongly recommended that a variety of learner-centred delivery methods are 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 then other aspects can 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 'e.g.' 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 'e.g.' 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/assessment |
|---|
| Whole-class teaching:<br>● outline the purpose and use of continuous improvement and problem solving in engineering and manufacturing<br>● identify the accepted quality gurus and outline the main points of each of their philosophies.<br>Individual/small-group activities:<br>● research the work of Crosby, Deming, Juran and Ishikawa and identify similarities and differences. |
| Whole-class teaching:<br>● describe the concept of continuous improvement and explain the use of different techniques<br>● explain issues relating to cost, safety, quality and general working procedures and practices.<br>Individual/small-group activity:<br>● investigate the principles of continuous improvement, and its impact upon company performance<br>● learners investigate procedures and practices of own company or those of a given local employer<br>● practise the use of practical tools and techniques, e.g. Gantt chart. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, P3, M1, D1)** |
| Individual/small-group activity:<br>● 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. |

| Topic and suggested assignments/activities/assessment |
|---|
| Whole-class teaching:<br>● outline the various quality tools that are used in industry<br>● explain and discuss the problems associated with manufacturing; consider poor quality, out sourcing, maintenance and other issues.<br>Individual/small-group activity:<br>● select the most appropriate quality tools for given example organisations. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P4, P5, M2, D2)** |
| Whole-class teaching:<br>● explain the means of planning and monitoring and the use of timelines<br>● describe the use of standard operating procedures<br>● describe the use of visual management techniques in relation to Kaizen activities<br>● discuss issues relating to implementation – management support, training needs, and motivation, legislation and union responses.<br>Small-group activity:<br>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.<br>**Assignment 3 (P5)** |
| Whole-class teaching:<br>● explain the main constraints and problems that can arise when implementing an improvement activity.<br>Individual/small-group activities:<br>● select a work area and consider the overall performance level compared to best practice<br>● using case study material review a variety of company based schemes. |
| Individual/small-group activities:<br>● 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<br>● review data collection, agreement on corrective actions and overall decision making. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P6)** |
| Unit review and evaluation. |

## Assessment guidance

Evidence of outcomes of learning 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 assess 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 minimising 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 and evaluate their improvement methodology.

The evidence must be generated in a form suitable for inclusion in the learner's portfolio. This could include standard forms (e.g. PDCA forms, data gathering forms, minutes of team meetings), quality tools, images (e.g. 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 outcomes of learning. 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, P3, M1, D1 | Investigation into the Principles of Continuous Improvement | Outline basic principles, Gurus etc.<br>Guidance on application to own organisation. | Structured investigation. |

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| 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. |

## Suggested resources

### Books

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

# Unit 26: Workplace Organisation and Standard Operating Procedures

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20682G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge, understanding and skills of how to investigate and evaluate workplace organisations 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 informed 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 alphanumeric 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.

## Outcomes of learning

On completion of this unit a learner should:

1 Understand the principles 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).

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 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 Identify 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 Explain the benefits of introducing a standard operating procedure | |
| P4 Describe different examples of visual display found in a manufacturing environment referring to principles of visual management | | |
| P5 Describe different examples of visual control found in a manufacturing environment | | |
| P6 Describe the principles of standardised work | | |
| P7 Produce a standard operating procedure | | |

| 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 Describe the functions of a standard operating procedure, standard combination sheet and a standard work chart | | |

## Unit content

**1 Understand the principles of the 5S/5C process**

Principles of 5S/5Cs:

- understand the need for workplace (Gemba) organisation
- identify the correct location for machines, tools, equipment and inventory
- Sort out and Clear out
- Straighten and Configure
- Shine and Clean
- Standardisation and 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, e.g. lack of ownership, complexity, inaccuracy, corrupted reports, poor circulation, currency and validity of information
- inputs, processes, and outputs
- information required to develop a local visual management system
- benefits of visual management

Visual display:

- where to apply visual display
- good practice, e.g. accurate and relevant, eye catching, simple
- location
- team boards
- storyboards
- PDCA worksheets
- business and local key performance indicators, e.g. 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
- elements of good practice, e.g. 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 principles 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, e.g. 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 additionally 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

## Information for delivery staff

### Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

The delivery approach for this unit may be to work in a particular manufacturing sector and work area only, e.g. 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 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 sound underpinning knowledge and skills needed effectively to improve workplace organisation and standard operating procedures in most industrial settings.

