# City & Guilds Level 2 Certificate/Diploma in Engineering Operations (Knowledge) (4510-11/12)

**Version 2.2 (April 2023)**

## Qualification Handbook

# Qualification at a glance

| | |
|---|---|
| **Subject area** | Engineering |
| **City & Guilds number** | 4510 |
| **Age group approved** | 16+ |
| **Entry requirements** | None |
| **Assessment types** | Short Answer, Centre Devised |
| **Approvals** | Fast track approval |
| **Support materials** | Assessment pack |
| **Registration and certification** | Consult the Walled Garden/Online Catalogue for last dates |

| Title and level | City & Guilds qualification number | Ofqual accreditation number | GLH | TQT |
|---|---|---|---|---|
| City & Guilds Level 2 Certificate in Engineering Operations (Knowledge) | 4510-11 | 603/6595/X | 220 | 230 |
| City & Guilds Level 2 Diploma in Engineering Operations (Knowledge) | 4510-12 | 603/6596/1 | 370 | 390 |

| Version and date | Change detail | Section |
|---|---|---|
| V1.0 September 2020 | Ofqual accreditation no. added | |
| V2.0 July 2021 | Added optional City & Guilds devised assessments | 4 Assessment |
| V2.1 August 2021 | Added optional City & Guilds devised assessments | 4 Assessment strategy |
| V2.2 April 2023 | Qualification regulatory table updated with GLH and TQT<br>Unit 201 AC 1.5 range updated<br>Appendix 1 updated and Appendix 2 deleted<br>Page numbering updated | Qualification at a glance<br>Unit 201 Working in an Engineering Environment<br>Appendices<br>Throughout |

**Contents**

# 1 Introduction

This document tells you what you need to do to deliver the qualification:

| Area | Description |
|---|---|
| Who is the qualification for? | Those working as engineering operatives within the engineering and manufacturing sector. |
| What does the qualification cover? | This qualification allows learners to develop the knowledge required for employment and/or career progression in the engineering and manufacturing industry sector in general. |
| What opportunities for progression are there? | Upon completion, apprentices will have achieved the on-programme knowledge qualification. This is a mandatory component of the level 2 engineering operative apprenticeship framework. Whilst progression into further study is an option, the intent for this standard is that progression is into one of the job roles defined within the standard as an operative. |
| Who did we develop the qualification with? | This qualification has been developed in collaboration with the Engineering and Manufacturing Employer Group which included the following organisations: Roquette UK, William Hare Ltd, JCB, MoveTech, Ministry of Defence, KMF, Severfield (UK) Limited, Royal Armoured Corps, Cooney Marine, Unipres (UK) limited, Quinton Major, Renishaw, Siemens, CSPS. |
| Is it part of an apprenticeship framework or initiative? | Yes. This qualification forms part of the on-programme engineering operative apprenticeship standard.<br><br>The qualification can also be used for full time students who would like to gain the knowledge that will enable them to progress into further training. |

## Structure

**City & Guilds Level 2 Certificate in Engineering Operations (Knowledge) (4510-11)**
Learners must achieve the mandatory unit (201), plus a minimum of 3 optional units from (202-247). This qualification has a minimum qualification time of 220 and a TQT of 230.

**City & Guilds Level 2 Diploma in Engineering Operations (Knowledge) (4510-12)**
Learners must achieve the mandatory unit (201), plus a minimum of 6 optional units from (202-247). This qualification has a minimum qualification time of 370 and a TQT of 390.

| City & Guilds unit number | Unit title | GLH |
|---|---|---|
| **Mandatory** | | |
| 201 | Working in an engineering environment | 70 |
| **Optional** | | |
| 202 | Engineering techniques | 40 |
| 203 | Engineering mathematics and science principles | 70 |
| 204 | Fitting and assembly techniques | 50 |
| 205 | Business improvement techniques | 60 |
| 206 | Principles of turning and milling | 80 |
| 207 | Manual turning techniques | 50 |
| 208 | Manual milling techniques | 50 |
| 209 | Grinding techniques | 50 |
| 210 | Principles of computer numerical control (CNC) machining/fabrication | 50 |
| 211 | Computer numerical control (CNC) turning techniques | 50 |
| 212 | Computer numerical control (CNC) milling techniques | 50 |
| 213 | Computer aided design (CAD) | 50 |
| 214 | Electrical and electronic principles | 40 |
| 215 | Electrical and electronic testing methods | 50 |
| 216 | Electrical and electronic systems and devices | 40 |
| 217 | Fabrication and welding principles | 50 |
| 218 | Manual welding techniques | 70 |

| City & Guilds unit number | Unit title | GLH |
|---|---|---|
| **Optional** | | |
| 219 | Producing components from metal plate | 50 |
| 220 | Producing components from sheet metal | 50 |
| 221 | Sheet metalwork technology | 50 |
| 222 | Non-fusion thermal joining methods | 50 |
| 223 | Thermal cutting techniques | 40 |
| 224 | Engineering maintenance safety practices | 40 |
| 225 | Engineering maintenance techniques | 50 |
| 226 | Engineering maintenance planning | 50 |
| 227 | Engineering materials processes | 60 |
| 228 | Electrical installation methods, wiring and circuit protection | 50 |
| 229 | Basic electrical circuit inspection, testing and fault diagnosis | 50 |
| 230 | Building services engineering pipework fixing, bending and jointing methods | 50 |
| 231 | Building services engineering pipework fabrication processes and techniques | 50 |
| 232 | Building services pipework systems | 50 |
| 233 | Building services engineering systems and their layout requirements | 50 |
| 234 | Installation and servicing of refrigeration equipment | 50 |
| 235 | Installation and servicing of air-conditioning equipment | 50 |
| 236 | Design of security systems | 50 |
| 237 | Installation of security systems | 50 |
| 238 | Plan and carry out a project in engineering | 60 |
| 239 | Applied mathematics in engineering | 70 |
| 240 | Leading a team in engineering | 40 |
| 241 | Engineering manufacturing techniques | 50 |

| City & Guilds unit number | Unit title | GLH |
|---|---|---|
| **Optional** | | |
| 242 | Engineering design techniques | 50 |
| 243 | Marketing an engineering product | 50 |
| 244 | Additive manufacturing (3D printing) | 40 |
| 245 | Effective working practices in an engineering environment when working on military vehicles and equipment | 30 |
| 246 | Principles of military vehicle and equipment maintenance | 60 |
| 247 | Procedures and processes for fault identification on military vehicles and mechanical systems | 70 |

**Barred units**

**Unit 206 is barred with units 207 and 208**

If unit 206 is undertaken then units 207 and 208 cannot be taken

**Unit 210 is barred with units 211 and 212**

If unit 210 is undertaken then units 211 and 212 cannot be taken

## Total Qualification Time

Total Qualification Time (TQT) is the total amount of time, in notional hours, which represents an estimate of the total amount of time expected for a learner to achieve and demonstrate the achievement of the level of attainment a necessary to award a qualification.

TQT is comprised of the following two elements:

1) The number of hours which an awarding organisation has assigned to a qualification for Guided Learning, and
2) An estimate of the number of hours a learner will be likely to spend in preparation, study or any other form of participation in education or training, including assessment, which takes place as directed by - but, not under the immediate guidance or supervision of a lecturer, supervisor, tutor or other education or training provider.

| Title and level | GLH | TQT |
|---|---|---|
| City & Guilds Level 2 Certificate in Engineering Operations (Knowledge) | 220 | 230 |

| Title and level | GLH | TQT |
|---|---|---|
| City & Guilds Level 2 Diploma in Engineering Operations (Knowledge) | 370 | 390 |

# 2 Centre requirements

## Approval

If your centre is approved to offer the following qualifications:

Level 2 Certificate in Engineering - Manufacturing Technology (2850-20)
Level 2 Certificate in Engineering - Maintenance Technology (2850-21)
Level 2 Certificate in Engineering - Fabrication and Welding Technology (2850-22)
Level 2 Certificate in Engineering - Electrical & Electronics Technology (2850-23)

Level 2 Diploma in Engineering - Manufacturing Technology (2850-24)
Level 2 Diploma in Engineering - Maintenance Technology (2850-25)
Level 2 Diploma in Engineering - Fabrication and Welding Technology (2850-26)
Level 2 Diploma in Engineering - Electrical & Electronics Technology (2850-27)

then you can apply for fast track approval of the new Level 2 Certificate/Diploma in Engineering Operations (Knowledge) using the fast track approval form, available from the City & Guilds website.

To offer these qualifications, new centres will need to gain both centre and qualification approval. Please refer to the Centre Manual - Supporting Customer Excellence for further information.

Centre staff should familiarise themselves with the structure, content and assessment requirements of the qualifications before designing a course programme.

## Internal quality assurance

Approved centres must have effective quality assurance systems to ensure optimum delivery and assessment of qualifications.

Quality assurance includes initial centre approval, qualification approval and the centre's own internal procedures for monitoring quality. Centres are responsible for internal quality assurance and City & Guilds is responsible for external quality assurance.

Standards and rigorous quality assurance are maintained by the use of:

- Internal quality assurance
- City & Guilds external quality assurance.

In order to carry out the quality assurance role, Internal Quality Assurers must have appropriate teaching and vocational knowledge and expertise. Assessor/Verifier (A/V) units are valued as qualifications for the centre, but they are not currently a requirement for this qualification.

Additionally, those involved in internal quality assurance must:

- have experience in quality management/internal verification
- hold or be working towards an appropriate teaching/training/assessing qualification
- be familiar with the occupation and technical content covered within the qualification.

## Resource requirements

### *Centre staffing*

Staff delivering these qualifications must be able to demonstrate that they meet the following occupational expertise requirements. They should:

- be occupationally competent or technically knowledgeable in the areas for which they are delivering training and/or have experience of providing training. This knowledge must be to the same level as the training being delivered
- have recent relevant experience in the specific area they will be assessing
- have credible experience of providing training.

Centre staff may undertake more than one role, e.g. tutor and assessor or internal verifier, but cannot internally verify their own assessments. They must:

- be technically knowledgeable in the area(s) for which they are delivering training/assessing, with appropriate qualifications.

## Learner entry requirements

City & Guilds does not set entry requirements for these qualifications. However, centres must ensure that candidates have the potential and opportunity to gain the qualifications successfully.

Individual employers will set the criteria, but employers who recruit learners without English and Maths at level 1 (or equivalent), must ensure that the learner achieves this requirement and take the test for Level 2, prior to completion of the Apprenticeship.

This qualification is a mandatory component of the on-programme phase of the Engineering Operative Apprenticeship Standard for the following occupational engineering job roles; maintenance operative, mechanical manufacturing operative, electrical and electronic operative, fabrication operative, materials, processing, finishing operative, and technical support operative.

The Standard and Assessment plan was designed by Employers. Centres should make themselves familiar with the Standard, Assessment Plan and Employer Occupational Brief requirements, details of which can be found at:
https://www.gov.uk/government/collections/apprenticeship-standards

## Age restrictions

City & Guilds cannot accept any registrations for learners under 16 as these qualifications are not approved for learners under 16.

# 3 Delivering the qualification

## Initial assessment and induction

An initial assessment of each candidate should be made before the start of their programme to identify:

- if the candidate has any specific training needs
- support and guidance they may need when working towards their qualifications
- the appropriate type and level of qualification.

We recommend that centres provide an induction programme so the candidate fully understands the requirements of the qualifications, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

## Support materials

The following resources are available for these qualifications:

| Description | How to access |
|---|---|
| Sample assessment pack | www.cityandguilds.com |

# 4 Assessment

## Summary of assessment methods

### *Candidates must:*

- have completed the relevant assessment for the Mandatory unit
- have completed the relevant assessment for each optional unit chosen.

### *Available assessments/assignments*

City & Guilds has written the following assessments to use with this qualification. These assessments are 'externally set, internally marked.'

- Short answer tests for Mandatory unit 201
- Short answer tests for Optional unit 202
- Short answer tests for Optional unit 203
- Short answer tests for Optional unit 204
- Short answer tests for Optional unit 206
- Short answer tests for Optional unit 207
- Short answer tests for Optional unit 208
- Short answer tests for Optional unit 209
- Short answer tests for Optional unit 210
- Short answer tests for Optional unit 211
- Short answer tests for Optional unit 212
- Short answer tests for Optional unit 213
- Short answer tests for Optional unit 214
- Short answer tests for Optional unit 218
- Short answer tests for Optional unit 225
- Short answer tests for Optional unit 227
- Short answer tests for Optional unit 242

City & Guilds has produced guidance for centres to develop their own centre devised assessments for units 202-247, available from the City & Guilds website. (see separate Centre Devised Assessments guidance).

Centres may choose whether to create their own assessments, or use the assessments devised by City & Guilds.

| Assessment Types | | | | |
|---|---|---|---|---|
| **Unit** | **Title** | **Assessment method** | **Grading** | **Where to obtain assessment materials** |
| 201 | Working in an engineering environment | Externally set, internally marked assessment | P/X | www.cityandguilds.com |
| 202 | Engineering techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 203 | Engineering mathematics and science principles | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 204 | Fitting and assembly techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 205 | Business improvement techniques | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 206 | Principles of turning and milling | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | Where to obtain assessment materials |
|---|---|---|---|---|
| 207 | Manual turning techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 208 | Manual milling techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 209 | Grinding techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 210 | Principles of computer numerical control (CNC) machining/fabrication | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 211 | Computer numerical control (CNC) turning techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | Where to obtain assessment materials |
|---|---|---|---|---|
| 212 | Computer numerical control (CNC) milling techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 213 | Computer aided design (CAD) | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 214 | Electrical and electronic principles | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 215 | Electrical and electronic testing methods | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 216 | Electrical and electronic systems and devices | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 217 | Fabrication and welding principles | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | Where to obtain assessment materials |
|---|---|---|---|---|
| 218 | Manual welding techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 219 | Producing components from metal plate | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 220 | Producing components from sheet metal | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | |
|---|---|---|---|---|
| 221 | Sheet metalwork technology | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 222 | Non-fusion thermal joining methods | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 223 | Thermal cutting techniques | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 224 | Engineering maintenance safety practices | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 225 | Engineering maintenance techniques | Externally set, internally marked assessment Or Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 226 | Engineering maintenance planning | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 227 | Engineering materials processes | Externally set, internally marked assessment Or Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 228 | Electrical installation methods, wiring and circuit protection | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 229 | Basic electrical circuit inspection, testing and fault diagnosis | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | |
|---|---|---|---|---|
| 230 | Building services engineering pipework fixing, bending and jointing methods | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 231 | Building services engineering pipework fabrication processes and techniques | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 232 | Building services pipework systems | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 233 | Building services engineering systems and their layout requirements | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 234 | Installation and servicing of refrigeration equipment | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 235 | Installation and servicing of air-conditioning equipment | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 236 | Design of security systems | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 237 | Installation of security systems | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | Where to obtain assessment materials |
|---|---|---|---|---|
| 238 | Plan and carry out a project in engineering | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 239 | Applied mathematics in engineering | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 240 | Leading a team in engineering | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 241 | Engineering manufacturing techniques | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 242 | Engineering design techniques | Externally set, internally marked assessment<br>Or<br>Centre devised, internally set and marked assessment | P/X | www.cityandguilds.com |
| 243 | Marketing an engineering product | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 244 | Additive manufacturing (3D printing) | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 245 | Effective working practices in an engineering environment when working on military vehicles and equipment | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |

| Unit | Title | Assessment method | Grading | Where to obtain assessment materials |
|---|---|---|---|---|
| 246 | Principles of military vehicle and equipment maintenance | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |
| 247 | Procedures and processes for fault identification on military vehicles and mechanical systems | Centre Devised Internally set and marked assessment | P/X | www.cityandguilds.com |

## Assessment requirements

## Assessment strategy

Mandatory unit 201 and Optional units 202-204, 206-214, 218, 225, 227, 242 are assessed by a short answer test, which is graded Pass/Fail only. This may be a test created by City & Guilds or Centre devised. Centres may choose whether to create their own assessments, or use the assessments devised by City & Guilds. The test is marked by the centre and externally quality assured.

Optional units 205, 215-217, 219-224, 226, 228-247 are assessed by short answer tests, which are centre devised, internally marked by centres and externally quality assured. These assessments are graded Pass/Fail only.

### *Test Specifications*

The way the knowledge is covered by each externally marked test is laid out in the tables below. Further details are available in the document *Developing centre devised assessments* available on the City & Guilds website.

**Assessment title:** 4510-201 Working in an engineering environment
**Assessment type:** Short answer test
**Assessment conditions:** Supervised examination conditions
**Grading:** P/X

| | **Duration: 2 hours** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 201** | 1. Understand health and safety requirements in engineering | 22 | 31 |
| | 2. Understand how engineering businesses are organised | 16 | 23 |
| | 3. Know types of workshop equipment and their applications | 16 | 23 |
| | 4. Understand fitting and assembly activities | 16 | 23 |
| | **Total** | **70** | **100** |

**Assessment title:** 4510-202 Engineering techniques
**Assessment type:** Short answer test
**Assessment conditions:** Supervised examination conditions
**Grading:** P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 202** | 1. Understand drawings used by engineering businesses | 26 | 65 |
| | 2. Understand quality processes in engineering | 14 | 35 |
| | **Total** | **40** | **100** |

**Assessment title:** 4510-203 Engineering mathematics & science principles
**Assessment type:** Short answer test
**Assessment conditions:** Supervised examination conditions
**Grading:** P/X

| | **Duration: 1 hour 30 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 203** | 1. Understand arithmetical and trigonometrical applications | 15 | 21 |
| | 2. Know how to determine perimeters, areas and volumes of shapes | 15 | 21 |
| | 3. Understand terminology used in engineering science | 17 | 25 |
| | 4. Understand the effect of changes of temperature on engineering materials | 9 | 13 |
| | 5. Understand the properties of engineering material | 14 | 20 |
| | **Total** | **70** | **100** |

**Assessment title:** 4510-204 Workshop fitting and assembly techniques
**Assessment type:** Short answer test
**Assessment conditions:** Supervised examination conditions
**Grading:** P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 204** | 1. Understand engineering health and safety requirements | 20 | 40 |
| | 2. Understand fitting and assembly techniques | 30 | 60 |
| | **Total** | **50** | **100** |

**Assessment title:** 4510-205 Business improvement techniques
**Assessment type:** Centre devised short answer test
**Assessment conditions:** Supervised examination conditions
**Grading:** P/X

| | Duration: 1 hour 30 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 205** | 1. Understand the concept of continuous improvement | 20 | 33 |
| | 2. Understand what is meant by workplace organisation | 14 | 23 |
| | 3. Understand what is meant by visual management | 10 | 17 |
| | 4. Understand problem solving techniques | 16 | 27 |
| | **Total** | **60** | **100** |

**Assessment title**: 4510-206 Principles of turning and milling
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 2 hours | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 206** | 1. Know equipment required for turning and milling operations | 34 | 43 |
| | 2. Understand how to produce manually machined components | 32 | 40 |
| | 3. Understand how to meet quality requirements for machining components | 14 | 17 |
| | **Total** | **80** | **100** |

**Assessment title**: 4510-207 Manual turning techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 207** | 1. Know the equipment required for turning operations | 18 | 36 |
| | 2. Understand how to produce turned components on a lathe | 24 | 48 |
| | 3. Understand how to meet quality requirements for turning operations | 8 | 16 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-208 Manual milling techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 208** | 1 Know the equipment required for milling operations | 18 | 36 |
| | 2 Understand how to produce components on a milling machine | 24 | 48 |
| | 3 Understand how to meet quality requirements for milling operations | 8 | 16 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-209 Grinding techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 209** | 1. Know the equipment required for grinding operations | 20 | 40 |
| | 2. Understand how to produce components on grinding machines | 20 | 40 |
| | 3. Understand how to meet quality requirements for grinding operations | 10 | 20 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-210 Principles of CNC machining/fabrication
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 210** | 1. Understand the equipment available for CNC fabrication operations | 24 | 48 |
| | 2. Understand the programming of CNC fabrication machinery | 16 | 32 |
| | 3. Understand the benefits and limitations of using CNC fabrication machinery | 10 | 20 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-211 CNC turning techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 211** | 1. Know the equipment required for CNC turning operations | 24 | 48 |
| | 2. Understand how to produce turned components on a CNC lathe | 20 | 40 |
| | 3. Understand quality requirements for CNC turning operations | 6 | 12 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-212 CNC milling techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 212** | 1. Know the equipment required for CNC milling operations | 22 | 44 |
| | 2. Understand how to produce components on a CNC mill | 22 | 44 |
| | 3. Understand quality requirements for CNC milling operations | 6 | 12 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-213 Computer aided design (CAD)
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 213** | 1. Understand the principles of using a CAD system | 24 | 48 |
| | 2. Know the main capabilities of CAD software | 26 | 52 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-214 Electrical and electronic principles
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 214** | 1. Understand electrical and electronic circuit principles | 8 | 20 |
| | 2. Understand the units of measurement used to quantify electrical parameters | 7 | 18 |
| | 3. Understand methods of calculating values in electrical and electronic circuits | 25 | 62 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-215 Electrical and electronic testing methods
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 215** | 1. Understand the units of measurement used to quantify electrical parameters | 14 | 28 |
| | 2. Understand the applications of electrical and electronic test equipment | 24 | 48 |
| | 3. Understand electrical and electronic test equipment calibration techniques | 12 | 24 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-216 Electrical and electronic systems and devices
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 216** | 1. Understand the functions of electrical and electronic components and devices | 24 | 60 |
| | 2. Understand methods of representing electrical and electronic systems | 16 | 40 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-217 Fabrication and welding principles
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 217** | 1. Understand the equipment available to produce fabricated components | 14 | 28 |
| | 2. Understand cutting and forming methods used for fabrication | 18 | 36 |
| | 3. Understand the joining and assembly methods for fabrication | 18 | 36 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-218 Manual welding techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 2 hours** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 218** | 1. Understand safe working practices associated with welding processes | 12 | 17 |
| | 2. Understand principles of manual welding | 20 | 29 |
| | 3. Understand the Manual Metal Arc (MMA) welding process | 6 | 9 |
| | 4. Understand the Metal Inert Gas/Metal Active Gas (MIG/MAG) welding processes | 10 | 14 |
| | 5. Understand the Tungsten Inert Gas (TIG) welding process | 10 | 14 |
| | 6. Understand inspection methods for weld defects | 12 | 17 |
| | **Total** | **70** | **100** |