The outcomes of learning are ordered appropriately and it would be reasonable to deliver 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 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 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, DVDs or other videos, 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 and 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 'e.g.' 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 'e.g.' needs to be taught or assessed. Tutors should recognise that progress should be adapted both to the specifics of the workplace involved, as well as to evolving best practice.

**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.

| **Topics and suggested assignments, activities and assessments** |
|---|
| Whole-class teaching:<br>● introduce the principles of 5S/5Cs and outline the main benefits<br>● explain the purpose of selection of work area<br>● describe red tagging procedures.<br>Small-group activity:<br>● learners critically evaluate their own experience or company with respect to the benefits, challenges and effectiveness of continuous improvement.<br>Individual learner activities:<br>● select a work area for evaluation based upon own organisation or case study of local business. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1)** |
| Whole-class teaching:<br>● introduction to the principles of visual display techniques<br>● explain the problems that can occur with traditional reporting systems and describe the benefits of visual management.<br>Small-group activity:<br>● discuss information required to develop a local visual management system. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, P5, M2, D1)** |
| Whole-class teaching:<br>● explain the principles of visual control, coding systems, kanban and workshop management re-tooling and systems.<br>Small-group activities:<br>● investigate the use of visual control in a local or national manufacturer. |
| Whole-class teaching:<br>● explain the philosophy of standardised working and the use SOPs.<br>Small-group activities:<br>● apply philosophy of standardised working to own experience, off the job training or other local examples<br>● carry out a review of SOP documentation – own company or local case studies<br>● discuss the benefits of SOP in terms of productivity, quality and profitability. |

| Topics and suggested assignments, activities and assessments |
|---|
| Prepare for and carry out assignment.<br>**Assignment 3 (P6, P7, P8, M3, D2)** |
| Unit review and evaluation. |

## Assessment guidance

Evidence of outcomes of learning 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 describe the principles of 5S/5C and the benefits these 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 of how standardised operations improve an organisation's performance to link P6, P8 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 by asking learners to produce a standard operating procedure for an activity connected with the learner's employment or an engineering activity within the learning environment and explain the benefits of its introduction for the merit grade (M3). 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 (e.g. PDCA forms, data gathering forms), minutes of team meetings, standard operating procedures, images (e.g. 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 outcomes of learning. In order to help this process, tutors should guide learners and, where appropriate, provide standard documentation or 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 suggested 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 or report. |
| P3, P4, P5, M2, D1 | Basic Visual Systems | Learners carry out a review of visual systems as applied in their company. | Written investigation or report. |
| P6, P7, P8, M3, D2 | Standard Operating Procedures in the Manufacturing Workshop | Learners carry out a review of SOPs in their company. | Written investigation or report. |

## Suggested resources

### Books

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

**Websites**

| | |
|---|---|
| http://en.wikipedia.org/wiki/Takt_time | Wikipedia article about takt time with links to related materials |
| http://www.hse.gov.uk/research/rrpdf/rr919.pdf | The HSE view of Standard Operating Procedures and Impediments to their Implementation |
| http://www.fao.org/docrep/w7295e/w7295e04.htm | Food and Agriculture Organisation SOP website |
| http://www.regionalskillstraining.com/sites/default/files/content/QSW%20Book%202.pdf | 'Quality Standards in the Workplace' by Regional Skills and Training Pty Ltd (Australia) |
| https://workspace.imperial.ac.uk/insolex/Public/17%20Workplace%20Organizatin%20N%20Visual%20Management%20Techniques.pdf | The Imperial College view of workplace organisation in the form of a PDF of a PPT presentation |

# Unit 27: PC Hardware and Software Installation and Configuration

| | |
|---|---|
| Level: | **2** |
| Notional Learning Hours: | **100 (including 60 GLH)** |
| Unit value (NLH/10): | **10** |
| SRF unit code: | **20683G** |

**This unit is internally assessed**

## Unit aim

This unit develops learners' knowledge and skills 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 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 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 the installation of new devices, thus prolonging the computer's working life. The hardware and software must be brought together and harmonised in order to operate in an efficient manner.