**Assessment title**: 4510-219 Producing components from metal plate
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 219** | 1. Understand tools and equipment used to produce metal plate components | 18 | 36 |
| | 2. Understand cutting methods for metal plate | 12 | 24 |
| | 3. Understand forming methods for metal plate | 6 | 12 |
| | 4. Understand joining and assembly methods for metal plate | 14 | 28 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-220 Producing components from sheet metal
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 220** | 1. Understand tools and equipment used to produce sheet metal components | 16 | 32 |
| | 2. Understand cutting methods for sheet metal | 8 | 16 |
| | 3. Understand forming methods for sheet metal | 10 | 20 |
| | 4. Understand joining and assembly methods for sheet metal | 16 | 32 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-221 Principles of sheet and plate metal work technology
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 221** | 1. Understand methods of work organisation | 14 | 28 |
| | 2. Understand cutting and forming principles | 24 | 48 |
| | 3. Know pattern development techniques | 12 | 24 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-222 Non-Fusion thermal joining methods
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 222** | 1. Understand the soft soldering method of joining metals | 15 | 30 |
| | 2. Understand the hard-soldering method of joining metals | 15 | 30 |
| | 3. Understand the use of adhesives to join materials | 20 | 40 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-223 Thermal cutting techniques
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 223** | 1. Understand the principle of oxy-fuel thermal cutting | 26 | 65 |
| | 2. Understand the principle of plasma cutting | 8 | 20 |
| | 3. Understand the principle of laser cutting | 6 | 15 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-224 Engineering maintenance safety
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 224** | 1. Understand safe working practices, tools and equipment for maintenance activities | 30 | 75 |
| | 2. Know how to clean and restore work areas following maintenance activities | 10 | 25 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-225 Engineering maintenance techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 225** | 1. Understand fault diagnostic methods | 14 | 28 |
| | 2. Understand measuring systems and instrumentation | 10 | 20 |
| | 3. Understand how plant and equipment is maintained | 26 | 52 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-226 Engineering maintenance planning
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 226** | 1 Understand different types of planned maintenance | 18 | 36 |
| | 2 Understand health and safety requirements for planning maintenance activities | 12 | 24 |
| | 3 Understand the planning of maintenance activities | 20 | 40 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-227 Engineering materials
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 30 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 227** | 1. Understand the properties of materials | 24 | 40 |
| | 2. Understand methods by which the properties of materials can be changed | 12 | 20 |
| | 3. Understand failure mechanisms in materials | 24 | 40 |
| | **Total** | **60** | **100** |

**Assessment title**: 4510-228 Electrical installation methods, wiring and circuit protection
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 228** | 1. Understand the principles of electrical circuit wiring | 16 | 32 |
| | 2. Know electrical installation and wiring methods | 26 | 52 |
| | 3. Understand the applications of electrical circuit protection devices | 8 | 16 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-229 Electrical circuit inspection, testing and fault diagnosis
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 229** | 1. Understand safe electrical isolation procedures | 10 | 20 |
| | 2. Understand methods of inspecting, testing and fault-finding electrical circuits | 34 | 68 |
| | 3. Know standards and guidance relating to electrical testing and fault diagnosis | 6 | 12 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-230 Building services engineering pipework fixing, bending and jointing methods
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 230** | 1. Understand the materials used in domestic pipework applications | 4 | 8 |
| | 2. Understand methods of bending pipework | 6 | 12 |
| | 3. Understand methods of joining pipes | 10 | 20 |
| | 4. Understand methods of fixing pipework to the fabric of a building | 16 | 32 |
| | 5. Understand methods of testing domestic pipework | 14 | 28 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-231 Building services engineering pipework fabrication processes and techniques
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 231** | 1. Understand pipework fabrication and installation methods | 24 | 48 |
| | 2. Understand methods of supporting domestic pipework | 10 | 20 |
| | 3. Understand methods of testing domestic pipework | 16 | 32 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-232 Building services pipework systems
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 232** | 1. Understand hot and cold water supply systems used for domestic plumbing | 16 | 32 |
| | 2. Understand the principles of central heating systems | 12 | 24 |
| | 3. Understand above ground discharge systems | 10 | 20 |
| | 4. Understand energy and environmental issues arising from heating and water usage | 12 | 24 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-233 Building services engineering systems and their layout requirements

**Assessment type**: Centre devised short answer test

**Assessment conditions**: Supervised examination conditions

**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| **Unit 233** | **Learning Outcome** | **Number of marks** | **%** |
| | 1. Understand types of cold water systems used in domestic buildings | 16 | 32 |
| | 2. Understand types of hot water systems used in domestic buildings | 10 | 20 |
| | 3. Understand the principles of central heating systems | 10 | 20 |
| | 4. Understand types of sanitary pipework systems | 10 | 20 |
| | 5. Understand energy sources used in the building services industry | 4 | 8 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-234 Installation and servicing of refrigeration equipment
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 30 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 234** | 1. Understand the principles of thermodynamics | 17 | 28 |
| | 2. Understand the operating principles and controls for refrigeration systems | 11 | 18 |
| | 3. Understand the principles of installing refrigeration systems | 22 | 37 |
| | 4. Understand the principles of maintaining and servicing refrigeration systems | 10 | 17 |
| | **Total** | **60** | **100** |

**Assessment title**: 4510-235 Installation and servicing of air-conditioning equipment
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 30 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 235** | 1. Understand the principles of thermodynamics | 17 | 28 |
| | 2. Understand the operating principles and controls for air-conditioning systems | 11 | 18 |
| | 3. Understand the principles of installing air-conditioning systems | 22 | 37 |
| | 4. Understand the principles of maintaining and servicing air-conditioning systems | 10 | 17 |
| | **Total** | **60** | **100** |

**Assessment title**: 4510-236 Installation of security systems
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 30 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 236** | 1. Understand types of security systems | 10 | 16 |
| | 2. Understand circuit wiring and transmission paths | 22 | 37 |
| | 3. Understand the design considerations of security systems | 22 | 37 |
| | 4. Understand the testing requirements of security systems | 6 | 10 |
| | **Total** | **60** | **100** |

**Assessment title**: 4510-237 Installation of security systems
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 237** | 1. Understand site planning for a security system | 8 | 20 |
| | 2. Understand safety considerations for installation | 12 | 30 |
| | 3. Know methods of installing security systems | 14 | 35 |
| | 4. Understand procedures for commissioning and handover | 6 | 15 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-238 Project management in engineering
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 30 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 238** | 1. Understand the importance of project management | 14 | 23 |
| | 2. Understand how to plan, monitor and review a project | 46 | 77 |
| | **Total** | **60** | **100** |

**Assessment title**: 4510-239 Applied mathematics in engineering
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 2 hours** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 239** | 1. Apply principles of algebra to solve engineering problems | 11 | 16 |
| | 2. Apply principles of calculus and use graphs to solve engineering problems | 26 | 37 |
| | 3. Apply principles of trigonometry to solve engineering problems | 15 | 21 |
| | 4. Apply statistics to solve engineering problems | 18 | 26 |
| | **Total** | **70** | **100** |

**Assessment title**: 4510-240 Leading an engineering team
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 240** | 1. Understand approaches to leading a team | 18 | 45 |
| | 2. Understand types of communication used in engineering businesses | 8 | 20 |
| | 3. Understand how to resolve problems and conflict in the workplace | 14 | 35 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-241 Engineering manufacturing techniques
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 241** | 1. Understand how to prepare for manufacturing operations | 16 | 32 |
| | 2. Understand the principles of manufacturing operations | 20 | 40 |
| | 3. Understand factors that affect the efficiency of manufacturing | 14 | 28 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-242 Engineering design techniques
**Assessment type**: Short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 242** | 1. Understand the factors that affect the development of a product design specification (PDS) | 20 | 40 |
| | 2. Understand strategies and techniques used to develop design solutions | 18 | 36 |
| | 3. Understand the factors that affect the evaluation of a product design | 12 | 24 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-243 Marketing engineered products
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour 15 minutes | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 243** | 1. Understand the principles of marketing | 20 | 40 |
| | 2. Understand the marketing process for an engineered product | 22 | 44 |
| | 3. Understand marketing as a communication method | 8 | 16 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-244 Additive manufacturing (3D printing)
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | Duration: 1 hour | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 244** | 1. Understand the principles of additive manufacturing | 12 | 30 |
| | 2. Understand the set-up and operation of 3D printing | 28 | 70 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-245 Effective working practices in an engineering environment when working on military vehicles and equipment

**Assessment type**: Centre devised short answer test

**Assessment conditions**: Supervised examination conditions

**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 245** | 1. Understand the procedures for carrying out an engineering activity on military vehicles and equipment. | 16 | 32 |
| | 2. Understand data used for engineering activities | 22 | 44 |
| | 3. Understand the importance of quality control | 12 | 24 |
| | **Total** | **50** | **100** |

**Assessment title**: 4510-246 Principles of military vehicle and equipment maintenance
**Assessment type**: Centre devised short answer test
**Assessment conditions**: Supervised examination conditions
**Grading**: P/X

| | **Duration: 1 hour** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 246** | 1. Understand the different types of maintenance | 22 | 55 |
| | 2. Understand the procedures for maintenance on military equipment in line with the technical literature available | 12 | 30 |
| | 3. Understand the procedures for removing and replacing components | 6 | 15 |
| | **Total** | **40** | **100** |

**Assessment title**: 4510-247 Procedures and processes for fault identification on military vehicles and mechanical systems

**Assessment type**: Centre devised short answer test

**Assessment conditions**: Supervised examination conditions

**Grading**: P/X

| | **Duration: 1 hour 15 minutes** | | |
|---|---|---|---|
| | **Learning Outcome** | **Number of marks** | **%** |
| **Unit 247** | 1. Understand the function of military vehicles and mechanical systems | 10 | 22.5 |
| | 2. Understand how to identify the symptoms of a fault | 16 | 35 |
| | 3. Understand procedures for rectifying / remedying faults | 9 | 20 |
| | 4. Understand the process for testing / checking the function of equipment following repair | 10 | 22.5 |
| | **Total** | **45** | **100** |

# 5 Grading

## Grading of individual assessments

A Pass reflects the minimum requirements that are expressed in the unit.

Candidates must achieve a pass in all components for the qualification to be achieved, as per the marking scheme provided.

# 6 Units

## Structure of the units

These units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Learning outcomes, which are comprised of a number of assessment criteria.

# Unit 201 Working in an Engineering Environment

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 70 |
| **Unit aim:** | The aim of this unit is to introduce learners to basic principles of working in engineering environment. It provides the learner with knowledge of the information, tools and equipment needed to create products. They will also learn about basic business concepts relating to organisational structure, communication and quality systems |

## Learning outcome

The learner will:

1 Understand health and safety requirements in engineering

## Assessment criteria

The learner can:

1.1 Describe the key requirements of health and safety legislation in engineering
1.2 Explain the health and safety responsibilities of employers and employees
1.3 Explain safe working practices in engineering
1.4 Describe fire prevention and control methods
1.5 Describe types of safety signs and their applications
1.6 Explain the risk assessment process

## Range

AC1.1 Health and safety legislation

- Health and Safety at Work Act
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations
- Control of Substances Hazardous to Health Regulations (COSHH)
- Manual Handling Operations Regulations
- Reporting of Diseases and Dangerous Occurrence Regulations
- Electricity at Work Regulations

AC1.3 Safe working practices

- Appropriate PPE for task
- Ensuring area is safe prior to commencing work
- Safe isolation of energy sources

- Reinstating work area on completion e.g. tool storage, waste disposal, cleaning

AC1.4 Fire prevention

- The fire triangle
- Types of fire extinguishers and their application
- Evacuation procedures

AC1.5 Types of safety signs

- Warning
- Mandatory
- Prohibition
- Emergency escape or first aid
- Firefighting
- Hazardous substances

AC1.5 Applications

- Shape
- Colour
- Pictogram

AC1.6 Risk assessment:

- Hazard
- Risk: (likelihood, severity, number of people involved)
- Control measures
- Hierarchy of control

---

## Learning outcome

The learner will:

2 Understand how engineering businesses are organised

## Assessment criteria

The learner can:

2.1 Describe sectors of the engineering industry
2.2 Explain characteristics of engineering businesses
2.3 Describe the functional areas of engineering businesses
2.4 Explain factors that cause change in engineering businesses
2.5 Explain the principles and methods of communication
2.6 Describe the types of communication used in engineering businesses

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## Range

AC2.1 Sectors

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- Aerospace
- Automotive
- Construction & civil
- Defence
- Electrical & electronic
- Manufacturing
- Marine
- Power generation
- Petrochemical

AC2.2 Characteristics of businesses

- Size
- Geographical operation: local, national, international
- Organisational structures: product, functional, matrix
- Roles and responsibilities

AC2.3 Functional areas

- Support e.g. human resources, administration
- Sales and marketing
- Distribution
- Production
- Maintenance
- Quality
- Product development

AC2.4 Factors

- Market pull
- Technology push
- Legislation
- Environmental

AC 2.5 Principles and methods of communication

- Two-way process
- Exchange of information
- Methods of communication (oral, written, electronic, non-verbal)
- Formal/informal

AC2.6 Types of communication

- Job cards
- Standard operating procedures
- Bill of materials
- Technical reports
- Emails
- Virtual and augmented reality
- Mobile applications

---

## Learning outcome

The learner will:

3 Know types of workshop equipment and their applications

## Assessment criteria

The learner can:

3.1 Describe engineering workshop tools and their applications
3.2 Describe types of marking out tools and their applications
3.3 Describe types of measuring equipment and their applications

---

## Range

AC3.1 Tools including:

- Hacksaws
- Files
- Chisels
- Drills
- Taps and dies
- Screwdrivers
- Spanners
- Hammers and mallets
- Pliers
- Torque wrenches

AC3.2 Marking out tools including:

- Rules
- Dividers

- Scribers
- Punches
- Scribing blocks
- Engineers square
- Protractors
- Callipers

AC3.2 Applications including:

- Profiles (square/rectangular, circles, radial, angular)
- Hole positions (linear, pitch circle diameter - PCD)
- Angles
- Use of datums and the avoidance of accumulated error

AC3.3 Measuring equipment including:

- Micrometers (internal, external, depth)
- Tape measures
- Vernier Callipers
- Rules
- Engineers square
- Protractors
- Dial test indicators (DTI)
- Coordinate measuring machine (CMM)

---

## The learner will:

4 Understand fitting and assembly activities

## Assessment criteria

The learner can:

4.1 Identify information required and information sources for engineering activities
4.2 Describe the processes used for fitting and assembly
4.3 Explain the purpose of quality systems in engineering

---

## Range

AC4.1 Information

- Health and safety requirements
- Quantity to be produced
- Materials and components required

- Tools and equipment
- Dimensions and tolerances
- Quality checks
- Order of operations
- Finishes

AC4.1 Sources of information including:

- Engineering drawings
- Specifications
- Production plans
- Job cards
- Technical manuals
- Standards: national, international
- Codes of practice

AC4.2 Processes
Work holding

- Work holding devices
- Jigs and fixtures

Fitting

- Filing
- Grinding
- Chiselling
- Sawing

Assembly

- Bolting
- Screwing
- Riveting
- Welding
- Soldering
- Brazing
- Adhesives
- Use of Washers
- Methods to prevent loosening of bolts/screws: (plastic insert, adhesives, spring and star washers)

AC4.3 Quality systems

- Quality assurance
- Quality control
- Inspections
- Conformance/fitness for purpose
- Customer requirements
- Reference of standards

- Safety requirements
- Quality records
- Traceability
- Corrective action procedures

# Unit 201 Working in an Engineering Environment

## Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills and safe behaviours whilst working in an engineering environment.

It is suggested that learning is based on engineering information such as engineering drawings. From this, the learner can interpret the information presented and consider the appropriate tools, equipment and machinery required to create industrial products in the workplace. Learners can then consider the operational requirements and processes that will deliver the product from the engineering information.

# Unit 202 Engineering Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | The aim of this unit is to introduce learners to two of the key techniques used by engineering businesses: engineering drawings and quality processes. Learners will gain an understanding of different types of engineering drawings and how they are interpreted. They will learn the difference between quality control and quality assurance and how these are applied in engineering. |

## Learning outcome

The learner will:

1 Understand drawings used by engineering businesses

## Assessment criteria

The learner can:

1.1 Explain types of drawings used in engineering

1.2 Describe information available on engineering drawings

1.3 Describe the types of symbols used on engineering drawings

1.4 Explain the benefits and limitations of Computer Aided Drawing (CAD) compared to manual drawing

## Range

AC1.1 Types of engineering drawings

- Part
- General assembly
- Orthographic: first angle, third angle
- Isometric
- Exploded
- Section
- Detail
- Breakout
- Freehand sketches

AC1.2 Information on engineering drawings

- Dimensions
- Line types
- Zones
- Title block
- Scale

- Paper size
- Revision
- Tolerance
- Associated drawings
- Bill of Materials (BoM)/parts list

AC1.3 Types of symbols

Mechanical symbols

- Diameter
- Counterbore
- Countersink
- Depth
- Centre mark

Geometric Dimensioning and Tolerancing (GDT) symbols

- Datum
- Parallelism
- Perpendicularity
- Concentricity
- Flatness
- Straightness

Surface finishing symbols

- Roughness (Ra Value)
- Surface type

AC1.4 Benefits

- Ability to edit
- Distribution
- Document control
- Accuracy
- Storage
- Ability to simulate testing
- Ability to transfer instructions to CNC equipment

Limitations

- Data security
- Training requirements
- Cost

## Learning outcome

The learner will:

2 Understand quality processes in engineering

## Assessment criteria

The learner can:

2.1 Explain the principles of quality assurance and quality control

2.2 Explain the characteristics of quality assurance

2.3 Explain the types and methods of quality control

## Range

AC2.1 Principles

- Definition of quality
- Difference between quality assurance and quality control
- Reasons for equipment calibration
- Dimensional tolerance
- Product specification

AC2.2 Characteristics of quality assurance

- Documentation: inspection reports, test results
- Right first time - prevention of defects
- Systems and procedures

AC2.3 Types and methods of quality control

- Objective assessment of finished products
- Subjective assessment of finished products
- Measurement of components during manufacture
- Sampling methods related to volume of production and criticality
- Statistical process control for high volume manufacture

# Unit 202 Engineering Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the product from the engineering information.

Learning Outcome 1 AC1.2
Information from drawings should be in accordance with the conventions in relevant standards e.g. BSEN 8888

Learning Outcome 2 AC2.1
Quality assurance is considered as preventative and related to systems. Quality control is considered as reactive where issues are detected after occurrence.

# Unit 203 Engineering Mathematics & Science Principles

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 70 |
| **Unit aim:** | This unit is concerned with the basic principles of mathematics and science, along with the materials technology that underpin engineering applications. It covers common applied engineering calculations, the application of different types of materials and their properties. |

## Learning outcome

The learner will:

1 Understand arithmetical and trigonometrical applications

## Assessment criteria

The learner can:

1.1 Perform simple arithmetic operations on integers and decimal numbers
1.2 Determine fractions and percentages
1.3 Use rules of arithmetical preference to solve simple equations
1.4 Use a scientific calculator to determine numbers when raised to a given power
1.5 Apply appropriate degree of accuracy to express numbers
1.6 Solve simple trigonometrical problems

## Range

AC1.1
Addition, subtraction, multiplication, division

AC1.2
Proper and improper fractions, determination of percentages and conversion to ratios

AC1.3
BODMAS (Brackets, Of, Division, Multiplication, Addition, Subtraction)

AC1.4
Squares ($x^2$) and square roots ($\sqrt{x}$), cubes ($x^3$) and cube roots ($\sqrt[3]{x}$)

AC1.5
Rounding-off, decimal places, significant figures, approximations, fractions as a decimal quantity

AC1.6
Sine, cosine, tangent

## Learning outcome

The learner will:

2 Know how to determine perimeters, areas and volumes of shapes

## Assessment criteria

The learner can:

2.1 Identify 2D and 3D shapes
2.2 Describe properties of 2D shapes
2.3 Apply Pythagoras' theorem
2.4 Calculate perimeters of simple shapes
2.5 Determine areas of 2D shapes
2.6 Determine volumes of 3D shapes

## Range

AC2.1 2D shapes

- Rectangle
- Square
- Triangle
- Circle

3D shapes

- Cube
- Cuboid
- Cylinder
- Cone
- sphere

AC2.2 Properties

- Rectangle (four sides, all angles 90º)
- Square (rectangle with four equal sides)
- Triangle (three sides, total of internal angles = 180º)
- Circle (one full circle = 360º)

## Learning outcome

The learner will:

3 Understand terminology used in engineering science

## Assessment criteria

The learner can:

3.1 Describe common terms used in engineering science
3.2 Name the units used to quantify the terms used in engineering
3.3 Perform calculations relating to the common terms used in engineering

## Range

AC3.1 Common terms

- Length
- Mass
- Time
- Force
- Velocity
- Acceleration
- Moment
- Pressure
- Efficiency
- Density

AC3.2 Units

- Length: metre (m)
- Mass: kilogramme (kg)
- Time: second (s)
- Force: newton (n)
- Velocity: metre per second (m/s)
- Acceleration: metre per second squared ($m/s^2$)
- Moment: newton metre (nm)
- Pressure: Pascal or Newton per metre squared (Pa or $N/m^2$)
- Efficiency: No units it is a ratio or a percentage
- Density: mass per unit volume ($kg/m^3$)

AC3.3 Calculations

- Mass
- Force
- Velocity
- Acceleration
- Moment

- Pressure
- Efficiency
- Density

## Learning outcome

The learner will:

4 Understand the effect of changes of temperature on engineering materials

## Assessment criteria

The learner can:

4.1 Explain the difference between heat and temperature
4.2 Explain the effect of changes of temperature on the physical state of a material
4.3 Explain the effect of changes of temperature on the dimensions of a material
4.4 Perform simple calculations on the effect of temperature on materials

## Range

AC4.2 Physical state

- Solid
- Liquid
- Gas

AC4.4 Calculations

- Sensible heat
- Latent heat
- Coefficient of expansion

## Learning outcome

The learner will:

5 Understand the properties of engineering materials

## Assessment criteria

The learner can:

5.1 Describe the types of materials used in common engineering applications
5.2 Describe the physical properties of materials
5.3 Explain the mechanical properties of materials

## Range

AC5.1 Materials

- Ferrous metals
  - carbon steels (low, medium, high),
  - stainless steels (austenitic, ferritic, martensitic),
  - cast iron
- Non-ferrous metals
  - aluminium and aluminium alloys
  - copper and copper alloys (brass, bronze)
- Non-metallic materials
  - plastics (thermoplastic, thermosetting),
  - composites (glass fibre, carbon fibre, aramid fibre)
  - rubber

AC5.2 Physical properties

- Melting points of metals
- Density
- Colour
- Magnetism
- Corrosion resistance
- Conductivity
- Insulation

AC5.3 Mechanical properties

- Strength (compressive, tensile)
- Toughness
- Hardness
- Elasticity
- Ductility
- Malleability

# Unit 203 Engineering Mathematics & Science Principles

## Supporting Information

### *Unit guidance*

Centres may provide a formula sheet to support the assessment for this unit.

# Unit 204 Workshop Fitting and Assembly Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with knowledge of the tools, equipment and machinery used to create components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a component against a specification. |

## Learning outcome

The learner will:

1 Understand engineering health and safety requirements

## Assessment criteria

The learner can:

1.1 Describe the legislation affecting health and safety in engineering
1.2 Describe safe working practices in engineering
1.3 Explain the process for carrying out risk assessments

## Range

AC1.1 Legislation

- Health and Safety at Work Act
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations
- Control of Substances Hazardous to Health Regulations (COSHH)
- Manual Handling Operations Regulations
- Reporting of Diseases and Dangerous Occurrence Regulations
- Electricity at Work Regulations

AC1.2 Safe working practices

Safety signs

- Warning
- Mandatory
- Safe condition
- Prohibition

Identification of fire extinguishers
- Colour of extinguishers
- Type of fire used for

General housekeeping
- Storage of tools
- Disposal of waste
- Reinstating work area after use

AC1.3 Risk assessment
- Identification of hazards
- Assess risk (severity, likelihood, number affected, risk rating)
- Recommendation of control measures
- Record findings
- Review controls

## Learning outcome

2. Understand fitting and assembly techniques

## Assessment criteria

The learner can:

2.1 Explain considerations required when planning engineering workshop activities
2.2 Explain the purpose and limitations of tools and equipment required for fitting and assembly
2.3 Explain fitting and assembly operations
2.4 Explain quality checks and the equipment used to carry them out

## Range

AC2.1 Planning considerations
- Health and safety
- Working environment
- Drawings/specifications
- Materials
- Equipment
- Tools
- Time

- Quality checks
- Tolerances
- Sequence of operations

AC 2.2 Purpose and limitations of tools and equipment

- Tools: Screwdrivers, hammer, spanners, wrenches, pliers, hand held drills, hacksaws
- Measuring equipment: micrometers, Vernier callipers, engineering rules

AC 2.3 Fitting and assembly operations

- Filing
- Scraping
- Lapping
- Polishing
- Blue bedding
- Drilling
- Threading
- Permanent: brazing, soldering, welding (MIG, MAG, TIG, Oxyacetylene), adhesives, riveting
- Semi-permanent: screws, bolts

AC 2.4 Quality checks

- Functional checks
- Surface finish
- Dimensional checks
- Visual inspection

Equipment used to carry out quality checks

- Micrometers: internal, external, depth
- Multimeters
- Vernier Calliper
- Comparison plates
- Rules
- Protractors
- Gauges/ slip gauges
- Dial test indicator (DTI)
- Coordinate measuring machine (CMM)

# Unit 204 Workshop Fitting and Assembly Techniques

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required.

Assessment of outcomes could be through the presentation of engineering information or presentations on the types of machinery and components.

# Unit 205 Business Improvement Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit aim:** | The aim of this unit is for learners to gain an understanding of the importance of continuous improvement to engineering businesses. They will learn how to categorise work and different types of waste. They will learn about different techniques used for business improvement and how they are used in engineering businesses. |

## Learning outcome

The learner will:

1 Understand the concept of continuous improvement

## Assessment criteria

The learner can:

1.1 Explain the meaning of continuous improvement
1.2 Describe continuous improvement strategies commonly used in engineering
1.3 Explain benefits of applying continuous improvement techniques
1.4 Define each stage of the plan–do–check–act (PDCA) improvement cycle
1.5 Explain the categories of waste in relation to business improvement

## Range

AC1.2 Strategies including

- Kaizen and Lean (elimination of waste)
- Quality circles (teams of employees using their knowledge to improve processes and resolve problems)
- Six Sigma (improved consistency and reduced scrap in high volume manufacturing by managing the process capability)
- Total Quality Management (TQM) (all members of an organisation work together to make improvements that result in increased customer satisfaction)

AC1.3 Benefits including

- Reduced cost e.g. production
- Improved quality e.g. reduced defects
- Improved safety e.g. safe to use
- Improved working practices e.g. reduced operator motion

- Improved delivery e.g. reduced transportation time, reduced lead time
- Reduction of waste e.g. over processing, excess inventory
- Resource utilisation e.g. reduced waiting time
- Improved customer satisfaction e.g. meeting customer requirements

AC1.5 Categories of waste

- Transport
- Inventory
- Motion
- Waiting
- Over production
- Over processing
- Defects
- Skills/unrecognised people potential

---

## Learning outcome

The learner will:

2 Understand workplace organisation

## Assessment criteria

The learner can:

2.1 Explain the meaning of workplace organisation
2.2 Describe the benefits of having an organised working environment
2.3 Explain the potential effects of a disorganised work environment
2.4 Describe the 5S approach to workplace organisation
2.5 Explain the importance of Standard Operating Procedures (SOPs) within workplace organisation

---

## Range

AC2.3 Effects

- Poor quality
- Increased costs
- Reduced efficiency
- Poor delivery times
- Poor morale/teamwork
- Poor health and safety

AC2.4 5S approach

- Sort (decide what is needed)
- Set in order (organise)
- Shine (clean)
- Standardise

---

- Sustain

## Learning outcome

The learner will:

3 Understand visual management

## Assessment criteria

The learner can:

3.1 Explain the meaning of visual management
3.2 Describe the benefits of applying good visual management
3.3 Describe different types of visual management

## Range

AC3.2 Benefits

- Accurate and relevant
- Eye-catching
- Simple
- Greater ownership

AC3.3 Types of visual management

- Shadow boards
- PDCA worksheets
- Colour coding
- Floor footprints
- Storyboards
- Gauges
- Photographs/pictures
- Labelling
- Lights
- Schedule boards
- Kanban (pull systems)
- Graphs
- Management boards
- Other area-specific types of visual management

## Learning outcome

The learner will:

4 Understand problem solving techniques

## Assessment criteria

The learner can:

4.1 Explain what is meant by a problem within a work environment

4.2 Describe the benefits of solving work related problems

4.3 Describe different techniques used for identifying and analysing problems

4.4 Explain the importance of applying the appropriate corrective action and eliminating the root cause of a problem

---

## Range

AC4.3 Techniques

- Tally charts
- Flow charts
- Histogram/pareto chart
- Benchmarking
- Process mapping
- Correlation diagram
- Run diagram
- Statistical process control
- Control charts
- Gantt charts
- Root cause paths
- Value stream maps
- Ishikawa diagrams (cause and effect, fishbone)
- Brainstorming
- Mind mapping
- 5 why analysis

---

# Unit 205 Business Improvement Techniques

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as a part of an apprenticeship programme. A combination of theory and practice is more likely to reinforce the learning required to achieve the apprenticeship standard.

# Unit 206 Principles of Turning and Milling

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 80 |
| **Unit aim:** | This unit enables the learner to understand the principles of manual turning and milling skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create machined components. They will understand how the machinery is set up and operated safely. They will also develop knowledge of the processes required to create machined components. Learners will develop an understanding of quality requirements and evaluation techniques to ensure quality of a component against a specification. |

## Learning Outcome

The learner will:

1. Know equipment required for turning and milling operations

## Assessment Criteria

The learner can:

1.1 Describe the characteristics and function of parts of a lathe
1.2 Describe the characteristics and function of parts of a milling machine
1.3 Describe the characteristics and types of workholding devices
1.4 Describe cutting tools and their purpose
1.5 Describe the characteristics and use of measuring equipment

## Range

AC 1.1 Parts of a lathe

- Isolators
- Speed control
- Feed control
- Chuck
- Emergency stops
- Coolant system
- Tailstock
- Headstock
- Bed

- Guards

AC 1.2 Parts of a milling machine

- Isolators
- Speed control
- Feed control
- Emergency stops
- Coolant system
- Base
- Column
- Ram
- Knee
- Turret/head
- Guards and interlocks
- Quill
- Spindle
- Work table
- Tool holding device

AC1.3 Workholding devices

Lathe

- 3 jaw chucks
- 4 jaw chucks
- Collet chucks
- Face plates
- Between centres
- Travelling steadies
- Fixed steadies

Milling machine

- Machine vice (fixed, swivel)
- T slot and clamps
- Angle plate
- V block and clamps
- Dividing head

AC1.4 Cutting tools

Lathe

- Tool types: roughing and finishing, turning, boring, grooving, undercutting, parting, forming, reaming, tapping, threading, drilling
- Characteristics: tool angles: rake and clearance, approach, materials, ISO Coding for indexable inserts
- Characteristics of cutting fluids and compounds

Milling machine

- Tool types: end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, fly cutter, dovetail cutter, drills, reamers, taps
- Characteristics: tool angles, materials
- Characteristics of cutting fluids and compounds

AC1.5 Measuring equipment

- Micrometers: internal, external, depth
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges/ slip gauges
- Dial test indicator (DTI)
- Coordinate measuring machine (CMM)

## Learning outcome

The learner will:

2. Understand how to produce manually machined components

## Assessment criteria

The learner can:

2.1 Describe safety issues and control measures associated with manual machining
2.2 Describe the characteristics of different types of machined features
2.3 Describe alignment techniques for workholding devices and workpieces
2.4 Describe the techniques for mounting cutting tools
2.5 Explain how the process parameters vary for different materials and component dimensions

## Range

AC2.1 Safety issues

- Hazards: flying debris, entanglement, ejected workpieces, moving parts, sharp edges, heat
- Controls: machine safety checks, PPE, safe working practices, guards

AC2.2 Characteristics of machined features

Lathe

- Faces: datum, flat, perpendicular, parallel, tapered, knurling
- Diameters: internal, external, bored, tapered, concentric, eccentric
- Shoulders
- Grooves/undercuts

- Holes: drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed
- Threads: internal, external

Milled

- Faces: datum, flat, perpendicular, parallel, tapered, step, slots: enclosed, open ended, tee
- Recesses
- Holes: drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, bored
- Threads: internal

AC2.3 Alignment techniques

- Mounting, alignment and removal of workholding device into/from machine
- Mount, secure and align the workpiece

AC2.4 Techniques for mounting cutting tools

Lathe

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to centre height
- Orientate tool to workpiece

Milling

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to work datum

AC 2.5 Materials

- Mild steel
- Brass
- Nylon
- Aluminium

---

## Learning outcome

The learner will:

3. Understand how to meet quality requirements for machining operations

## Assessment criteria

The learner can:

3.1 Describe methods of monitoring machine performance

3.2 Describe methods of evaluating machined components against specification requirements

## Range

AC3.1 Monitoring machine performance:

- Potential defects: symptoms, causes, resolution
- In-process checks: trial cuts, dimensional check of workpiece, surface finish of workpiece
- Check condition of cutting tools

AC3.2 Evaluation methods:

- Turning quality criteria (tolerance, surface finish, concentricity, parallelism) from engineering information (drawings, specifications)
- Milling quality criteria (tolerance, surface finish, parallelism) from engineering information (drawings, specifications)
- Application of inspection techniques: measurement, visual

# Unit 206 Principles of Turning and Milling

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

Learning Outcome 2 AC 2.5

Graphs may be used to demonstrate variations in process parameters as described in AC 2.5.

# Unit 207 Manual Turning

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit enables the learner to acquire the essential knowledge and understanding needed to develop manual turning skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create turned components. They will learn how machinery is set up and operated safely and the processes to be followed to create turned components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a turned component against a specification. |

## Learning outcome

The learner will:

1 Know the equipment required for turning operations

## Assessment criteria

The learner can:

1.1 Describe the characteristics and function of parts of a lathe

1.2 Describe the characteristics and types of workholding devices

1.3 Describe cutting tools and their purpose

1.4 Describe the characteristics and use of measuring equipment

## Range

AC1.1 Parts of a lathe

- Isolators
- Speed control
- Feed control
- Chuck
- Emergency stops
- Guards
- Coolant system
- Tailstock
- Headstock
- Bed

AC1.2 Workholding devices

- 3 jaw chucks
- 4 jaw chucks
- Collet chucks
- Face plates
- Between centres
- Travelling steadies
- Fixed steadies

AC1.3 Cutting tools

- Tool types: roughing and finishing, turning, boring, grooving, undercutting, parting, forming, reaming, tapping, threading, drilling
- Characteristics: tool angles: rake and clearance, approach, materials, ISO Coding for indexable inserts
- Characteristics of cutting fluids and compounds

AC1.4 Measuring equipment

- Micrometers: internal, external, depth
- Vernier Calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

## Learning outcome

The learner will:

2 Understand how to produce turned components on a lathe

## Assessment criteria

The learner can:

2.1 Describe safety issues associated with the use of a lathe and control measures

2.2 Describe the characteristics of different types of turned features

2.3 Describe alignment techniques for workholding devices and workpieces

2.4 Describe the techniques for mounting cutting tools

2.5 Explain how the process parameters vary for different materials and component dimensions

## Range

AC2.1 Safety issues

- Hazards: flying debris, entanglement, ejected workpieces, moving parts, sharp edges, heat
- Controls: machine safety checks, PPE, safe working practices

AC2.2 Characteristics of different types of features

- Faces: datum, flat, perpendicular, parallel, tapered, knurling
- Diameters: internal, external, bored, tapered, concentric, eccentric
- Shoulders
- Grooves/undercuts
- Holes: drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed
- Threads: internal, external

AC2.3 Alignment techniques

- Mounting, alignment and removal of workholding device into/from machine
- Mount, secure and align the workpiece

AC2.4 Techniques for mounting cutting tools

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to centre height
- Orientate tool to workpiece

AC2.5 Materials

- Mild steel
- Brass
- Nylon
- Aluminium

## Learning outcome

The learner will:

3 Understand how to meet quality requirements for turning operations

## Assessment criteria

The learner can:

3.1 Describe methods of monitoring machine performance

3.2 Describe methods of evaluating turned components against specification requirements

## Range

AC3.1 Monitoring machine performance

- Potential defects: symptoms, causes, resolution
- In-process checks: trial cuts, dimensional check of workpiece, surface finish of workpiece
- Check condition of cutting tools

AC3.2 Evaluation methods

- Quality criteria (tolerance, surface finish, concentricity, parallelism) from engineering information (drawings, specifications)
- Application of inspection techniques: measurement, visual

# Unit 207 Manual Turning

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 208 Manual Milling Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit enables the learner to acquire the essential knowledge and understanding needed to develop manual milling skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create milled components. They will learn how machinery is set up and operated safely and the processes to follow to create milled components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a milled component against a specification. |

## Learning outcome

The learner will:

1 Know the equipment required for milling operations

## Assessment criteria

The learner can:

1.1 Describe the characteristics and function of parts of a milling machine
1.2 Describe the characteristics and types of workholding devices
1.3 Describe cutting tools and their purpose
1.4 Describe the characteristics and use of measuring equipment

## Range

AC1.1 Parts of a milling machine

- Isolators
- Speed control
- Feed control
- Emergency stops
- Coolant system
- Base
- Column
- Ram
- Knee
- Turret/head

- Guards and interlocks
- Quill
- Spindle
- Work table
- Tool holding device

AC1.2 Workholding devices

- Machine vice (fixed, swivel)
- T slot and clamps
- Angle plate
- V block and clamps
- Dividing head

AC1.3 Cutting tools

- Tool types: (end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, fly cutter, dovetail cutter, drills, reamers, taps)
- Characteristics: (tool angles, materials)
- Characteristics of cutting fluids and compounds

AC1.4 Measuring equipment

- Micrometers (internal, external, depth)
- Vernier Calliper
- Comparison plates
- Rules
- Protractors
- Angle gauges
- Slip gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

## Learning outcome

The learner will:

2 Understand how to produce components on a milling machine

## Assessment criteria

The learner can:

2.1 Describe safety issues associated with the use of a mill and control measures

2.2 Describe characteristics of different types of milled features

2.3 Explain alignment techniques for workholding devices and workpieces

2.4 Explain techniques for mounting cutting tools

2.5 Explain how the process parameters vary for different materials and component dimensions

## Range

AC2.1 Safety issues

- Hazards: (flying debris, entanglement, moving parts, sharp edges, heat)
- Controls: (safety checks, PPE, safe working practices, machine guards)

AC2.2 Milled features

- Faces: (datum, flat, perpendicular, parallel, tapered, Step, Slots: enclosed, open ended, tee)
- Recesses
- Holes: (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, bored)
- Internal threads

AC2.3 Alignment techniques

- Mounting, alignment and removal of workholding device into/from machine
- Mount, secure and align the workpiece

AC2.4 Techniques for mounting cutting tools

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning tool to work datum

AC2.5 Materials

- Mild steel
- Brass
- Nylon
- Aluminium

Process parameters

- Spindle speed (RPM) = Cutting speed x 1000 / π x drill diameter

## Learning outcome

The learner will:

3 Understand how to meet quality requirements for milling operations

## Assessment criteria

## The learner can

3.1 Describe methods of monitoring machine performance

3.2 Describe methods of evaluating milled components against specification requirements

---

## Range

AC3.1 Monitoring machine performance

- Potential defects: (symptoms, causes, resolution)
- In-process checks: (trial cuts, dimensions of workpiece, surface finish of workpiece)
- Check condition of cutting tools

AC3.2 Evaluating milled components

- Identify quality criteria (tolerance, surface finish, parallelism) from engineering information (drawings, specifications)
- Application of inspection techniques: (measurement, visual)

---

# Unit 208 Manual Milling Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 209 Grinding Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with knowledge of the tools, equipment and machinery used to create components on a grinding machine. They will learn how machinery is set up and operated safely and the processes to be followed to create components on a grinding machine. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a ground component against a specification. |