This unit aims to develop learners' knowledge and skills 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.

## Outcomes of learning

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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 basic operation of a PC system, with reference to different types of computers | 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 different needs | M2 Plan the installation of an operating system selecting 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 appropriate documentation for system details, configuration procedures and test results for a PC system | |
| P4 Carry out correct installation and configuration of different hardware components using safe working practices | | |
| P5 Install and configure different software applications correctly, customising one of them | | |
| P6 Install an operating system correctly and confirm hardware is functioning correctly | | |

| **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 Assemble a PC system according to a given specification | | |
| P8 Test and configure a PC system correctly | | |

## Unit content

**1 Know the basic operation of standard PC systems**

Basic operation of PC systems:

- block diagram identifying main system components, e.g. input and 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, e.g. digital cameras, wand scanner, flatbed scanners, video camera
- hand devices, e.g. keyboards, touch screens, mouse, joystick, trackball, digitiser tablet and crosshair, touchpad, microphones, sensing devices

Output devices:

- monitors
- printers, e.g. inkjet, laser, graph plotter
- sound systems
- storage devices
- modems

**2 Be able to install and configure standard PC hardware components**

Motherboards:

- formats, e.g. baby advanced technology (AT), ATX, NLX
- power supply types
- voltage regulator, e.g. linear, switched
- peripheral component interconnection (PCI), industry standard architecture (ISA), memory slots
- onboard adapters

Microprocessors:

- types, e.g. dual core, quad-core, Pentium Celeron, Centrino, AMD-Sempron and alternatives
- CPU, e.g. sockets, cooling systems, processor speed, over-clocking

Memory types:

- volatile
- permanent
- hard disk, e.g. tracks, sectors and clusters, virtual file allocation table (VFAT), NTFS
- defragmentation
- cache
- semiconductor, e.g. random-access memory (RAM), DRAM (EDO, SDRAM), ROM, PRAM, EPROM, EAROM, EEPROM (flash PROM)
- chip types, e.g. single and dual in line memory module (SIMM/DIMM)
- Optical Laser Discs, e.g. CD, CD ROM, CD-R, CD-RW, DVD, DVD-ROM, DVD-R, DVD-RAM, DVD+RW, DVD-RW and FMD-ROM
- external, e.g. 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, e.g. industry standard architecture (ISA), extended ISA (EISA), local bus peripheral component interconnection (PCI) and video electronic standards association (VESA)
- external, e.g. 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, e.g. system power supply, hard disk, RAM, adaptor cards, hard drives, sound cards, graphics cards
- peripherals, e.g. printers, scanners, cameras
- configure for system
- interrupt request (IRQ) considerations
- use safe working practices, e.g. manual handling and 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, e.g. utilities, testing, virus and other malware protections, device drivers, applications, file system structure and file types

Install and set-up software applications:

- installation, e.g. standard, custom
- copyright and licensing considerations
- setting operating characteristics
- uninstall

Operating System (OS):

- types, e.g. disk operating system (DOS), Windows family, UNIX, network operating system (NOS)

Install and set-up an operating system:

- OS types and relationships
- operating system, e.g. install, upgrade
- basic input and 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, e.g. manual handling and 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, e.g. determine set-up optimum
- documentation, e.g. system configuration procedures

## Information for delivery staff

### Essential requirements

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

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

The delivery of this unit should be a mixture of 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 resources. The peripherals that allow for input and output (transput) 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, in addition to personal safety, and the preservation of the integrity of the software and hardware resourced.

The outcomes of learning are ordered logically and could be delivered 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 'e.g.' 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 'e.g.' needs to be taught or assessed. Flexibility should be shown, especially in regard to teaching the use of the newest, most economical and most effective devices.