## Learning outcome

The learner will:

1 Know the equipment required for grinding operations

## Assessment criteria

The learner can:

1.1 Identify types of grinding machines and their differences
1.2 Identify characteristics and function of parts of grinding machines
1.3 Describe characteristics, function and limitations of workholding devices
1.4 Identify characteristics, function and limitations of abrasive wheels
1.5 Describe characteristics, function and limitations of measuring equipment

## Range

AC1.1 Types of grinding machines

- Cylindrical (internal, external)
- Surface (horizontal, vertical)
- Universal
- Off-hand/ bench grinder

AC1.2 Parts of grinding machines

- Isolators

- Wheels
- Table control
- Emergency stops
- Coolant system
- Guards and interlocks
- Tail stock
- Feed systems
- Local Extraction and Ventilation (LEV) system
- Flanges
- Rests

AC1.3 Characteristics, function of workholding devices

- Chucks: (3 self centring (scroll) and 4 jaw (independent), magnetic, collet)
- Vices: (fixed, swivel, universal)
- V blocks and clamps
- Mandrels: (solid, expanding)

Limitations of workholding devices

- Shapes
- Types of material
- Size of component

AC1.4 Characteristics of abrasive wheels

- Shapes of wheel: (straight, cylinder, single taper, double taper, single concaved, straight cup)
- Types of wheel: (material: aluminium oxide, silicon carbide, bond type: vitrified, grain size, grade, structure, treatment)

Function

- Effects of cutting fluids/coolants

Limitations of abrasive wheels

- Removal rate of material

AC1.5 Characteristics and function of measuring equipment

- Micrometres: (internal, external, depth)
- Vernier calliper
- Comparison plates: (Rubert blocks)
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

Limitations

- Accuracy of reading between manual and digital – operator skill
- Gauges to check conformity to limit

## Learning outcome

The learner will:

2 Understand how to produce components on grinding machines

## Assessment criteria

The learner can:

2.1 Describe safety issues and training requirements associated with the use of grinding machines
2.2 Identify components to be produced and wheel selection
2.3 Identify techniques for securing workholding devices
2.4 Describe methods of balancing and mounting abrasive wheels
2.5 Describe methods of maintaining abrasive wheels
2.6 Explain the principles of planning grinding operations

## Range

AC2.1 Safety issues

- Hazards: (flying debris, entanglement, dust, sparks, explosion of wheel, ejected workpieces, moving parts, sharp edges, heat)
- Controls: (safety checks, PPE, safe working practices)

Training requirements

- Provision and Use of Work Equipment Regulations (PUWER)
- Appointed person responsibilities
- Mandatory signs
- Guarding
- Manual handling

AC2.2 Components to be produced

- Surfaces (flat, perpendicular, parallel, angular)
- Diameters (internal, external)
- Steps
- Tapers
- Grooves/undercuts
- Slots
- Profiles

AC2.3 Securing techniques

- Chucks secured to spindle
- Vices clamped to table
- Vee blocks clamped to table or magnetic table
- Mandrels held between centres

AC2.4 Methods for balancing and mounting abrasive wheels

- Balancing wheels: (parallel ways: knife edges, overlapping discs, hub flanges)
- Securing abrasive wheels on the machine spindle
- Truing and dressing: (fixed installation diamond, portable diamond)
- Testing the mounted wheel

AC2.5 Methods of maintaining abrasive wheels

- Handling and storage of wheels
- Trueing the wheel
- Dressing the wheel

AC2.6 Principles of planning grinding operations

- Critical path
- Sequence of operations

---

## Learning outcome

The learner will:

3 Understand how to meet quality requirements for grinding operations

## Assessment criteria

The learner can:

3.1 Describe monitoring of machine performance

3.2 Identify defects and methods of rectifying them

3.3 Describe how to evaluate ground components against specification requirements

---

## Range

AC3.1 Monitoring machine performance

- In-process checks: (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of wheel, potential defects)
- Check for potential defects: (symptoms, causes, resolution)

AC3.2 Defects and methods of rectifying them

- Wheel chatter - True wheel, increase feed, use softer grade
- Rough finish - Finer grit wheel, use harder grade, increase work traverse
- Wheel loading - Use coarser grit, dress wheel, increase work traverse

AC3.3 Evaluate components against specification

- Identify quality criteria (tolerance, surface finish, flatness, squareness, concentricity) from engineering information (drawings, standards)
- Application of inspection techniques (measurement, visual)

# Unit 209 Grinding Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 210 Principles of CNC Machining/Fabrication

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with knowledge of the tools, equipment and machinery used to create components with CNC fabrication equipment. They will learn how machinery is set up and operated safely and the processes to be followed to create components. Learners will develop an understanding of quality requirements and how the control offered by CNC can improve production and the quality of a product. |

## Learning outcome:

The learner will:

1. Understand the equipment available for CNC fabrication operations

## Assessment criteria

The learner can:

1.1 Describe the types of equipment available for CNC fabrication

1.2 Explain the function and characteristics of CNC fabrication equipment

1.3 Explain the health and safety requirements specific to CNC equipment

## Range

AC1.1 Types of equipment

- Guillotines
- Folders
- Press brakes
- Mechanical saws
- Turret punches
- Cutting machines (laser, plasma, water jet)

AC1.2 Function and characteristics

- Guillotines
- Backstops
- Front stops

- Cut length limiting
- Material thickness adjustments
- Programming options: (stored programs, stop adjustment, part cutting)
- Rake adjustment

Folders

- Clamping options
- Angle adjustment
- Backstops

Press brakes

- Axis controls (Y; X; R; Z1 + Z2)
- Programming options: (stored programs, visualisation of part manipulation)

Saws

- Bandsaws
- Circular saws
- Mechanical hacksaw
- Automatic material cutting: (clamping, material feed, part counts)

Turret punches

- Sheet clamping methods
- Processes: (cutting, bending, louvres)
- Automatic tooling changes
- Automatic material feed

Cutting machines (laser, plasma, water jet)

- Programming options: (stored programmes, nesting)

AC1.3 Health and safety requirements

- Electrical screening
- Shut down procedures
- Water beds for plasma cutting
- Slurry filtration and disposal for water jet cutting (COSHH Regulations)

## Learning outcome

The learner will:

2. Understand the programming of CNC fabrication machinery

## Assessment criteria

The learner can:

2.1 Describe manual data programming of CNC fabrication machinery

2.2 Describe remote programming of CNC fabrication machinery

---

## Range

AC2.1 Manual data programming

- Retrieval of stored programs
- One-off programs
- Material data: (type, thickness, width)
- Back and front stop data
- Feed rates: (saws)
- Rake angles: (guillotines)
- Angles: (folders, press brakes)
- Tooling: (turret punches, press brakes)
- Basic shape databases: (cutting machines)
- Nesting systems: (cutting machines)
- Number of items

AC2.2 Remote programming

- Benefits and limitations of remote programming
- Methods of transferring data to machinery
- File types (step, dxf, software specific)

---

## Learning outcome

The learner will:

3. Understand the benefits and limitations of using CNC fabrication machinery

## Assessment criteria

The learner can:

3.1 Explain the benefits and limitations related to component quality

3.2 Explain the benefits related to efficiency

---

## Range

AC3.1 Benefits and limitations

- Importance of calibration
- Expected accuracy of CNC machinery
- Relationship between data entry and component accuracy
- Repeatability

AC3.2 Benefits

- Material nesting
- Improved production methods
- Recall of stored programs

# Unit 210 Principles of CNC Machining/Fabrication

Supporting Information

## *Unit guidance*

This unit focuses on how machinery can be controlled by CNC. It does not require learners to understand or describe complex programming methods. Learners will need to understand the basic CNC controlling of a range of fabrication equipment and the types of data that can be input directly, retrieved from the machine memory or transferred from another source.

This unit is closely related to the fabrication principles unit, where basic principles of cutting by shear, forming, and health and safety that can be applied to all fabrication equipment are covered generically.

Learning Outcome 1
This requires learners to explain the types of fabrication equipment that can be CNC controlled and the parts and function that benefit from this control. Health & safety using these processes is covered in the fabrication principles used.

Learning Outcome 2
Manual data programming refers to machines that have the CNC controller connected directly to the machine. Remote programming refers to, for example, CAD drawings produced in an office that are then transferred to the laser cutting machine via the intranet.

# Unit 211 CNC Turning Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with knowledge of the tools, equipment and machinery used to create turned components. They will learn how machinery is set up and operated safely and the processes to be followed to create turned components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a turned component against a specification. |

## Learning outcome

The learner will:

1 Know the equipment required for CNC turning operations

## Assessment criteria

The learner can:

1.1 Identify the characteristics and function of parts of a CNC lathe
1.2 Identify characteristics and function of workholding devices
1.3 Describe characteristics of cutting tools
1.4 Explain characteristics and limitations of measuring equipment

## Range

AC1.1 Characteristics and function of parts of a CNC lathe

- Isolators
- Emergency stops
- Coolant system
- Tailstock
- Guards and interlocks
- Tool holding device: (automatic tool changer, wedge locks, VDI tool holders)

- Control: (machine page, tool offset page, workshift page, program directory, program editor)
- Open loop control
- Closed loop control
- Servo motors/stepper motors
- Recirculating ball screws: (internal ball return, external ball return)
- Positional transducers

AC1.2 Characteristics and function of workholding devices

- 3 jaw chucks: (hydraulic, pneumatic, serrated based, soft, hard)
- Collet chucks
- Face drivers

AC1.3 Characteristics of cutting tools

- Tool types: (roughing, finishing, grooving, parting off, screw cutting, reaming, tapping, threading, drilling, profiling, boring)
- Classification of ISO coding for indexable inserts
- Types of cutting tool materials: (high speed steel (HSS), cobalt-chromium alloy, carbide)
- Characteristics of cutting tools: (shape, size, tip radius, rake angle, clearance angles, cutter length)
- Tool holder characteristics: (left/right hand tool, approach angle, clamping system, insert shape and size)
- Types and effects of cutting fluids

AC1.4 Characteristics and limitations of measuring equipment

- Micrometers: (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)

Limitations

- Accuracy of reading between manual and digital – operator skill
- Gauges to check for conformity to limit

## Learning outcome

The learner will:

2 Understand how to produce turned components on a CNC lathe

## Assessment criteria

The learner can:

2.1 Identify safety issues and control measures associated with the use of a CNC lathe
2.2 Describe characteristics of turned features
2.3 Identify techniques for mounting cutting tools
2.4 Describe different methods of inputting CNC programs
2.5 Explain the principles of planning CNC turning operations

---

## Range

AC2.1 Safety issues

- Hazards: (entanglement, ejected workpieces, moving parts, sharp edges, heat)
- Controls: (safety checks, COSHH, Manual handling, PPE, safe working practices)
- Mandatory safety signs

AC2.2 Characteristics of turned features

- Faces: (datum, flat, parallel, tapered)
- Diameters: (internal, external, bored, tapered, concentric, eccentric)
- Shoulders
- Grooves/undercuts
- Holes: (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed)
- Threads: (internal, external)

AC2.3 Techniques for mounting cutting tools

- Tools secured in tool holding devices
- Tools set in correct position
- Tools set in geometric offset

AC2.4 Inputting CNC programs

- Coding: (machine axes, Cartesian coordinates absolute and incremental)
- Machine management: (spindle start/stop, coolant on/off, tool change, end of program, optional stop)
- Terminology: (part programs, word address, conversational)
- Methods of inputting program: manual, USB flash drive, Intranet, Direct Numerical Control (DNC))
- Methods of proving part programs: proof read, graphic simulation, single block, rapid override

AC2.5 Principles of planning CNC turning operations

- Critical path
- Sequence of operations

## Learning outcome

The learner will:

3 Understand quality requirements for CNC turning operations

## Assessment criteria

The learner can:

3.1 Describe ways to monitor machine performance

3.2 Describe ways to evaluate turned components against specification requirements

## Range

AC3.1 Monitor machine performance

- In-process checks: (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools)
- Check for potential defects: (symptoms, causes, resolution)

AC3.2 Evaluating turned components against specification

- Identify quality from engineering drawings: (tolerance, surface finish, concentricity, parallelism, tapers, threads, radii)
- Apply inspection techniques: (measurement, visual)

# Unit 211 CNC Turning Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 212 CNC Milling Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with knowledge of the tools, equipment and machinery used to create milled components. They will learn how machinery is set up and operated safely and the processes to be followed to create milled components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a milled component against a specification. |

## Learning outcome

The learner will:

1 Know the equipment required for CNC milling operations

## Assessment criteria

The learner can:

1.1 Identify characteristics and function of parts of CNC mills
1.2 Identify characteristics, function and limitations of workholding devices
1.3 Describe characteristics and limitations of cutting tools
1.4 Explain characteristics and limitations of measuring equipment

## Range

AC1.1 Characteristics and function of parts of a CNC mill

- Isolators
- Emergency stops
- Coolant system
- Guards and interlocks
- Automatic tool changer

- Control: (machine page, tool offset page, workshift page, program directory, program editor)
- Open loop control
- Closed loop control
- Servo motors/stepper motors
- Recirculating ball screws: (internal ball return, external ball return)
- Positional transducers

AC1.2 Characteristics, function of workholding devices

- Machine vice
- Clamps
- Fixtures

Limitations

- Machine vice: hold square, hexagon, parallel sided and cylindrical with a Vee block

AC1.3 Characteristics and limitations of cutting tools

- Tool types: (end mill, slot mill, shell cutter, bullnose cutter, corner rounding cutter, dovetail cutter, drills, reamers, taps)
- Characteristics of cutting tools: (tool angles, materials: High Speed Steel (HSS), stellite carbide)
- Effects of cutting fluids

AC1.4
Characteristics of measuring equipment

- Micrometres (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Engineers square
- Coordinate Measuring Machine (CMM)

Limitations

- Accuracy of reading between manual and digital – operator skill
- Gauges to check for conformity to limit
- Square provides a 900 angle to a datum face

## Learning outcome

The learner will:

2 Understand how to produce components on a CNC mill

## Assessment criteria

The learner can:

2.1 Identify safety issues and control measures associated with the use of a CNC mill

2.2 Describe characteristics of different types of milled features

2.3 Identify techniques for securing workholding devices

2.4 Identify techniques for mounting cutting tools

2.5 Describe different methods of inputting CNC programs

2.6 Explain the principles of planning CNC milling operations

## Range

AC2.1 Safety issues

- Hazards: (entanglement, moving parts, sharp edges, heat)
- Controls: (safety checks, COSHH, Manual handling, PPE, safe working practices, machine guards)
- Mandatory safety signs

AC2.2 Characteristics of milled features

- Faces: (datum, flat, perpendicular, parallel, tapered)
- Steps
- Slots: (enclosed, open ended, tee, dovetail)
- Recesses
- Holes: (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, bored, internal threads)

AC2.3 Securing techniques

- Vices clamped to table
- Vee blocks clamped to table
- Clamps include stepped

AC2.4 Techniques for mounting cutting tools

- Cutting tools secured in tool holding devices
- Tool set in correct position
- Use of different types of carousel
- Tool set in geometry offset

AC2.5 Inputting CNC programs

- Coding: (machine axes, Cartesian coordinates, absolute and incremental)
- machine management: (spindle start/stop, coolant on/off, tool change, end of program, optional stop)
- Terminology: (part programs, word address, conversational)
- Methods of inputting program: (manual, USB flash drive, Intranet, Direct Numerical Control (DNC))
- Methods of proving part programs: (proof read, graphic simulation, single block, rapid override)

AC2.6 Principles of planning CNC milling operations

- Critical path
- Sequence of operations

## Learning outcome

The learner will:

3 Understand quality requirements for CNC milling operations

## Assessment criteria

The learner can:

3.1 Describe ways to monitor machine performance

3.2 Describe ways to evaluate milled components against specification requirements

## Range

AC3.1 Monitor machine performance

- In-process checks: (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools)
- Check for potential defects: (symptoms, causes, resolution)

AC3.2 Evaluate milled components

- Identify quality criteria from engineering drawings: (tolerance, surface finish, parallelism, tapers, threads, radii)
- Apply inspection techniques: (measurement, visual)

# Unit 212 CNC Milling Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

Learning is based on engineering information such as engineering drawings. From this, learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the turned component in the engineering information.

# Unit 213 Computer Aided Design (CAD)

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with the principles and capabilities of a CAD system. These include health & safety requirements, benefits and limitations and applications. |

## Learning outcome

The learner will:

1 Understand the principles of using a CAD system

## Assessment Criteria

1.1 Explain the health & safety requirements for a safe CAD working environment
1.2 Describe applications of CAD software
1.3 Identify current standards used for CAD drawing
1.4 Explain the purpose of storage and data management
1.5 Explain the benefits and limitations of using CAD software compared to manual drawing

## Range

AC1.1 Health & Safety

- Health and Safety (Display Screen Equipment) regulations
- Hazards associated with the use of CAD

AC1.2 Applications of CAD software

- 2D drawing
- 3D modelling
- Virtual testing
- Simulation (models, electrical circuits, fluid power systems)

AC1.4 Storage and data management

- Labelling/ file name conventions
- File format

- Version management
- Indexing
- Correct storing of files

AC1.5 Benefits

- Ability to edit
- Distribution
- Document control
- Accuracy
- Storage
- Ability to simulate testing
- Ability to transfer instructions to CNC equipment

Limitations

- Data security
- Training requirements
- Cost

## Learning outcome

The learner will:

2 Know the main capabilities of CAD software

## Assessment criteria

The learner can:

2.1 Describe the key operating features of CAD software
2.2 Describe the key operating features used in part modelling
2.3 Describe the key operating features used in assembly modelling

## 3 Range

AC2.1 Operating features

- Navigation
- Use of pre-designed templates
- Use line types
- Styles and colours
- View placement
- Scale command
- Annotate (dimension, text, symbols)

AC2.2 Part modelling features

- Navigation
- Create geometry

- Modify geometry
- Dimension
- Line types
- Extrusion
- Constraints

AC2.3 Assembly modelling features

- Navigation
- Grounding
- Positioning
- Align command
- Offset command
- Mate command
- Constraints

# Unit 213 Computer Aided Design (CAD)

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

Learning Outcome 1 AC1.3

Standards from drawings should be in accordance with the conventions in relevant standards e.g. BSEN 8888

# Unit 214 Electrical and Electronic Principles

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | This unit will provide the knowledge and understanding of the basic principles, components and devices that make up electrical and electronic systems. It covers electrical and electronic circuits, the functions and applications of components and devices, and the ways in which systems and circuits are represented. |

## Learning outcome:

The learner will:

1 Understand electrical and electronic circuit principles

## Assessment criteria

The learner can:

3.1 Explain electrical and electronic terms, laws and theorems

3.2 Explain types of electrical current and their advantages/disadvantages

## Range

AC1.1 Laws and theorems

- Electron theory
- Ohm's law
- Watt's law
- Magnetism
- Fleming's rules
- Electrostatic theory
- Electrical energy
- Electrical efficiency

Terms

- Voltage
- Current
- Resistance
- Power

AC1.2 Electrical current

- Alternating current (AC)

- Direct current (DC)

## Learning outcome

The learner will:

2 Understand the units of measurement used to quantify electrical parameters

## Assessment criteria

The learner can:

2.1 State the SI units used to measure electrical parameters

2.2 Convert units to different multiples and submultiples

## Range

AC2.1 Parameters

- Resistance
- Capacitance
- Inductance
- Voltage
- Current
- Frequency
- Time
- Power
- Energy
- Magnetic flux
- Magnetic flux density

AC2.2 Multiples and submultiples

- Pico
- Nano
- Micro
- Milli
- Kilo
- Mega

## Learning outcome

The learner will:

3 Understand methods of calculating values in electrical and electronic circuits

## Assessment criteria

The learner can:

3.1 Calculate values using Ohm's law
3.2 Calculate values using Watt's law
3.3 Calculate resistance in series and parallel circuits
3.4 Determine values using the resistor colour code
3.5 Calculate electrical energy transferred in a circuit
3.6 Calculate the efficiency of an electrical appliance

---

## Range

AC3.1 Values – Ohm's law

- Voltage
- Current
- Resistance

AC3.2 Values – Watt's law

- Power
- Voltage
- Current

AC3.3 Circuits

- Maximum of 3 resistors in series
- Maximum of 3 resistors in parallel

---

# Unit 214 Electrical and Electronic Principles

Supporting Information

## *Unit guidance*

This unit could be taught effectively using CAD software to simulate the functions of electrical and electronic components. Centres could also use product analysis to investigate the application of different components.

Tutors should ensure that they keep up to date with current industry standards for e.g. BS3939 or IEC 60062:2016

# Unit 215 Electrical and Electronic Testing Methods

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the knowledge and understanding of methods used to test electrical and electronic circuits and components. It covers the units of measurement used to quantify electrical parameters, the functions and applications of electrical test equipment and the main principles of calibration. |

## Learning outcome

The learner will:

1 Understand the units of measurement used to quantify electrical parameters

## Assessment criteria

The learner can:

1.1 Explain electrical and electronic laws and theorems
1.2 State the SI units used to measure electrical parameters
1.3 Convert units to different multiples and submultiples

## Range

AC1.1 Laws and theorems

- Electron theory
- Ohm's law
- Watt's law
- Magnetism
- Fleming's rules
- Electrostatic theory

AC1.2 Parameters

- Resistance
- Capacitance
- Inductance
- Voltage
- Current

- Frequency
- Time
- Power
- Energy
- Magnetic flux
- Magnetic flux density

AC1.3 Multiples and submultiples

- Pico
- Nano
- Micro
- Milli
- Kilo
- Mega

---

## Learning outcome

The learner will:

2 Understand the applications of electrical and electronic test equipment

## Assessment criteria

The learner can:

2.1 Describe the characteristics of waveform signal types
2.2 Explain the purpose and benefits/limitations of test equipment
2.3 Describe how test equipment is used to measure electrical parameters

---

## Range

AC2.1 Waveform signal types

- Sinusoidal
- Square
- Triangle
- Sawtooth
- Ramp
- Pulse

Waveform characteristics

- Frequency
- Periodic time
- Peak to peak
- Peak
- Root mean squared (RMS)
- Phase shift
- Offset

AC2.2 Test equipment

- Digital multimeter
- Function generator
- Oscilloscope
- Frequency counter
- Logic probe
- Computer simulation/virtual instruments

AC2.3 Parameters

- Resistance
- Current
- Voltage (AC circuits, DC circuits)
- Signal amplitude
- Signal frequency
- Logic state

---

## Learning outcome

The learner will:

3 Understand electrical and electronic test equipment calibration techniques

## Assessment criteria

The learner can:

3.1 Explain the principles of test equipment calibration

3.2 Describe procedures used to validate test equipment functionality

---

## Range

AC3.1 Principles of calibration

- Need for calibration
- Accuracy
- Precision
- Resolution
- Linear
- Non-linear
- Recording
- Certification
- Frequency

AC3.2 Procedures

- Calibration checks (frequency, reference against known values, reference against calibrated equipment)

- Zero checks (nulling leads, zeroing meter displays, parallax checks)
- Records/documentation

# Unit 215 Electrical and Electronic Testing Methods

Supporting Information

## *Unit guidance*

Although this is a knowledge unit, tutors could provide access to appropriate test equipment for the purpose of understanding their features, functions and applications.

Industrial examples of applications of how the testing methods and equipment covered in this unit are used in the workplace could be used to enhance learning.

Learning Outcome 2 AC2.2

This unit has been updated to reflect industry practices in relation to the use of digital testing equipment rather than analogue.

# Unit 216 Electrical and Electronic Systems and Devices

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | This unit will provide the knowledge and understanding of components and devices that make up electrical and electronic systems. It covers electrical and electronic circuits, the functions and applications of components and devices, and the ways in which systems and circuits are represented. |

## Learning outcome

The learner will:

1 Understand the functions of electrical and electronic components and devices

## Assessment criteria

The learner can:

1.1 Describe the functions and applications of input, process, output and interface devices

1.2 Describe the functions and applications of passive components

1.3 Explain advantages/disadvantages of programmable microcontrollers

## Range

AC1.1 Input devices

- Switches: push-to-make, push-to-break, rocker, toggle, tilt, reed
- Sensors: light dependent resistors, thermistors, infra-red sensors, pressure sensor

Process devices

- Timers
- Counters
- Logic gates: AND, OR, NOT
- Amplifiers
- Regulators
- Microcontrollers

Output devices

- Lamps
- Light emitting diodes
- Buzzers

- Loudspeakers
- Motors

Interface devices
- Bipolar transistors
- Field-effect transistors
- Darlington drivers
- Relays

AC1.2 Passive components
- Resistors: fixed, variable
- Capacitors: polarised, non-polarised
- Diodes: signal, rectifier
- Inductors
- Fuses

---

## Learning outcome

The learner will:

2 Understand methods of representing electrical and electronic systems

## Assessment criteria

The learner can:

2.1 Explain the purpose of types of diagrams used to represent electrical and electronic systems

2.2 Interpret symbols and abbreviations (to current industry standards) of components used in circuit schematics

---

## Range

AC2.1 Types of diagrams
- Schematic
- Circuit diagram
- Wiring diagram
- Systems block diagram
- Flow chart

AC2.2 Components
- Switches
- Light dependent resistors
- Thermistors
- Logic gates
- Lamps
- Light emitting diodes
- Buzzers

---

- Loudspeakers
- Motors
- Transistors
- Relays
- Resistors
- Capacitors
- Diodes
- Inductors
- Fuses
- Power supplies

# Unit 216 Electrical and Electronic Systems and Devices

## Supporting Information

### *Unit guidance*

This unit could be taught effectively using CAD software to simulate the functions of electrical and electronic components. Centres could also use product analysis to investigate the application of different components.

Tutors should ensure that they keep up to date with current industry standards for component symbols and abbreviations e.g. BS3939

# Unit 217 Fabrication and Welding Principles

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with the knowledge of basic principles related to fabrication and welding methods. These include measuring, marking out, cutting by shear, forming, thermal cutting, joining and assembly methods. |

## Learning outcome

The learner will:

1 Understand the equipment available to produce fabricated components

## Assessment criteria

The learner can:

1.1 Describe the types of equipment available for marking out
1.2 Describe the types and purpose of datums
1.3 Explain marking out methods for a range of features
1.4 Describe fabrication hand tools, equipment and their application

## Range

AC1.1 Equipment to include

- Scribers
- Scribing block
- French chalk
- Centre and dot punch
- Rules
- Tape measures
- Vernier callipers
- Vernier height gauges
- Squares (engineers, adjustable and plate)
- Protractors
- Dividers and trammels
- Laser lines
- Marking out tables

AC1.2 Datums

- Line
- Edge
- Centre point

Purpose

- Avoidance of accumulated error
- Provide a reference point

AC1.3 Marking out methods

- Direct marking
- Use of templates
- Tracing/transfer methods

Features

- Circles
- Radii
- Pitch Circle Diameter (PCD)
- Hole centres
- Angles
- Rectangular profiles
- Curved profiles

AC1.4 Hand tools and equipment

- Hammers and mallets
- Work holding magnets
- Clamps
- Centre finders
- Punches (centre, dot)
- Drifts and wedges
- Vices
- Anvils

## Learning outcome

The learner will:

2 Understand cutting and forming methods used for fabrication

## Assessment criteria

The learner can:

2.1 Describe the principles that underpin cutting by shear methods

2.2 Describe equipment used for cutting by shear and their applications
2.3 Describe the principles that underpin chip forming cutting methods
2.4 Describe equipment used for chip forming cutting and their applications
2.5 Describe types of forming equipment available for fabrication and their application

## Range

AC2.1 Principles

- Purpose of rake angle
- Purpose of shear angle
- Purpose of blade gap
- Influence of shear strength

AC2.2 Equipment

- Guillotine
- Punching
- Universal steel worker
- Shears (hand, bench, rotary)
- Mechanical nibblers

AC2.3 Principles

- Purpose of chip formation
- Purpose of rake angle
- Purpose of relief angle

AC2.4 Equipment

- Drills
- Drill bits (steel, masonry, hole saws)
- Saws (circular, bandsaws, hand)

AC2.5 Forming equipment

- Bending rolls
- Folders
- Press brakes
- Horizontal bender

## Learning outcome

The learner will:

3 Understand the joining and assembly methods for fabrication

## Assessment criteria

The learner can:

3.1 Describe non-thermal permanent joining methods and their applications

3.2 Describe non-thermal temporary joining methods and their applications

3.3 Describe thermal fusion joining methods and their applications

3.4 Describe thermal non-fusion joining methods and their applications

3.5 Describe assembly methods for fabrication and their applications

## Range

AC3.1 Non-thermal permanent

- Riveting (hollow (pop), self-piercing)
- Clinching

AC3.2 Non-thermal temporary

- Screws
- Nuts, bolts and washers

AC3.3 Thermal fusion

- Welding (MIG/MAG, TIG, MMA, FCAW)

AC3.4 Thermal non-fusion

- Soldering
- Brazing

AC3.5 Assembly methods

- Alignment methods (straight edge, levels, laser lines, string lines, dumpy levels, drifts, dogs and wedges)
- Work holding (tack bolts, tack welding, clamps, fixtures, magnets)
- Bolt tightening (surface preparation, tightening sequence, torque wrenches, part turn method, bolt locking methods: split pins, castle nuts, adhesives, wiring)

# Unit 217 Fabrication and Welding Principles

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

Learning Outcome 3
There is no requirement for learners to have in depth knowledge and understanding of the the welding processes included in the range for AC3.3 as these are covered in other units

# Unit 218 Manual Welding

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 70 |
| **Unit aim:** | In this unit learners will understand health and safety requirements for arc welding, the equipment and consumables used and the welding parameters. They will also understand weld defects and inspection techniques. |

## Learning outcome

The learner will:

1 Understand safe working practices associated with welding processes

## Assessment criteria

The learner can:

1.1 Describe Personal Protective Equipment (PPE) used in welding processes

1.2 Describe hazards associated with welding processes and ways of minimising them

1.3 Explain the importance of restoring the work area and following correct procedures for waste disposal

1.4 Describe post welding activities

## Range

AC1.1 Personal Protective Equipment

- Headshield
- Filter lens
- Cover lens
- Light reactive filters
- Gauntlets
- Protective footwear
- Eye protection
- Flame retardant overalls
- Leather apron
- Skull cap
- Leather jacket
- Air fed mask

AC1.2 Hazards

Fume hazards

- Visible (particulate)
- Invisible (gaseous)

Minimised by

- Use of extraction (background, local)
- Air fed mask
- Respirator

Electrical hazards

- Shock hazards
- Fire
- Burns

Minimised by

- Use of electrical insulation

Exposure to light hazards

- Visible light
- Infra-red
- Ultra-violet

Minimised by

- PPE (types, purpose)
- Screening

Fire hazards

- Burns from hot metal
- Fire risks

Minimised by

- Use of tools e.g. tongs
- PPE
- Housekeeping i.e. keeping work area clear of flammable materials

AC1.3 Restore the work area

- Leave work area free of unused consumables
- Clean work area
- Putting tools and equipment into safe storage

AC1.4 Post welding activities

- Cleaning
- Slag removal
- Spatter removal
- Wire brushing
- Removal of excess weld metal where required

## Learning outcome

The learner will:

2 Understand principles of manual welding

## Assessment criteria

2.1 Describe the function of equipment used for preparing and finishing welded joints
2.2 Explain different joint types and welding positions
2.3 Explain different welding techniques
2.4 Describe assembly and distortion control methods
2.5 Describe a weld procedure specification
2.6 Describe the weldability of common materials

## Range

AC2.1 Equipment

- Grinders
- Linishers
- Files
- Chipping hammer
- Wire brushes
- Hammer and chisel

AC2.2 Joint types

- Fillet
- Lap
- Butt

Welding positions

- Flat – PA position
- Horizontal/vertical – PB position
- Horizontal – PC position
- Vertical upwards – PF position

AC2.3 Welding techniques

- Stringer beading
- Weaving
- Single-pass
- Multiple-run

AC2.4 Assembly and distortion control

- Clamping
- Alignment jigs
- Run on/off plates
- Tack welds

- Weld sequence

AC2.6 Materials

- Carbon and low alloy steel
- High alloy ferritic/martensitic steel
- Austenitic stainless steel
- Nickel and nickel alloys
- Aluminium and aluminium alloys

## Learning outcome

The learner will:

3 Understand the Manual Metal Arc (MMA) welding process

## Assessment criteria

The learner can:

3.1 Describe the major components of welding equipment
3.2 Describe different types of electrodes and storage requirements
3.3 Describe the parameters for welding

## Range

AC3.1 Components welding equipment

- Power supply
- Welding leads (welding, return, earth)
- Electrode holder
- Return clamp

AC3.2 Types of electrodes

- Cellulosic
- Rutile
- Basic

Storage requirements

- Temperature
- Humidity

AC3.3 Parameters

- Welding current (alternating (A.C.), direct (D.C.), current ranges to electrode sizes: Ø2.5mm, Ø3.2mm, Ø4.0 mm)
- Voltage (open circuit, arc voltage)

## Learning outcome

The learner will:

4 Understand the Metal Inert Gas/Metal Active Gas (MIG/MAG) welding processes

## Assessment criteria

The learner can:

4.1 Describe the major components of welding equipment
4.2 Describe different types of filler wire and storage requirements
4.3 Identify shielding gases for MIG/MAG welding
4.4 Explain the parameters for welding

## Range

AC4.1 Components of welding equipment

- Power supply
- Welding leads: welding, return, earth
- Torch/gun
- Return clamps
- Shielding gas control: regulator, flow meter

AC4.2 Filler wire

- Solid wires: copper coated, reel sizes
- Cored wire: flux cored, self-shielded

Storage requirements

- Temperature
- Humidity

AC4.3 Shielding gases

- argon/ carbon dioxide Ar/$CO_2$
- carbon dioxide $CO_2$
- argon/oxygen Ar/$O_2$
- argon/helium Ar/He

AC4.4 Parameters

- Welding current: direct (D.C.), electrode positive
- Voltage: open circuit, arc voltage
- Relationship between arc voltage and wire feed speed ranges to filler wire sizes
- Shielding gas flow rates

## Learning outcome

The learner will:

5 Understand the Tungsten Inert Gas (TIG) welding process

## Assessment criteria

The learner can:

5.1 Describe the major components of welding equipment
5.2 Describe types of tungsten electrodes and their sizes
5.3 Describe different filler wires and storage requirements
5.4 Identify shielding gases for TIG welding process
5.5 Describe the parameters for welding

## Range

AC5.1 Components of welding equipment

- Power supply
- Welding leads (welding, return, earth)
- Torch/gun
- Return clamps
- Shielding gas control (regulator, flow meter)

AC5.2 Tungsten electrodes

- Types (thoriated, zirconiated, ceriated, lanthanated)
- Sizes (Ø1.6 mm, Ø2.4 mm, Ø3.2 mm)

AC5.3 Filler wires

- Copper coated steel
- Stainless steel
- Aluminium
- Common sizes - Ø1.6 mm, Ø2.4 mm, Ø3.2 mm

Storage requirements

- Temperature
- Humidity

AC5.4 Shielding gases

- argon Ar
- helium He
- argon/helium Ar/He

AC5.5 Parameters

- Welding current
- Voltage (open circuit, arc voltage)

## Learning outcome

The learner will:

6 Understand inspection methods for weld defects

## Assessment criteria

The learner can:

6.1 Explain the causes of causes of weld defects and how their occurrence can be reduced

6.2 Explain quality assessment techniques

6.3 Describe workshop destructive testing techniques

## Range

AC6.1 Causes of weld defects

- Lack of continuity
- Even or irregular weld profile
- Incorrect weld size or profile
- Undercutting
- Overlap
- Inclusions
- Porosity
- Surface cracks
- Internal cracks
- Lack of fusion: root, side wall, inter-run
- Lack of penetration

AC6.2 Quality assessment methods

- Visual including weld gauges
- Non-destructive testing techniques: dye penetrant, magnetic particle

AC6.3 Destructive testing techniques

- Macroscopic examination
- Nick-break test
- Bend tests

# Unit 218 Manual Welding

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required. The unit will allow learners to develop the knowledge for manual welding processes.

Learning Outcome 2

Principles of manual welding is applicable to all manual welding processes and should be taught in the context of each process.

# Unit 219 Producing Components from Metal Plate

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with the knowledge of producing metal plate components. This includes measuring, marking out, cutting to size, forming and joining methods. |

## Learning outcome:

The learner will:

1 Understand tools and equipment used to produce metal plate components

## Assessment criteria

The learner can:

1.1 Describe tools and equipment available for marking out and their applications
1.2 Explain marking out methods for a range of features
1.3 Explain the importance of datums when marking out
1.4 Describe metal plate hand tools, equipment and their applications

## Range

AC1.1 Marking out tools and equipment, to include

- Scribers
- Scribing blocks
- Centre and dot punch
- Rules
- Tape measures
- Vernier callipers
- Vernier height gauges
- Squares (engineers, adjustable and plate)
- Protractors
- Dividers and trammels
- Laser lines
- Marking out tables

AC1.2 Methods

- Direct marking
- Use of templates
- Tracing/transfer method
- Use of datums: line, edge, point

Features

- Circles
- Radii
- Pitch Circle Diameter (PCD)
- Hole centres
- Angles
- Rectangular profiles
- Curved profiles

AC1.4 Hand tools, equipment

- Hammers and mallets
- Work holding magnets
- Clamps
- Dogs and wedges
- Punches (centre, dot)
- Vices

---

## Learning outcome

The learner will:

2 Understand cutting methods for metal plate

## Assessment criteria

The learner can:

2.1 Describe equipment used for cutting by shear and their application

2.2 Describe equipment used for chip forming and their application

---

## Range

AC2.1 Cutting by shear equipment

- Guillotine
- Punching
- Bench shears
- Rotary shears
- Mechanical nibblers and shears

AC2.2 Chip forming equipment

---

- Drilling machines: hand, pneumatic, battery, pillar, radial arm
- Drill bits for steel and masonry and hole saws
- Sawing: circular, bandsaws, reciprocating

## Learning outcome

The learner will:

3 Understand forming methods for metal plate

## Assessment criteria

The learner can:

3.1 Describe the process of forming of metals

3.2 Describe forming equipment and their applications

## Range

AC3.1 Forming

- Rolling
- Folding

AC3.2 Forming equipment

- Bending rolls: pinch, pyramid, 4 roll, vertical
- Folders: universal, box and pan
- Press brakes
- Horizontal benders

## Learning outcome

The learner will:

4 Understand joining and assembly methods for metal plate

## Assessment criteria

The learner can:

4.1 Describe non-thermal temporary joining methods and their applications

4.2 Describe thermal fusion joining methods and their applications

4.3 Explain assembly methods for fabrication and their applications

## Range

AC4.1 Non-thermal temporary

- Screws: self-tapping, self-drilling
- Nuts, bolts and washers

AC4.2 Thermal fusion

- Welding: MIG/MAG, flux cored, TIG, MMA, submerged arc

AC4.3 Assembly methods

- Alignment methods: straight edge, levels, laser lines, string lines
- Work holding: tack welding, tack bolts, clamps, fixtures, magnets
- Bolt tightening sequence
- Bolt locking methods: split pins, castle nuts, adhesives, wiring

# Unit 219 Producing Components from Metal Plate

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

For the purpose of this unit metal plate is defined as having a minimum thickness of >3mm

There is no requirement for learners to be taught the principles as part of this unit. They do however need to understand the applications of each welding process.

Learning outcome 4 AC 4.2
The principles of welding processes are covered in Unit 218 – Manual Welding.

# Unit 220 Producing Components from Sheet Metal

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with the knowledge of producing sheet metal components. This includes measuring, marking out, cutting to size, forming, stiffening and joining methods. |

## Learning outcome:

The learner will:

1. Understand tools and equipment used to produce sheet metal components

## Assessment criteria

The learner can:

1.1 Describe tools and equipment available for marking out and their applications
1.2 Explain marking out methods for a range of features
1.3 Explain the importance of datums when marking out
1.4 Describe sheet metal hand tools, equipment and their applications

## Range

AC1.1 Marking out tools and equipment, to include

- Scribers
- Scribing blocks
- Centre and dot punch
- Rules
- Tape measures
- Vernier callipers
- Vernier height gauges
- Squares (engineers, adjustable and plate)
- Protractors
- Dividers and trammels
- Laser lines
- Marking out tables

AC1.2 Methods

- Direct marking
- Use of templates
- Tracing/transfer method
- Use of datums (line, edge, point)

Features

- Circles
- Radii
- Pitch Circle Diameter (PCD)
- Hole centres
- Angles
- Rectangular profiles
- Curved profiles

AC1.4 Hand tools and equipment

- Hammers and mallets
- Stakes
- Work holding magnets
- Clamps
- Punches (centre, dot)
- Vices

---

## Learning outcome

The learner will:

2 Understand cutting methods for sheet metal

## Assessment criteria

The learner can:

2.1 Describe equipment used for cutting by shear and their application

2.2 Describe equipment used for chip forming and their application

---

## Range

AC2.1 Cutting by shear equipment

- Guillotine
- Punching
- Hand shears
- Bench shears
- Rotary shears
- Mechanical nibblers and shears

AC2.2 Chip forming equipment

- Drilling machines: hand, pneumatic, battery, pillar
- Drill bits for steel and masonry and hole saws

- Saws: circular, bandsaws, jigsaws

## Learning outcome

The learner will:

3 Understand forming methods for sheet metal

## Assessment criteria

The learner can:

3.1 Describe the processes of forming metals
3.2 Describe forming equipment and their applications
3.3 Describe methods of stiffening sheet metal

## Range

AC3.1 Forming

- Rolling
- Folding
- Stretching
- Shrinking

AC3.2 Forming equipment

- Bending rolls: pinch, pyramid, cone rolls
- Folders: universal, box and pan
- Press brakes

AC3.3 Stiffening methods

- Return bends
- Hems
- Rolled edges
- Stiffening ribs
- Swaged beads
- Angle bends

## Learning outcome

The learner will:

4 Understand joining and assembly methods for sheet metal

## Assessment criteria

The learner can:

4.1 Describe non-thermal permanent joining methods and their applications
4.2 Describe non-thermal temporary joining methods and their applications
4.3 Describe thermal fusion joining methods and their applications
4.4 Describe thermal non-fusion joining methods and their applications

4.5 Explain assembly methods for fabrication and their applications

## Range

AC4.1 Non-thermal permanent

- Riveting: hollow (pop), self-piercing
- Clinching

AC4.2 Non-thermal temporary

- Screws: self-tapping, self-drilling
- Nuts, bolts and washers

AC4.3 Thermal fusion

- Welding: MIG/MAG, TIG, resistance

AC4.4 Thermal non-fusion

- Soldering
- Brazing

AC4.5 Assembly methods

- Alignment methods: straight edge, levels, laser lines, string lines
- Work holding: tack welding, clamps, fixtures, magnets
- Bolt tightening sequence
- Bolt locking methods: split pins, castle nuts, adhesives, wiring

# Unit 220 Producing Components from Sheet Metal

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

For the purpose of this unit sheet metal is defined as having a maximum thickness of 3mm

There is no requirement for learners to be taught the principles as part of this unit. They do however need to understand the applications of each welding process.