**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.

| **Topics and suggested assignments, activities and assessment** |
|---|
| Whole-class teaching:<br>● introduction to unit, scheme of work and assessment<br>● introduce the different types of computers and explain the basic operation of PC systems<br>● explain the purpose and use of input devices including different types of image processing and hand devices<br>● explain the purpose and use of monitors, printers, sound systems, modems and storage devices. |
| Individual learner research:<br>● investigating operation of PC systems and purpose and use of input and output devices. |
| Prepare for and carry assignment.<br>**Assignment 1 (P1, P2)** |
| Whole-class teaching:<br>● explain and demonstrate the installation and configuration of motherboards, microprocessors and types of memory<br>● explain and demonstrate the installation and configuration of display systems, standard interfaces, bus systems and power supply systems.<br>Practical workshop sessions:<br>● practise installation and configuration of hardware components. |
| Individual learner research:<br>● investigating hardware components, practising hardware installation and configuration. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, M1)** |
| Whole-class teaching:<br>● explain the main features of software packages and demonstrate how to install, configure and customise software applications<br>● explain the main types of operating systems and demonstrate their installation and set-up<br>● explain and demonstrate safe working practices.<br>Practical workshop sessions:<br>● practise installation and configuration of software applications and operating systems. |

| Topics and suggested assignments, activities and assessment |
|---|
| Individual learner research:<br>● investigating software applications and practising software procedures, including OS installation and configuration. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P5, P6, M2)** |
| Whole-class teaching:<br>● explain and demonstrate how to assemble a PC according to a specification to meet specific requirements<br>● explain and demonstrate safe working practices<br>● explain and demonstrate how to configure and test PC systems.<br>Practical workshop sessions:<br>● practise the commissioning, installation and configuration of complete PC systems. |
| Individual learner research:<br>● investigating and practising the installation and configuration of complete PC systems. |
| Prepare for and carry out assignment.<br>**Assignment 4 (P7, P8, M3, D1, D2)** |
| Unit summary and review. |

## Assessment guidance

Learners' summative assessment will be carried out on an individual basis, though 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 is an appropriate learning aspiration.

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, or where appropriate software configuration. The log could contain a description of the task undertaken, the instructions provided (annotated to record progress or difficulties), a list of tools and equipment provided and their condition, photographs that have been annotated to explain procedures and problems encountered together with other material information. Such supporting activity evidence would then validate the tutor or witness observations and oral questioning records.

The links through the grading criteria to the higher-grade levels need to be explicit in the tasks and the assignment brief generally, 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, the learner should be 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, testing and configuration (P7 and P8) with learners capturing evidence by using 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, 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 | Installation Hardware | Install hardware components for a computer maintenance company. | A practical assignment supported by tutor observation and where appropriate witness statements and a written report or logbook of the task undertaken. |

| Criteria covered | Assignment title | Scenario | Assessment method |
| --- | --- | --- | --- |
| P5, P6, M2 | Software Installation | Install software packages and an operating system for a computer maintenance company. | A practical assignment supported by tutor observation or where appropriate witness statements and a written report or logbook of the task undertaken. |
| P7, P8, M3, D1, D2 | Assembling PC Systems | Assemble, test and configure a PC system for a local business. | A practical assignment supported by tutor observation and where appropriate witness statements and a written report or logbook of the task undertaken. |

## Suggested resources

### Books

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

### Websites

| | |
| --- | --- |
| http://www.webopedia.com/TERM/C/configuration.html | As selection of links and download agent |
| https://www.pearsonschoolsandfecolleges.co.uk/Secondary/ICT/BTEC/BTECLevel2FirstIT/Resources/Additionalmaterialforusers/Unit7InstallingComputerHardware.pdf | Pearson "Installing Computer Hardware" downloadable PDF for schools |
| http://www.buzzle.com/articles/computer-software-and-hardware-installation.html | Links to various PC hardware and software topics |

# Unit 28: Mobile Communications Technology in Engineering

Level: **2**

Notional Learning Hours: **50 (including 30 GLH)**

Unit value (NLH/10): **5**

SRF unit code: **20684G**

**This unit is internally assessed**

## Unit aim

This unit develops 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.