Learning Outcome 4 AC 4.3
The principles of welding processes are covered in Unit 218 – Manual Welding.

# Unit 221 Principles of Sheet and Plate Metal Work

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with the knowledge of basic principles related to sheet and plate metal technology. This includes work organisation, pattern development and cutting and forming |

## Learning outcome:

The learner will:

1 Understand methods of work organisation

## Assessment criteria

The learner can:

1.1 Describe preparations before commencing metal work tasks

1.2 Explain the use of nesting to minimise waste

## Range

AC1.1 Preparations

- Health and Safety: work area, protection of others, risk assessment
- Work information: engineering drawings, job instructions, bill of materials, tools
- Material checks
- Equipment checks

## Learning outcome

The learner will:

2 Understand cutting and forming principles

## Assessment criteria

The learner can:

2.1 Explain the principles of cutting by shear

2.2 Describe how cutting by shear principles are applied to metal working equipment

2.3 Explain the principles of chip forming

2.4 Describe how chip forming principles are applied to metal working equipment

---

## Range

AC2.1 Principles

- Purpose of rake angle
- Purpose of shear angle
- Purpose of blade clearance
- Influence of material shear strength

AC2.2 Equipment

- Guillotine
- Punching
- Bench shears

AC2.3 Principles

- Methods of chip formation
- Purpose of rake angle
- Purpose of relief angle

AC2.4 Equipment

- Drill bits
- Sawing machines

---

## Learning outcome

The learner will:

3 Know pattern development techniques

## Assessment criteria

The learner can:

3.1 Describe methods of parallel line pattern development

3.2 Describe methods of radial line pattern development

3.3 Describe methods of triangulation pattern development

---

## Range

AC3.1 Parallel line

- Cylinder elbows (900 and 1350)
- Rectangular elbows (900 and 1350)
- Cylinder branches (900 and 1350)

---

AC3.2 Radial line

- Right cones and frustums

AC3.3 Triangulation

- Rectangular hoppers
- Square to round transformers (on centre only)

# Unit 221 Principles of Sheet and Plate Metal Work

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 222 Non Fusion Thermal Joining Methods

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit provides the learner with the knowledge of basic principles related to non-thermal joining methods. These include soldering, adhesives and sealants. |

## Learning outcome:

The learner will:

1 Understand the soft soldering method of joining metals

## Assessment criteria

The learner can:

1.1 Describe the principles of soft soldering
1.2 Describe the consumables used for soft soldering
1.3 Describe soft soldering heat sources
1.4 Describe the stages required to complete a soft soldered joint

## Range

AC1.1 Principles

- Capillary attraction
- Inter-metallic compound
- Flux action (wetting, cleaning, oxidisation control)

AC1.2 Consumables

- Fluxes: active, passive
- Solders: tin lead alloys for general purposes, tin zinc for joining aluminium

AC1.3 Heat sources

- Soldering iron
- Gas torch

AC1.4 Stages for soft soldered joints

- Joint design: socket, lap
- Cleaning: mechanical, chemical
- Flux application
- Joint assembly
- Heat application

## Learning outcome

The learner will:

2 Understand the hard-soldering method of joining metals

## Assessment criteria

The learner can:

2.1 Describe the principles of hard soldering
2.2 Describe the consumables used for hard soldering
2.3 Describe hard soldering heat sources
2.4 Describe the stages required to complete a hard-soldered joint

## Range

AC2.1 Principles

- Capillary attraction
- Inter-metallic compound
- Flux action: wetting, cleaning, oxidisation control

AC2.2 Consumables

- Fluxes
- Spelters: brass alloys, silver alloys

AC2.3 Heat sources

- Gas torch

AC2.4 Stages for hard soldered joints

- Joint design: socket, lap
- Cleaning: mechanical, chemical
- Flux application
- Joint assembly
- Heat application

## Learning outcome

The learner will:

3 Understand the use of adhesives to join materials

## Assessment criteria

The learner can:

3.1 Describe the principles of joining using adhesives
3.2 Explain types of adhesives used to join materials and their applications
3.3 Describe the stages to complete an adhesive joint
3.4 Describe the applications of sealants in engineering

## Range

AC3.1 Principles

- Method of adhesion: solvent, chemical bonding, physical bonding
- Adhesive thickness
- Adhesion strength
- Surface area

AC3.2 Adhesive types

- Epoxy resin
- Solvent cements
- Cyanoacrylates

AC3.3 Completion stages

- Joint design
- Cleaning: mechanical, chemical
- Adhesive application
- Joint assembly
- Adhesive activation

AC3.4 Sealant applications

- Gap sealing
- Marine repair
- Water proofing
- Windscreen bonding

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# Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 223 Thermal Cutting Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | This unit provides the learner with the knowledge related to thermal cutting including principles, equipment requirements and related health and safety. |

## Learning outcome:

The learner will:

1. Understand the principle of oxy-fuel thermal cutting

## Assessment criteria

The learner can:

1.1 Explain the principle of oxy-fuel thermal cutting
1.2 Identify the types of gases available for oxy-fuel thermal cutting
1.3 Describe the flame used for oxy-fuel thermal cutting
1.4 Describe the equipment used for oxy-fuel thermal cutting
1.5 Describe the safe use and applications of oxy-fuel cutting

## Range

AC1.1 Principle

- Gas combustion
- Ignition temperature
- Exothermic reaction

AC1.2 Gases

- Oxygen
- Acetylene
- Propane

AC1.3 Flame

- Conditions
  - Neutral
  - Oxidising

    - Carburising/reducing
- Parts of the flame: inner cone, outer envelope, hottest point

AC1.4 Equipment

- Cylinders: identification i.e. colours and thread type, safe storage
- Regulators
- Flash back arrestors
- Hoses
- Hose check valves
- Torches: controls, mixing chambers
- Nozzles: one-part, two-part, selection related to material thickness
- Component identification: left/right hand threads, notched nuts

AC1.5 Safe use

- PPE
- Cylinder handling and storage
- Gas pressures for cutting
- Safe procedures for flame ignition and extinguishing
- Fume particular and gaseous
- Methods of handling of hot metals
- Leak testing

Applications including

- Cutting materials to shape: plates, pipes, structural sections
- Piercing
- Bevel cutting: plates, pipes

---

## Learning outcome

The learner will:

2. Understand the principle of plasma cutting

## Assessment criteria

The learner can:

2.1 Explain the principle of plasma cutting

2.2 Describe the equipment used for plasma cutting

---

## Range

AC2.1 Principle

- Definition of plasma
- Pilot arc
- Transferred arc

AC2.2 Equipment

- Torches: water cooled, air cooled
- Nozzles
- Gas baffle
- Electrodes

---

## Learning outcome

The learner will:

3. Understand the principle of laser cutting

## Assessment criteria

The learner can:

3.1 Explain the principle of laser cutting

3.2 Describe the equipment used for laser cutting

---

## Range

AC3.1 Principle

- Acronym: light amplification by stimulated emission of radiation
- Beam concentration

AC3.2 Equipment

- Focus lens
- Nozzle
- CNC control

---

# Unit 223 Thermal Cutting Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 224 Engineering Maintenance Safety

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | This unit is to introduce learners to health and safety within engineering maintenance. In this unit the learners will cover safe working practices associated with a maintenance environment including lifting, moving, working at height and restoring the workplace. |

## Learning outcome

The learner will:

1. Understand safe working practices, tools and equipment for maintenance activities

## Assessment criteria

The learner can:

1.1 Describe health and safety in engineering maintenance
1.2 Describe the hazards associated with maintenance activities
1.3 Describe equipment used for working at height
1.4 Describe different types of lifting equipment
1.5 Describe safe lifting methods/techniques
1.6 Describe methods for moving heavy equipment across flat surfaces

## Range

AC1.1 Health & Safety

- Legislation/regulation

Safe working practices

- Wearing appropriate protective clothing and equipment
- Maintaining a clean and tidy work area
- Use of barriers and/or tapes
- Post warning signs
- Informing personnel of maintenance activities
- System isolation procedures for power and pressure sources
- Permit-to work procedures
- Preparing the work area e.g. Lifting plan
- Leaving the work area in a safe and clean condition

AC1.2 Hazards

- Handling of oils and grease
- Misuse of tools
- Misuse of access equipment
- Use of damaged or badly maintained tools
- Not adhering to maintenance procedures

AC1.3 Access/egress equipment

- Ladders
- Scaffolding
- Mobile platforms e.g. quick form scaffolding

AC1.4 Lifting equipment

- Chains
- Rope and wire slings
- Hooks
- Shackles
- Eye bolts
- Screw and hydraulic jacks
- Overhead gantry cranes
- Forklift trucks
- A frame/tripod
- Pulley blocks
- Pallet truck

AC1.5 Safe lifting methods/techniques

- Methods of sling attachment to prevent damage to sling machinery (protective padding, wooden blocks)
- Angle of splay between two leg sling chains not to exceed 120°
- Estimation of approximate weight
- Inspection records for lifting equipment are current
- Centre of gravity of load
- Safe working loads (SWL)

AC1.6 Methods

- Rollers and skate
- Crowbars
- Pull-lifts
- Lubricated plates

## Learning outcome

The learner will:

2. Know how to clean and restore work areas following maintenance activities

## Assessment criteria

The learner can:

2.1 Identify procedures for cleaning work areas following a spillage or leakage

2.2 Describe how to restore the work area following maintenance activities

## Range

AC2.1 Procedures for cleaning

- Erect warning signs/barriers
- Use approved waste disposal methods
- Absorbent substances
- Use of detergents and solvents

AC2.2 Restore the work area

- Leave the work area free of unused consumables
- Clean the work area
- Put tools and equipment into safe storage

# Unit 224 Engineering Maintenance Safety

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 225 Engineering Maintenance Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | Learners will understand fault diagnostic methods and develop knowledge and understanding of how basic measuring systems and instrumentation to maintain plant and equipment are used. |

## Learning outcome

The learner will:

1. Understand fault diagnostic methods

## Assessment criteria

The learner can:

1.1 Describe diagnostic methods used for fault finding

1.2 Describe diagnostic aids used in fault finding

## Range

AC1.1 Methods

- Sensory information: sight, sound, smell, touch
- Fault report
- Measurement
- Movement
- Alignment checks
- Instrumentation readings
- Fault location techniques: half-split, input-to-output, function testing, unit substitution, equipment self-diagnostics

AC1.2 Diagnostic aids

- Manuals
- Flow charts
- Troubleshooting guides
- Maintenance records
- Manufacturers maintenance logs
- Operator experience
- Previous repairs log

- model predictions

## Learning outcome

The learner will:

2. Understand measuring systems and instrumentation

## Assessment criteria

The learner can:

2.1 Describe how measuring equipment is used for maintenance operations
2.2 Identify instrumentation used in maintenance

## Range

AC2.1 Measuring equipment

- Rules, tapes
- Thermal imager
- Vibration tester
- Insulation resistance tests
- Digital multimeter/clamp meter
- Callipers: Vernier, digital
- Micrometer
- Feeler gauge
- Bore / depth gauge
- Dial test indicator (DTI)
- Deflection gauges

AC2.2 Basic instrumentation

- Sensors
- Gauges
- Instrument diagnostics
- Data loggers
- Diagnostic analysis

## Learning outcome

The learner will:

3. Understand how plant and equipment is maintained

## Assessment criteria

The learner can:

3.1 Explain preparation required for maintenance operations
3.2 Describe safe use of tools
3.3 Describe joining and bonding processes used in maintenance operations
3.4 Describe dismantling and reassembly methods

---

## Range

AC3.1 Maintenance operations preparation

- Risk assessment
- Permit to work obtained
- Method statements
- Ensure production ceased
- If required cleaning of machinery
- Isolation of equipment from power sources
- Barriers
- Safety locking padlocks
- Removal of guarding

AC3.2 Safe use of tools

- Inspection of tools before maintenance work
- Sourcing tools for specific operations

AC3.3 Joining and bonding processes

- Splicing into cables
- Replacement of cables by joining techniques
- Replacement of pipework systems e.g. fixed or flexible
- Joining techniques used in maintenance e.g. welding, soldering, brazing, adhesives

AC3.4 Dismantling and reassembly

- Removal of access panels to reach parts and components
- Removal of mechanical locking and securing mechanisms
- Release of any stored energy or substances
- Replacement of life limited parts
- Proof marking and appropriate storage of parts as they are removed
- Cleaning or refurbishment of removed parts
- Reporting the activities that were carried out

# Unit 225 Engineering Maintenance Techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes that will deliver the component in the engineering information.

# Unit 226 Engineering Maintenance Planning

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | In this unit learners will understand different maintenance methods and the techniques. They will understand the considerations required during planning to ensure effective planned maintenance activities that minimise the impact on production. |

## Learning outcome

The learner will:

1 Understand different types of planned maintenance

## Assessment criteria

The learner can:

1.1 Describe different types of planned maintenance
1.2 Explain the importance of planned preventative maintenance
1.3 Describe sources of data used in condition based monitoring

## Range

AC1.1 Types of maintenance

- Planned preventative maintenance
- Total productive maintenance (TPM)
- Condition based monitoring
- Cyclical maintenance
- Reactive maintenance

AC1.2 Importance of planned maintenance to

- Reduce downtime
- Maintain production
- Ensure maintenance completed within a fixed period
- Reduce accidents
- Reduce maintenance costs

AC1.3 Sources of data

- Temperature sensors
- Sound sensors
- Pressure sensors
- Smart technology
- Visual inspection/operator feedback

## Learning outcome

The learner will:

2 Understand health and safety requirements for planning maintenance activities

## Assessment criteria

The learner can:

2.1 Describe the purpose of a risk assessment for a maintenance activity

2.2 Identify legislation relevant to planning maintenance activities

## Range

AC2.1 Risk assessment

- Identification of hazards
- Evaluation of risk: severity, likelihood, people affected, risk rating
- Recommendation of control measures
- Permit to work

AC2.2 Legislation

- Health and Safety at Work Act (HASAWA)
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations (PPE)
- Lifting Operations and Lifting Equipment Regulations (LOLER)
- Control of Substances Hazardous to Health (COSHH)
- Working at heights regulations
- Pressure vessels regulations
- Electrical regulations

## Learning outcome

The learner will:

3 Understand the planning of maintenance activities

## Assessment criteria

The learner can:

3.1 Explain the considerations when planning for maintenance activities

3.2 Explain the planning process for maintenance activities

3.3 Describe types of resources required for planned maintenance

---

## Range

AC3.1 Considerations when planning

- Effect on production schedules including planned shutdown, periodic servicing
- Health & Safety requirements including implications for adjacent working areas
- Lead time to procure resources
- Availability of specialist equipment
- Availability of staff including holiday approvals, specialist contractors where required
- Sources of information: (manufacturers' manuals, data sheets, technical drawings)

AC3.2 Planning process

- Identify sequence of operations required
- Development of method statement
- Contingency planning for delays such as unplanned reactive maintenance
- Methods of monitoring maintenance progress including use of Gantt charts

AC3.3 Resource requirements

- Fluids: lubricants including oils and greases, coolants
- Consumables: filters, bearings, fuses
- Lifed items: high tensile bolts and washers, nylon insert nuts, locking devices, split pins, seals and gaskets

---

# Unit 226 Engineering Maintenance Planning

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 227 Engineering Materials

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit aim:** | When designing a product, the material that it is to be made from is selected based on the properties needed for the application. Sometimes it is necessary to modify the properties of the material to meet these needs. Further, when designing a product and selecting the material, consideration has to be given to how the product could fail.<br><br>In this unit learners will come to understand the properties of materials and how these are measured. They will also understand how the properties of a material can be changed and how materials fail. |

## Learning outcome

The learner will:

1 Understand the properties of materials

## Assessment criteria

The learner can:

1.1 Explain the difference between mechanical and physical properties

1.2 Describe the relative mechanical properties, physical properties, sustainability and applications of a range of materials

1.3 Describe how the mechanical properties of materials are measured

1.4 Explain the typical characteristics shown on a load-extension graph during the tensile testing of different types of materials

## Range

AC1.1- AC1.2

Mechanical properties

- Tensile strength
- Hardness
- Toughness

- Elasticity
- Plasticity
- Ductility
- Malleability

Physical properties

- Density
- Melting point
- Thermal and electrical conductivity
- Corrosion resistance
- Ability to be recycled

AC1.2 Materials

- Ferrous metals: cast iron; low carbon steel (<0.30 % carbon); medium carbon steel (0.3-0.7 % carbon); high carbon steel (0.7-1.4 % carbon); stainless steel
- Non-ferrous metals: aluminium and its alloys; copper and its alloys; zinc; nickel
- Thermoplastic polymers: high impact polystyrene (HIPS); polypropylene (PP); acrylonitrile-butadiene-styrene (ABS); acrylic (PMMA); polycarbonates
- Thermosetting polymers: melamine formaldehyde; urea formaldehyde; epoxy resin; polyester resin
- Elastomers: rubber; neoprene
- Engineering ceramics: silicon carbide; concrete
- Composites: glass reinforced plastics (GRP/fibreglass); carbon reinforced plastics (CRP)
- Smart materials: shape memory alloys (SMA), quantum tunnelling composite (QTC), thermochromic materials, photochromic materials

AC1.3 Measuring methods

- Tensile testing
- Toughness testing
- Hardness testing

AC1.4 Material types

- Ferrous metals
- Non-ferrous metals
- Ceramic
- Composite
- Thermosetting and thermoplastic polymers

Characteristics:

- Yield strength/yield point
- Ultimate tensile strength
- Elongation
- Necking
- Fracture

## Learning outcome

The learner will:

2 Understand methods by which the properties of materials can be changed

## Assessment criteria

The learner can:

2.1 Explain the effect of cold working on the mechanical properties of materials

2.2 Explain how heat treatment affects the microstructure and properties of metals

## Range

AC2.1 Effect of cold working

- Changes in mechanical properties caused by changes in the lattice structure and dislocation movement

AC2.2 Heat treatments

- Case hardening
- Quench hardening
- Tempering
- Normalising
- Annealing
- Precipitation hardening

Influences on the microstructure

- Grain size
- Compositional change
- Phase transformations in steel
- Formation of precipitates

## Learning outcome

The learner will:

3 Understand failure mechanisms in materials

## Assessment criteria

The learner can:

3.1 State the type of process that causes corrosion

3.2 Explain how corrosion can cause the failure of a metal part

3.3 Explain methods that can be used to manage corrosion in ferrous metals

3.4 Explain the causes of fatigue in metals and how the risk of this can be reduced

3.5 Explain the causes of material failure due to creep and how the risk of this can be reduced

## Range

AC3.1 Corrosion

- Oxidation of metals: including rusting of ferrous metals
- Formation of surface film of oxide on non-ferrous metals

AC3.2 Effect of corrosion

- Consumption of material
- Reduction in effective thickness leading to increased stress

AC3.3 Metals

- Cast iron
- Low, medium and high carbon steel

Methods

- Painting
- Plastic coating
- Galvanising
- Electrolytic (galvanic) protection

AC3.4 Causes of fatigue

- Cyclic loading below the yield stress
- Progressive crack growth
- Influence of stress raisers

AC3.5 Material fail due to creep

- Three stages of creep
- Influence of temperature and load

# Unit 227 Engineering Materials

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 228 Electrical Installation Methods, Wiring and Circuit Protection

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit will provide knowledge and understanding required to install electrical wiring systems and circuits in a domestic or commercial environment. It covers the main principles of circuit wiring, installation and wiring methods and the applications of circuit protection devices. |

## Learning outcome

The learner will:

1 Understand the principles of electrical circuit wiring

## Assessment criteria

The learner can:

1.1 State the regulations that apply to electrical installation

1.2 Describe the characteristics and applications of cable types

1.3 Explain the purpose of documentation required for electrical installations

## Range

AC1.1 Regulations

- IET (Institution of Engineering and Technology) wiring regulations
- The Electricity at Work Regulations

AC1.2 Cable types

- Single core
- Multicore
- Armoured
- Fire resistant

AC1.3 Documentation

- Risk assessments
- Method statements
- Permit to work

- Circuit diagrams
- Wiring diagrams
- Manufacturers' data sheets

## Learning outcome

The learner will:

2 Know electrical installation and wiring methods

## Assessment criteria

The learner can:

2.1 Describe the methods used to install electrical circuits, cables and wiring systems

2.2 Describe the tools and equipment used in electrical installations and their purpose

2.3 Describe cable termination methods

## Range

AC2.1 Electrical circuits

- Lighting circuits
  - 1-way
  - 2-way
  - intermediate
- Power circuits
  - ring final
  - radial
- Control circuits
- Socket outlet circuits

Wiring systems

- Conduit
- Trunking
- Cable tray
- Basket

AC2.2 Tools and equipment

- Screwdrivers
- Pliers
- Side cutters
- Drills
- Stripping tools
- Soldering irons
- Power tools

AC2.3 Cable termination methods including

- Crimp/compression connections
- Screw terminals
- Soldered connections

- Cable clamps
- Cable clips

## Learning outcome

The learner will:

3 Understand the applications of electrical circuit protection devices

## Assessment criteria

The learner can:

3.1 Explain the purpose and applications of circuit protection devices

3.2 Explain the factors that affect the selection of circuit protection devices.

## Range

AC3.1 Circuit protection devices

- Fuse
- Circuit breaker
- RCD

AC3.2 Factors

- Wire and circuit protection device ratings
- Fuse blow point
- Circuit breaker trip value
- Effects of current heating

# Unit 228 Electrical Installation Methods, Wiring and Circuit Protection

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 229 Electrical Circuit Inspection, Testing and Fault Diagnosis

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit will provide the knowledge and understanding required to inspect, test and diagnose faults in electrical circuits. It covers safe isolation procedures, methods of inspecting and testing circuits, the symptoms and causes of typical faults and the relevant standards and guidance. |

## Learning outcome

The learner will:

1 Understand safe electrical isolation procedures

## Assessment criteria

The learner can:

1.1 Explain the dangers of electricity and mains voltage
1.2 Explain the need to safely isolate circuits
1.3 Describe the methods used to safely isolate circuits

## Range

AC1.1 Dangers

- Electric shock
  - Burns
  - Muscle damage
  - Neurological damage
  - Heart stoppage
  - Electrocution/death
- Fire
- Arc flash

AC1.3 Methods

- Lock out processes
- Use of isolation devices

## Learning outcome

The learner will:

2 Understand methods of inspecting, testing and fault-finding electrical circuits

## Assessment criteria

The learner can:

2.1 Describe preparatory activities required prior to testing electrical circuits
2.2 Describe methods of testing electrical circuits
2.3 Explain the symptoms and causes of typical faults in electrical circuits
2.4 Describe fault diagnosis techniques.

## Range

AC2.1 Preparatory activities

- Safety checks
- Test instrument calibration checks
- Setting up of test instruments
- Removal of equipment covers / casings
- Mains supply isolation
- Cleaning of modules/components

AC2.2 Electrical circuits including

- Lighting circuits
- Socket outlet circuits

Test methods

- Use of measuring instruments
  - Multimeter
  - Continuity tester
  - Oscilloscope
  - Insulation resistance tester
  - Signal generator
- Visual inspection

AC2.3 Typical faults

- Damaged, faulty or deteriorated circuit parts
- Short circuits
- Ground faults
- Arcing

AC2.4 Fault diagnosis techniques

- Input to output checks
- Half split method
- Injection and sampling
- Component/unit substitution

- Functional testing
- Flow charts

## Learning outcome

The learner will:

3 Know standards and guidance relating to electrical testing and fault diagnosis

## Assessment criteria

The learner can:

3.1 State the regulations and requirements that apply to electrical testing and fault diagnosis

3.2 Describe the markers/labels used to identify wiring and cables

## Range

AC3.1 Regulations and requirements

- IET wiring regulations
- The Electricity at Work Regulations
- HSE guidance: (Safety in electrical testing at work, HSG85 Electricity at work safe working practices)

AC3.2 Markers/labels including

- Wiring/cable colour coding
- Coded tabs

# Unit 229 Electrical Circuit Inspection, Testing and Fault Diagnosis

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 230 Building Services Engineering Pipework Fixing, Bending and Jointing Methods

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit Aim** | This unit introduces knowledge supporting the installation of pipework systems for water. Learners will develop initial understanding of the materials used to make water pipes, and how pipes are bent into shape, joined together and fixed to the fabric of the building. They will also learn about how pipework is tested. |

## Learning outcome

The learner will:

1 Understand the materials used in domestic pipework applications

## Assessment criteria

The learner can:

1.1 State the materials used for domestic pipework applications
1.2 Explain the typical applications of pipes made from different materials

## Range

AC1.1-1.2 Materials

- Copper: R220 / soft (annealed), R250 / half hard, R290 / hard
- Plastics: acrylonitrile butadiene styrene (ABS), polyethylene (MDPE), polybutylene, polyvinyl chloride (PVC-u, MuPVC), polypropylene (PP).

AC1.2 Types of application

- Hot water supply
- Cold water supply
- Heating systems
- Sanitary pipework

## Learning outcome

The learner will:

2 Understand methods of bending pipework

## Assessment criteria

The learner can:

2.1 Calculate dimensions and measurements from scaled drawings and diagrams
2.2 Describe methods of producing different types of bends in copper pipes
2.3 Explain techniques used to determine and achieve bend dimensions when using different methods
2.4 Describe methods of bending plastic pipework

## Range

AC2.2-2.3 Types of bend

- 90$^{o}$ bends
- Offset bends

Bending methods

- Hand vice
- Spring bending
- Pipe bender/bending machine
- Use of heat, if required

AC2.3 Techniques

- Distribution of applied force
- Use of heat
- Use of templates or jigs

## Learning outcome

The learner will:

3 Understand methods of joining pipes

## Assessment criteria

The learner can:

3.1 Describe methods used to join copper pipes
3.2 Explain the advantages and disadvantages of the different joining methods used with copper pipes
3.3 Describe fittings used with plastic pipework and their applications

3.4 Describe methods of installing fittings used with plastic pipework
3.5 Describe methods of checking that fittings are sufficiently tight prior to testing
3.6 Identify faults in fittings

## Range

AC3.1, 3.2 Joining methods

Types of fitting (including methods of installation)

- Compression: manipulative and non-manipulative, type A and B.
- Capillary: integral and end feed
- Push fit

Thermal joining

- Soldering
- Brazing

AC3.2 Advantages and disadvantages related to:

- Joint integrity
- Joint stability/life
- Need to create a thread
- Use of heat
- Influence on flow characteristics

AC3.3 Types of fitting

- Push fit
- Compression
- Proprietary
- Ring seal
- Solvent welded

## Learning outcome

The learner will:

4 Understand methods of fixing pipework to the fabric of a building

## Assessment criteria

The learner can:

4.1 Describe fixing devices and their applications
4.2 Identify the tools and equipment required to install basic pipework systems
4.3 Describe methods of preparing building construction features for the installation of pipework systems
4.4 Describe methods of allowing for thermal movement of pipework
4.5 Describe methods of marking out for horizontal and vertical clips for copper pipework

4.6 Describe methods of fixing clips and brackets

4.7 Explain safety considerations when drilling and fixing clips and brackets

4.8 Describe methods of restoring the fabric of the building after installation, where required.

## Range

AC4.1 Fixing devices

- Clips: horizontal and vertical
- Brackets
- Screws: slotted head, phillips head, pozidrive
- Plastic plugs (for use with screws)
- Coach bolts
- Rawl bolts
- Nails

AC4.7 Considerations to include:

- Use of personal protective equipment (PPE): safety goggles, safety shoes
- Working at heights
- Electrical safety

## Learning outcome

The learner will:

5 Understand methods of testing domestic pipework

## Assessment criteria

The learner can:

5.1 Explain the importance of a visual inspection being carried out prior to filling a pipework system with water

5.2 Describe the British standard soundness test

5.3 Describe the method used to test a pipework for tightness

5.4 Describe the equipment used for pressure testing

5.5 Describe the method used to carry out a pressure test on pipework

5.6 Explain the actions to be taken if pipework fails a test

5.7 Explain how water pressure and flow rate is measured and recorded

5.8 Describe the typical water pressures required for domestic premises and problems arising from low water pressure

5.9 Explain safety considerations when testing pipework

# Unit 230 Building Services Engineering Pipework Fixing, Bending and Jointing Methods

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

Learning Outcome 5 AC5.2
The soundness test is as specified in BS 6700 Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages.

# Unit 231 Building services engineering pipework fabrication processes and techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit Aim** | This unit will provide knowledge and understanding of engineering pipework fabrication processes and techniques. It covers pipework fabrication and installation methods, methods of supporting domestic pipework and pipework testing methods. |

## Learning outcome

The learner will:

1 Understand pipework fabrication and installation methods

## Assessment criteria

The learner can:

1.1 Describe the purpose and applications of tools used in pipework fabrication and installation
1.2 Describe materials used for pipework applications and their typical sizes
1.3 Describe functions and applications of pipework fittings
1.4 Describe methods of jointing copper pipework
1.5 Describe methods of jointing low carbon steel pipework
1.6 Describe methods of jointing plastic pipework for different applications
1.7 Describe methods of bending pipework made from different materials
1.8 Describe methods of preparing construction features for pipework installation

## Range

AC1.1 Tools:

- Power tools
  - Drills
  - Pipe threading machines
  - Saws (bandsaws, circular saws, jigsaws)
- Hand tools
  - Bending tools
  - Chisels

- Grips
- Hammers
- Hand saws
- Hydraulic benders
- Manual pipe threaders
- Pipe cutters
- Pliers
- Pipe freezing kits
- Spanners
- Spirit levels
- Wrenches

AC1.2, 1.7 Materials:

- Copper
  - Soft tube (R220)
  - Half hard tubes (R250)
  - Hard copper tubes (R290)
- Plastic
  - Acrylonitrile butadiene styrene (ABS)
  - Polyvinyl Chloride un-plasticised (PVCu)
  - Polypropylene
  - Medium-density polyethylene (MDPE)
  - Polybutylene
  - Modified un-plasticised polyvinyl chloride (MuPVC)
- Low carbon steel

AC1.3 Fittings

- General fittings
  - Bends
  - Elbows
  - Manifolds
  - Tees
  - Reducers
  - Tap connectors
  - Flexible connectors
- Copper pipe fittings
  - Push fit
  - Press fit
  - Compression
  - Capillary

- Low carbon steel pipe fittings
  - Compression

- Threaded

AC1.4 Jointing methods

- Push fit
- Press fit
- Compression
- End feed
- Soldered

AC1.5 Jointing methods

- Compression
- Threaded

AC1.6 Jointing methods

- Push fit
- Compression
- Proprietary
- Ring seal
- Solvent weld

Applications

- Hot
- Cold
- Heating
- Sanitary

AC1.7 Bending methods

- Hand vice
- Spring bending
- Pipe bender/bending machine
- Use of heat, if required

Types of bends

- $90^0$
- Passover bends
- Sets and offsets

AC1.8 Methods including

- Removal and replacement of floor and subfloor
- Making holes in masonry surfaces
- Drilling holes in and notching floor joists
- Cutting chases

## Learning outcome

The learner will:

2 Understand methods of supporting domestic pipework

## Assessment criteria

The learner can:

2.1 Describe marking out methods for pipework fixings and brackets
2.2 Describe the applications of fixing devices
2.3 Describe the purpose and applications of clips and brackets
2.4 Describe methods of installing fixings and brackets for pipework

## Range

AC2.2 Fixing devices

- Screws
  - Slotted head
  - Phillips head
  - Pozidrive
- Plastic wall plugs
- Timber nails
- Masonry nails
- Heavy duty fixings
  - Rawlbolts
  - Coach bolts
- Specialist fixings
  - Drive in fixings
  - Cavity fixings

AC2.3 Applications including

- Supporting pipework
- Attaching radiators to walls
- Fitting and securing sanitary appliances

## Learning outcome

The learner will:

3 Understand methods of testing domestic pipework

## Assessment criteria

The learner can:

3.1 Explain the importance of a visual inspection being carried out prior to filling a pipework system with water

3.2 Describe the British standard soundness test

3.3 Describe the method used to test a pipework for tightness

3.4 Describe the equipment used for pressure testing

3.5 Describe the method used to carry out a pressure test on pipework

3.6 Explain the actions to be taken if pipework fails a test

3.7 Explain safety considerations when testing pipework

# Unit 231 Building services engineering pipework fabrication processes and techniques

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

Learning Outcome 3 AC3.2
The soundness test is as specified in BS 6700 Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages

# Unit 232 Building Services Pipework Systems

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit Aim** | This unit introduces types of pipework systems used in domestic applications. Learners will develop an understanding of hot and cold water supply systems, central heating systems and above ground discharge systems for the disposal of waste water. They will also consider environmental issues arising from energy usage for heating and water use in domestic environments. |

## Learning outcome

The learner will:

1 Understand hot and cold water supply systems used for domestic plumbing

## Assessment criteria

The learner can:

1.1 Outline the main requirements of regulations and standards for domestic water supply
1.2 Explain the importance of complying with the regulations and standards
1.3 Describe the types of water supply systems used for domestic plumbing
1.4 Identify the main components in water supply systems
1.5 Describe the layouts of different water supply systems
1.6 Identify the symbols used to represent components on system layout drawings
1.7 Explain the basic operation of water supply systems, including their advantages and disadvantages

## Range

AC1.1, 1.2 Regulations and standards

- Water Supply (Water Fittings) Regulations
- Building Regulations Approved Document G
- BS 8558 Water use in domestic buildings
- BS EN 806 Specifications for installations inside buildings conveying water for human consumption.

AC1.3 -1.5, 1.7 Types of system

- Hot and cold water supply
- Direct and indirect systems

AC1.4, 1.6 Components to include:

- Indirect water system: cistern, boiler, hot water cylinder, valves, taps
- Direct water system: combi-boiler, valves, taps

---

## Learning outcome

The learner will:

2 Understand the principles of central heating systems

## Assessment criteria

The learner can:

2.1 Identify the layouts of central heating systems
2.2 Describe the operating principles of central heating systems
2.3 Explain the difference between traditional and condensing boilers
2.4 Explain the operating principles of controls used on central heating systems
2.5 Describe methods of attaching radiators and pipework to walls and boards
2.6 Describe methods of bending copper pipe to required angles
2.7 Describe methods of joining copper pipes together

---

## Range

AC2.1-2.2 Central heating systems

- Open vented systems for heating only: gravity hot water and fully pumped
- Sealed systems for heating only: fully pumped with motorised zone valve
- Combi-boilers for heating and hot water

AC2.4 Controls

- Mechanical
- Electrical

AC2.5 Attaching radiators and pipework

- Marking out
- Drilling
- Use of horizontal and vertical clips
- Use of brackets

AC2.6 Bending methods

- Spring bending
- Pipe bender
- Use of a template or jig
- Use of heat, if required

AC2.7 Joining methods

- Threaded
- Soldered/brazed

## Learning outcome

The learner will:

3 Understand above ground discharge systems

## Assessment criteria

The learner can:

3.1 Identify the layouts of above ground discharge systems
3.2 Explain the advantages and disadvantages of different system types
3.3 Explain system design considerations
3.4 Explain the causes of issues that can occur in discharge systems and how these can be avoided
3.5 Describe the air test used for sanitary pipework including consideration of parameters

## Range

AC3.1, 3.2 Discharge systems

- Ventilated
- Unventilated

AC3.3 Design considerations

- Maximum run lengths and gradients of pipes
- Minimum distances from the invert level of the drain to the lowest appliances
- Sizes of soil and waste branch discharge pipes
- Minimum diameter for a discharge stack (75 mm)
- Reductions in stack diameter possible for urinals/waste appliances
- The outcomes of using undersize pipework
- The difference between a socket bend and a long radius bend
- Reasons that bends/offsets should not be used in the wetted section of the stack

AC3.4 Issues

- Hydraulic jump
- Crossflow
- Trap seal loss through self and induced siphonage

AC3.5 Test parameters

- Duration
- Maximum pressure during testing

## Learning outcome

The learner will:

4 Understand energy and environmental issues arising from heating and water usage

## Assessment criteria

The learner can:

4.1 Explain the importance of energy conservation in the home
4.2 Describe sources of heat losses from domestic buildings
4.3 Identify methods of conserving energy in the home
4.4 Describe common insulation methods for buildings
4.5 Explain the importance of conserving water
4.6 Describe ways to minimise water usage

## Range

AC4.2 Sources of heat losses

- Ventilation
- Conduction

AC4.3 Methods of energy conservation

- Heating only occupied areas
- Heating water only when it is required
- Using energy efficient appliances
- Insulation
- Use of heat pumps (water, air, ground source)
- Conversion of waste to energy (biomass)
- Solar panels for water heating and electricity generation

AC4.4 Insulation methods

- Blanket insulation
- Cavity wall (spray foam)
- Foam board
- Double glazing

AC4.6 Minimise water usage

- Eliminate unnecessary use
- Repurposing of waste water
- Use of high efficiency domestic appliances

# Unit 232 Building Services Pipework Systems

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 233 Building services engineering systems and their layout requirements

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit Aim** | This unit will provide knowledge and understanding of the systems associated with plumbing in building services and their layout requirements. It covers the types of cold and hot water systems used in domestic buildings, the principles of central heating systems, types of sanitary pipework systems and sources of energy used in the building services industry. |

## Learning outcome

The learner will:

1. Understand types of cold water systems used in domestic buildings

## Assessment criteria

The learner can:

1.1 Outline the main requirements of current regulations and standards for domestic water supply
1.2 Explain the importance of complying with the regulations and standards
1.3 Describe the requirements of the pipework system between the water main and the main internal stop valve in a domestic building
1.4 Explain the importance of correct water pressure
1.5 Describe the types of cold water systems used in domestic plumbing and their benefits/limitations
1.6 Interpret layout diagrams of cold water systems
1.7 Explain the causes of backflow in cold water systems

## Range

AC1.3 Pipework system:

- Connection to the main
- Communication pipe
- Service pipe
- Main external stop valve
- Meter and meter housing
- Below ground level pipework

AC1.5, 1.6 Types of systems

- Direct
- Indirect

---

## Learning outcome

The learner will:

2 Understand types of hot water systems used in domestic buildings

## Assessment criteria

The learner can:

2.1 Explain the factors that affect the selection of hot water systems
2.2 Describe the types of hot water systems used in domestic plumbing and their benefits/limitations
2.3 Interpret layout diagrams of hot water systems
2.4 Describe the purpose of pipes used in open vented hot water systems
2.5 Explain the causes of backflow in hot water systems

---

## Range

AC2.1 Factors:

- Type of building or property
- Amount of hot water needed
- Distance from hot water source to outlet
- Whether or not a secondary recirculation system is needed
- Safety issues
- Regulations and standards
- Guidance and instructions from manufacturers

AC2.2, 2.3 Types of systems

- Direct
  - Conventional boiler
  - Immersion heater
- Indirect
- Instantaneous water heaters
  - Combination boilers
  - Multipoint heaters
- Vented heaters

AC2.4 Pipes

- Vent pipe
- Cold feed pipe

---

## Learning outcome

The learner will:

3 Understand the principles of central heating systems

## Assessment criteria

The learner can:

3.1 Identify the layouts of central heating systems
3.2 Describe the operation of central heating systems
3.3 Describe the operation and requirements of gas-fired boilers
3.4 Describe the operation of flues

---

## Range

AC3.1-3.2 Central heating systems

- Open vented systems
  - Gravity fed
  - Fully pumped
- Sealed systems
  - Fully pumped
  - Combination boilers

AC3.3-3.4 Boilers

- Combi
- Condensing
- System

---

## Learning outcome

The learner will:

4 Understand types of sanitary pipework systems

## Assessment criteria

The learner can:

4.1 Describe the operation and applications of sanitary pipework systems
4.2 Explain the implications of trap seal loss
4.3 Describe the system layout features for the wet portion of the discharge stacks
4.4 Describe the system layout features for branch discharge pipework

## Range

AC4.1 Types of system

- Ventilated stack systems
    - Primary
    - Secondary
- Ventilated branch discharge system

AC4.3 System layout features

- Size of soil stacks
- Size of waste stacks
- Type and location of bends
- Proximity of low level connections
- Minimum distances from the invert level of the drain to the lowest appliances

AC4.4 System layout features

- Maximum lengths and gradients of pipes
- Sizes of soil and waste branch discharge pipes
- Use of traps and self-sealing valves
- Ventilation of branch discharge pipes
- Connection of multiple waste appliances to branch discharge pipes
- Connection of branch discharge pipes into the main stack

## Learning outcome

The learner will:

5 Understand energy sources used in the building services industry

## Assessment criteria

The learner can:

5.1 Describe types of energy sources

5.2 Explain the benefits and limitations of low and zero carbon energy sources

## Range

AC5.1 Energy sources

- High carbon
    - Electricity generated from non-renewable sources
- Low carbon
    - Biomass
    - Fuel cells
    - Heat pumps
- Zero carbon

- Solar (thermal, photovoltaic)
- Wind
- Hydroelectric
- Tidal

# Unit 233 Building services engineering systems and their layout requirements

## Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

Learning Outcome 1 AC1.1
Learners should know the main requirements of current regulations and standards for domestic water supply including

- Water Supply Regulations
- BS 8558 Water use in domestic buildings
- BS EN 806 Specifications for installations inside buildings conveying water for human consumption.