## Outcomes of learning

On completion of this unit a learner should:

1 Know 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.

## Assessment and grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the outcomes of learning 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 in mobile communications | 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 | | |
| P4 Describe the advantages and disadvantages of different mobile communication devices | | |
| P5 Set up and configure different mobile communications technology devices to meet user needs | | |

## Unit content

### 1 Know the characteristics and services available in mobile communications technologies

Current technologies and services:

- mobile communication technologies, e.g. infrared, Bluetooth, Wi-Fi, GSM, GPRS, 2.5G, 3G, mobile VoIP
- services, e.g. text messaging, email, video conferencing, video phones, video and picture messaging, internet

Quality issues:

- standards available, e.g. 802.11 (legacy) for Wi-Fi, IrDA for Infrared
- data transfer rates
- data capacity against cost
- effective ranges
- wireless access protocols, e.g. WAP
- SMS protocols

Licensing issues:

- unlicensed frequencies, e.g. 2.4Ghz
- licensed frequencies, e.g. cellular

Wireless networking:

- wireless access points, e.g. internet hotspots
- wireless network adaptors
- wireless encryption methods, e.g. WEP
- interference from other devices

### 2 Know about the implications of mobile communications

Social implications:

- changes in social interaction, e.g. text messaging, multimedia messaging, emails
- health issues
- other, e.g. 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, e.g. piggybacking, packet sniffing
- legal issues
- effects on communities, e.g. 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, e.g. PDA, mobile telephones, wireless enabled PCs
- configuration
- connectivity
- selection of device to meet user need
- ad-hoc data transfer

## Information for delivery staff

### Essential requirements

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:

- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk

### Delivery guidance

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 'e.g.' 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 'e.g.' 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/assessment |
|---|
| Whole-class teaching:<br>• introduction to unit, scheme of work and methods of assessment<br>• introduce and explain mobile communication technologies currently in use and the services available<br>• explain the quality issues that can affect mobile communications<br>• explain licensed and unlicensed frequencies<br>• explain the networking issues that can affect wireless communications. |
| Individual learner research:<br>• investigating mobile communication technologies and services. |
| Prepare for and carry out assignment.<br>**Assignment 1 (P1, P2, M1, D1)** |
| Whole-class teaching:<br>• explain and discuss the changes in social interaction and other social implications of mobile communications<br>• explain and discuss the moral and ethical implications of mobile communications technology<br>• discuss the advantages and disadvantages of using mobile communications. |
| Individual learner research:<br>• investigating implications and advantages and disadvantages of mobile communication technology. |
| Prepare for and carry out assignment.<br>**Assignment 2 (P3, P4, M2)** |
| Whole-class teaching:<br>• discuss applications of different mobile communication technologies.<br>Practical group exercise:<br>• using, connecting and configuring a range of mobile communication devices. |
| Individual learner research:<br>• researching and practising using, connecting and configuring mobile communication devices. |
| Prepare for and carry out assignment.<br>**Assignment 3 (P5)** |
| Feedback and unit summary. |

## Assessment guidance

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 describe 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 advantages and disadvantages 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 suggested assignments to meet local needs and resources.

| Criteria covered | Assignment title | Scenario | Assessment method |
|---|---|---|---|
| P1, P2, M1, 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, 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. |

## Suggested resources

### Books


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

# Annexes

# Annexe A: Calculation of the qualification grade

## Generic examples of calculation of the qualification grade above pass grade

Pearson will automatically calculate the qualification grade for learners when unit grades are submitted by the centre.

The two tables below (which are also included in *Section 5: Assessment and grading*) are used to calculate the qualification grade above pass. The generic examples that follow the tables demonstrate how the tables are used.

## Points available per unit value at specified unit grades and levels

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

| Unit level | Points per unit value | | |
|---|---|---|---|
| | 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* |
| Pearson BTEC International Level 2 Certificate | 85–94 | 95–99 | 100 and above |
| Pearson BTEC International Level 2 Extended Certificate | 170–189 | 190–199 | 200 and above |
| Pearson BTEC International Level 2 Diploma | 340–379 | 380–399 | 400 and above |

## Generic examples

Please note the following examples are generic and are not based on the units included in this specification.

**Generic example 1**

**Achievement of pass qualification grade**

A learner completing a Pearson BTEC International Level 2 Certificate, qualification value of 15, achieves the points required to gain a pass qualification grade and does not achieve the points to gain a merit grade.

| | **Level** | **Unit value** | **Grade** | **Grade points** | **Points per unit = unit value x grade points** |
|---|---|---|---|---|---|
| Unit 1 | 2 | 5 | Pass | 5 | 5 × 5 = 25 |
| Unit 2 | 2 | 5 | Pass | 5 | 5 × 5 = 25 |
| Unit 3 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| **Qualification grade totals** | | **15** | **Pass** | | **80** |

**Generic example 2**

**Achievement of merit qualification grade**

A learner completing a Pearson BTEC International Level 2 Certificate, qualification value of 15, achieves the points required to gain a merit qualification grade.

| | **Level** | **Unit value** | **Grade** | **Grade points** | **Points per unit = unit value x grade points** |
|---|---|---|---|---|---|
| Unit 1 | 2 | 5 | Pass | 5 | 5 × 5 = 25 |
| Unit 2 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| Unit 3 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| **Qualification grade totals** | | **15** | **Merit** | | **85** |

**Generic example 3**

**Achievement of distinction qualification grade**

A learner completing a Pearson BTEC International Level 2 Certificate, qualification value of 15, achieves the points required to gain a distinction qualification grade.

| | **Level** | **Unit value** | **Grade** | **Grade points** | **Points per unit = unit value x grade points** |
|---|---|---|---|---|---|
| Unit 1 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| Unit 2 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| Unit 3 | 2 | 5 | Distinction | 7 | 5 × 7 = 35 |
| **Qualification grade totals** | | **15** | **Distinction** | | **95** |

**Generic example 4**

**Achievement of merit qualification grade**

A learner completing a Pearson BTEC International Level 2 Extended Certificate, qualification value of 30, achieves the points required to gain a merit qualification grade.

| | Level | Unit value | Grade | Grade points | Points per unit = unit value x grade points |
|---|---|---|---|---|---|
| Unit 1 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| Unit 2 | 2 | 5 | Pass | 5 | 5 × 5 = 25 |
| Unit 3 | 2 | 5 | Distinction | 7 | 5 × 7 = 35 |
| Unit 6 | 2 | 10 | Pass | 5 | 10 x 5 = 50 |
| Unit 8 | 3 | 5 | Pass | 7 | 5 x 7 = 35 |
| **Qualification grade totals** | | **30** | **Merit** | | **175** |

**Generic example 5**

**Achievement of merit qualification grade**

A learner completing a Pearson BTEC International Level 2 Diploma, qualification value of 60, achieves the points required to gain a merit qualification grade.

| | Level | Unit value | Grade | Grade points | Points per unit = unit value x grade points |
|---|---|---|---|---|---|
| Unit 1 | 2 | 5 | Merit | 6 | 5 × 6 = 30 |
| Unit 2 | 2 | 5 | Pass | 5 | 5 × 5 = 25 |
| Unit 3 | 2 | 5 | Distinction | 7 | 5 × 7 = 35 |
| Unit 6 | 2 | 10 | Merit | 6 | 10 x 6 = 60 |
| Unit 9 | 1 | 5 | Merit | 4 | 5 x 4 = 20 |
| Unit 10 | 2 | 10 | Distinction | 7 | 10 x 7 = 70 |
| Unit 11 | 2 | 10 | Merit | 6 | 10 x 6 = 60 |
| Unit 14 | 2 | 10 | Merit | 6 | 10 x 6 = 60 |
| **Qualification grade totals** | | **60** | **Merit** | | **360** |

BTEC

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