# Unit 234 Installation and Servicing of Refrigeration Equipment

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit Aim** | This unit introduces knowledge specific to the refrigeration, air-conditioning and heat pump systems (RACHP) sector, focusing on refrigeration. Learners will develop an understanding of some of the key principles underlying refrigeration, the system controls, how refrigeration systems are installed (including safety considerations), and how refrigeration systems are serviced. |

## Learning outcome

The learner will:

1 Understand the principles of thermodynamics

## Assessment criteria

The learner can

1.1 Convert values between temperature scales
1.2 Define the laws of thermodynamics
1.3 Describe the concept of heat as energy in transition
1.4 Describe how heat is transferred
1.5 Describe latent heat processes
1.6 Describe sensible heat processes
1.7 Calculate the rate of heat transfer
1.8 Explain the implications of the ideal gas laws
1.9 Describe the impact of changing pressures on saturation temperatures for different substances
1.10 Explain the vapour compression cycle in single stage refrigeration
1.11 Determine variables using a pressure-enthalpy diagram

## Range

AC1.1 Temperature scales

- Celsius
- Kelvin

AC1.2 Laws of thermodynamics

- First law
- Second law

AC1.4 Heat transfer mechanisms

- Conduction
- Convection
- Radiation

AC1.5 Latent heat processes

- Melting (fusion)
- Freezing
- Sublimation
- Condensation
- Evaporation
- Boiling

AC1.6 Sensible heat processes

- Super heating
- Sub-cooling
- Cooling
- Heating

AC1.7 Calculations

- Q=mCt
- Q=mL
- Q/s=W

AC1.8 Ideal gas laws

- Boyle’s law
- Charles’ law
- Combined gas law

AC1.9 Range of substances

- Water
- Refrigerants

AC1.10 Refrigeration cycle

Functions of the compressor, condenser, expansion device, and evaporator

AC1.11 Variables

- Work done
- Refrigeration effect
- Total heat rejected

- Coefficient of performance
- Mass flow rate
- Pressure ratio
- Compressor power input
- Specific volume at suction
- Cooling capacity
- Heating capacity

---

## Learning outcome

The learner will:

2 Understand the operating principles and controls for refrigeration systems

## Assessment criteria

The learner can:

2.1 Describe the operating principles of refrigeration systems and their application
2.2 Describe the range of refrigeration systems in common use
2.3 Describe the operating principles of the system controls
2.4 Describe the operating principles for defrost systems
2.5 Describe control circuits used for refrigeration systems

---

## Range

AC2.1 Operating principles

- Temperature difference
- Defrost methods
- System controls
- 1st and 2nd law of thermodynamics

Applications

- Blast freezing
- Cold storage
- Chill storage
- Liquid chillers

AC2.2 Types of refrigeration system

- Domestic
- Commercial
- Industrial

AC2.3 Operating principles

- Electro-mechanical
- Electrical

Controls

- Pressure
- Temperature
- Time

AC2.4 Defrost systems

- Off cycle
- Electric
- Hot gas
- Saturated gas

## Learning outcome

The learner will:

3 Understand the principles of installing refrigeration systems

## Assessment criteria

The learner can:

3.1 Describe the information required to plan the activities
3.2 Describe the roles and responsibilities of persons involved in installation
3.3 Explain the safety considerations required for the installation
3.4 Identify the services required for the installation
3.5 Describe the methods used to form and join pipework
3.6 Describe methods of applying insulation to pipework systems
3.7 Describe methods of fixing and terminating different types of cabling
3.8 Identify test instruments and state their purpose
3.9 Describe how installation activities are documented

## Range

AC3.1 Required information

- Regulatory documents
- Industry codes of practice
- Manufacturers' instructions
- Installation specifications
- Design drawings for the installation

AC3.2 Roles

- Self
- Colleagues
- Supervisor
- Client
- General public
- Health and safety officer

AC3.3 Safety considerations

- Risk assessment: hazards, risks, control measures
- Method statement
- Permit to work
- Safe isolation of equipment
- Ventilation
- Personal protective equipment (PPE)

AC3.4 Services

- Electricity
- Water
- Drainage
- Ventilation
- Gas

AC3.5 Methods of forming pipework

- Bend
- Flare
- Swage

Methods of joining pipework

- Brazing
- Mechanical and compression joints

AC3.6 Methods of insulating pipework

- Pre-insulated
- Cut and glue
- Continuous
- Mitred
- Insulated tape

AC3.7 Types of cabling

- Multi-core flex
- Steel wire armoured
- Single conductor
- Twin and earth
- Braided sheath cable
- Screened

Termination methods

- Insulated crimps
- Non-insulated crimps

AC3.8 Test instruments

- Pressure gauges
- Service manifolds
- Thermometers
- Anemometers
- Sling psychrometers
- Hydrometers
- Scales
- Leak detectors
- Multimeter
- Ammeter
- Voltmeter
- Ohm meter
- Capacitance tester
- Eyes/visual inspection

AC3.9 Documentation

- Job sheet/card
- Commissioning sheet
- F gas records

---

## Learning outcome

The learner will:

4 Understand the principles of maintaining and servicing refrigeration systems

## Assessment criteria

The learner can:

4.1 Describe maintenance requirements for refrigeration systems

4.2 Identify sources of information which aid service and maintenance of refrigeration systems

4.3 Identify faults resulting from the failure of components and their symptoms

4.4 Describe how maintenance and servicing activities are reported

---

## Range

AC4.1 Maintenance requirements

- Preventative maintenance: cleaning, component replacement, leak testing, visual inspection
- Servicing: cleaning, component replacement, calibration, adjustment, testing
- Reactive maintenance

AC4.2 Sources of information

- Service reports and test certificates
- Operations manuals
- Log books

- Customer feedback
- Sensory data

AC4.3 Components:

- Compressors
- Condensers
- Evaporators
- Expansion devices
- Storage vessels
- Valves
- Fans
- Ancillary components: line driers, strainers, oil separators

# Unit 234 Installation and Servicing of Refrigeration Equipment

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 235 Installation and Servicing of Air-Conditioning Equipment

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit Aim** | This unit introduces knowledge specific to the refrigeration, air-conditioning and heat pump systems (RACHP) sector, focusing on air conditioning. Learners will develop an understanding of some of the key principles underlying air-conditioning, the system controls, how air-conditioning systems are installed (including safety considerations), and how air-conditioning systems are serviced. |

## Learning outcome

The learner will:

1 Understand the principles of thermodynamics

## Assessment criteria

The learner can:

1.1 Convert values between temperature scales
1.2 Define the laws of thermodynamics
1.3 Describe the concept of heat as energy in transition
1.4 Describe how heat is transferred
1.5 Describe latent heat processes
1.6 Describe sensible heat processes
1.7 Calculate the rate of heat transfer
1.8 Explain the implications of the ideal gas laws
1.9 Describe the impact of changing pressures on saturation temperatures for different substances
1.10 Explain the vapour compression cycle in single stage refrigeration
1.11 Determine variables using a pressure-enthalpy diagram

## Range

AC1.1 Temperature scales

- Celsius
- Kelvin

AC1.2 Laws of thermodynamics

- First law
- Second law

AC1.4 Heat transfer mechanisms

- Conduction
- Convection
- Radiation

AC1.5 Latent heat processes

- Melting (fusion)
- Freezing
- Sublimation
- Condensation
- Evaporation
- Boiling

AC1.6 Sensible heat processes

- Super heating
- Sub-cooling
- Cooling
- Heating

AC1.7 Calculations

- Q=mCt
- Q=mL
- Q/s=W

AC1.8 Gas laws

- Boyle’s law
- Charles’ law
- Combined gas law

AC1.9 substances

- Water
- Refrigerants

AC1.10 Refrigeration cycle

Functions of the compressor, condenser, expansion device, and evaporator.

AC1.11 Variables

- Work done
- Refrigeration effect
- Total heat rejected
- Coefficient of performance

- Mass flow rate
- Pressure ratio
- Compressor power input
- Specific volume at suction
- Cooling capacity
- Heating capacity

---

## Learning outcome

The learner will:

2 Understand the operating principles and controls for air-conditioning systems

## Assessment criteria

The learner can:

2.1 Describe the operating principles of air-conditioning systems and their application
2.2 Describe the range of air conditioning systems in common use
2.3 Describe the effect of air conditioning on its moisture content
2.4 Describe the operating principles of the system controls
2.5 Describe control circuits used for air-conditioning systems

---

## Range

AC2.1 Operating principles

- Temperature difference
- Airflow
- System controls
- 1st and 2nd law of thermodynamics

Applications

- Air conditioning
- Dehumidifiers

AC2.2 Systems

- Human comfort cooling/heating
- Close control
- Data system cooling
- De-humidification

AC2.4 Operating principles

- Electro-mechanical
- Electrical

Controls

- Pressure
- Temperature (for cooling, for heating)
- Time

## Learning outcome

The learner will:

3 Understand the principles of installing air-conditioning systems

## Assessment criteria

The learner can:

3.1 Describe the information required to plan the activities
3.2 Describe the roles and responsibilities of persons involved in installation
3.3 Explain the safety considerations required for the installation
3.4 Identify the services required for the installation
3.5 Describe the methods used to form and join pipework
3.6 Describe methods of applying insulation to pipework systems
3.7 Describe methods of fixing and terminating different types of cabling
3.8 Identify test instruments and state their purpose
3.9 Describe how installation activities are documented

## Range

AC3.1 Required information

- Regulatory documents
- Industry codes of practice
- Manufacturers' instructions
- Installation specifications
- Design drawings for the installation

AC3.2 Roles

- Self
- Colleagues
- Supervisor
- Client
- General public
- Health and safety officer

AC3.3 Safety considerations

- Risk assessment: hazards, risks, control measures
- Method statement
- Permit to work
- Safe isolation of equipment
- Ventilation

- Personal protective equipment (PPE)

AC3.4 Services

- Electricity
- Water
- Drainage
- Ventilation
- Gas

AC3.5 Methods of forming pipework

- Bend
- Flare
- Swage

Methods of joining pipework

- Brazing
- Mechanical and compression joints

AC3.6 Methods of insulating pipework

- Pre-insulated
- Cut and glue
- Continuous
- Mitred
- Insulated tape

AC3.7 Types of cabling

- Multi-core flex
- Steel wire armoured
- Single conductor
- Twin and earth
- Braided sheath cable
- Screened

Termination methods

- Insulated crimps
- Non-insulated crimps

AC3.8 Test instruments

- Pressure gauges
- Service manifolds
- Thermometers
- Anemometers
- Sling psychrometers
- Hydrometers
- Scales

- Leak detectors
- Multimeter
- Ammeter
- Voltmeter
- Ohm meter
- Capacitance tester
- Eyes/visual inspection

AC3.9 Documentation

- Job sheet/card
- Commissioning sheet
- F gas records

## Learning outcome

The learner will:

4 Understand the principles of maintaining and servicing air-conditioning systems

## Assessment criteria

The learner can:

4.1 Describe maintenance requirements for air-conditioning systems

4.2 Identify sources of information which aid service and maintenance of air-conditioning systems

4.3 Identify faults resulting from failure of components and their symptoms

4.4 Describe how maintenance and servicing activities are reported

## Range

AC4.1 Maintenance requirements

- Preventative maintenance: cleaning, component replacement, leak testing, visual inspection
- Servicing: cleaning, component replacement, calibration, adjustment, testing
- Reactive maintenance

AC4.2 Sources of information

- Service reports and test certificates
- Operations manuals
- Log books
- Customer feedback
- Sensory data

AC4.3 Components

- Compressors
- Condensers

- Evaporators
- Expansion devices
- Storage vessels
- Valves
- Fans
- Ancillary components: line driers, strainers, oil separators

# Unit 235 Installation and Servicing of Air-Conditioning Equipment

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 236 Design of Security Systems

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit Aim** | This unit introduces knowledge specific to the design of security systems. Learners will develop an initial understanding of different types of security system, their wiring and transmission paths, the installation of components and how systems are tested. |

## Learning outcome

The learner will:

1 Understand types of security systems

## Assessment criteria

The learner can:

1.1 Describe security systems and their applications
1.2 Describe the operating principles of access control systems relating to the functional system elements
1.3 Describe the methods used for access control
1.4 Describe formats used for detection in alarm systems
1.5 Explain the applications of CCTV

## Range

AC1.1 Security systems

- Access control
- Intruder alarm
- Hold up alarm
- Closed circuit television (CCTV)
- Fire detection and alarm systems

AC1.2 Elements

- Door controller
- Reader interface
- Administration reader
- Administration pc/server

AC1.3 Methods of access control

- Proximity
- Smart card
- Magnetic strip
- Bar code
- Biometric types: fingerprint, voice, retina

AC1.4 Formats used for detection

- Fixed
- Moveable
- Trap
- Perimeter

AC1.5 Applications

- Private property
- Retail business
- Office premises
- Transport authorities
- Public places
- Events
- Perimeter surveillance

---

## Learning outcome

The learner will:

2 Understand circuit wiring and transmission paths

## Assessment criteria

The learner can:

2.1 Explain the information needed about the site to support system design
2.2 Explain the requirement for primary and secondary power supplies
2.3 Describe the operation of power supplies
2.4 Describe the transmission of power in a security system
2.5 Explain the difference between bonding and earthing
2.6 State the practical applications of different cable types including limitations on their use
2.7 Describe methods for overcoming the problems of induced noise (rfi/emi) in system cables
2.8 Explain the advantages and disadvantages of linking system components to the system using different transmission methods
2.9 Describe methods for cable fixing and containment

## Range

AC2.1 Information

- Site survey
- Site/building plans
- Specification documents

AC2.3 Power supplies

- Full wave
- Rectification
- Smoothing
- Switched mode
- Constant current

AC2.4 Power transmission

- Voltage regulators
- Mains suppression filters
- Safety earth
- Functional earth

AC2.6 Cable types

- Thermoplastic or thermosetting insulated (non-sheathed)
- Flat multicore thermoplastic or thermosetting insulated and sheathed
- Mineral insulated copper conductors and sheath
- Multi-core thermoplastic (pvc)
- Data/communication cables
- Pvc single wire armoured
- Co-axial
- Twisted pair
- Fibre optic
- HDMI

AC2.7 Methods for overcoming noise

- Cable routing and installation
- Use of shielded cable
- Use of twisted pair cable
- Correctly configured functional earthing
- Avoidance of ground loops

AC2.8 Transmission methods

- Direct: hardwired, USB connection
- Ethernet
- Wifi/wireless connection
- Modems (GPRS, PSTN, GSM)

- Radio (RF)
- Integration with smart devices

## Learning outcome

The learner will:

3 Understand the design considerations of security systems

## Assessment criteria

The learner can:

3.1 State the basic principles of shock protection, circuit overload and short-circuit protection
3.2 State the function of circuit protection devices
3.3 Describe how a self-latching relay can be used as a means of switching higher currents
3.4 Describe the operating principles of the lock types used in access control systems
3.5 Describe the purpose of detection devices in an alarm system and their output characteristics
3.6 Explain the purpose of detection methods in an alarm system
3.7 Identify the purpose of control and indicating equipment (CIE) in an alarm system
3.8 Explain the requirements of standards and building regulations for the location of the CIE
3.9 State the influence of legislation, standards and regulatory bodies on CCTV
3.10 Explain the function of the main system elements of a CCTV system
3.11 Describe the operating principles, location and siting for the sensors used in fire detection systems
3.12 Describe the operating principles of common alarm output devices

## Range

AC3.2 Protection devices

- In-line fuses
- On-board self-resetting protection devices
- Suppression diodes
- Metal oxide varistor (MOV)

AC3.4 Lock types

- Maglock
- Shear mag
- Electric strike
- Shoot bolt
- Rim latch
- Solenoid handle lock
- Motorised lock

AC3.5 Detection devices

- Foil on glass
- Closed circuit wiring
- Contacts: roller shutter, door and window
- Magnetically operated switches
- Mechanically operated switches

AC3.6 Detection methods

- Active movement detection
- Passive movement detection
- Acoustic vibration detection (glass break)
- Structural vibration detection (impact)

AC3.9 Legislation and regulatory bodies

- Human Rights Act
- Data Protection Act and GDPR
- The Freedom of Information Act
- BS EN 50132
- The Information Commissioners Office

AC3.10 System elements

- Camera and lens
- Housing
- Control/switching equipment
- Display equipment
- Recording equipment
- Transmission system
- Composite video signal
- Scene lighting

AC3.11 Sensor types

- Manual call point
- Automatic detectors: point type heat (fixed temperature and rate of rise)
- Linear heat sensing cable
- Point type smoke (ionisation and optical)
- Linear optical beam smoke
- Aspirating
- Video image processing
- Combustion gas (carbon monoxide)
- Flame (infra-red and ultra-violet)

AC3.12 Output devices

- Bells
- Beacons
- Electronic sounders and sirens

- Voice sounders
- Radio pagers
- Pillow alarms

## Learning outcome

The learner will:

4 Understand the testing requirements of security systems

## Assessment criteria

The learner can:

4.1 State the purpose of test equipment and its applications

4.2 Describe the techniques for testing movement detection

## Range

AC4.1 Test equipment

- Multimeter
- Insulation resistance tester
- Mains polarity tester
- Battery tester
- Network (ethernet) cable tester
- Oscilloscope

# Unit 236 Design of Security Systems

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

The focus of this unit is the design aspect of security systems including different types of security system, wiring and transmission paths, installation of components and system testing.

This links closely with unit 237 where the content is specific to the installation of security systems including site planning, safety considerations and installation procedures.
This unit could also be studied either after or concurrently with units 228 and 229, which cover electrical installation methods, circuit inspection and testing and fault diagnosis.

# Unit 237 Installation of Security Systems

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit Aim** | This unit introduces knowledge specific to the installation of security systems. Learners will develop an initial understanding of site planning requirements, safety considerations when installing a system, installation procedures and handover procedures. |

## Learning outcome

The learner will:

1 Understand site planning for a security system

## Assessment criteria

The learner can:

1.1 Describe the information needed prior to starting installation
1.2 Calculate dimensions and measurements from scaled drawings and diagrams
1.3 Interpret schematic diagrams of security systems
1.4 Identify electro technical symbols from working drawings and specifications
1.5 Identify services which may be required for the installation

## Range

AC1.1 Information

- Manufacturers' instructions
- Installation specification documents
- Site/building plans
- Design drawings for the installation
- Schematic diagrams
- Permits to work
- Job cards

AC1.5 Services

- Electricity
- Water
- Drainage

- Ventilation
- Gas

## Learning outcome

The learner will:

2 Understand safety considerations for installation

## Assessment criteria

The learner can:

2.1 Describe the main stages of the risk assessment process
2.2 Explain the purpose of a method statement and permit to work
2.3 Identify types of electrical supply systems and their features
2.4 State the risks of electric shock when using extension leads and electrical tools/equipment
2.5 Describe the basic principles of shock protection, circuit overload and short-circuit protection
2.6 Describe methods of verifying and securing (locking off) isolation
2.7 Describe safety precautions for working at heights
2.8 Describe safety considerations and precautions for lifting and handling
2.9 Describe procedures for safe storage of tools and equipment
2.10 Describe how to dispose of waste appropriately

## Range

AC2.1 Stages of risk assessment

- Hazards
- Risks
- Control measures

## Learning outcome

The learner will:

3 Know methods of installing security systems

## Assessment criteria

The learner can:

3.1 Identify cable types and their applications
3.2 Describe methods of terminating cables
3.3 Describe methods for cable fixing and containment

3.4 State the requirements for installing wiring complete with specified mechanical protection between the control and indicating equipment (CIE) position and the point of detection

3.5 Identify the tools and fixings required to locate, install and connect enclosures and equipment to various types of surface

3.6 Describe the methods of installing different sensor devices

3.7 Describe the methods of installing and protecting closed circuit wiring

3.8 Describe the methods of restoring building fabric on completion of installation

## Range

AC3.1 Cable types

- Thermoplastic or thermosetting insulated (non-sheathed)
- Flat multicore thermoplastic or thermosetting insulated and sheathed
- Mineral insulated copper conductors and sheath.
- Multi-core thermoplastic (PVC)
- Data/communication cables
- PVC single wire armoured
- Co-axial
- Twisted pair
- Fibre optic

AC3.2 Termination methods

- Insulated crimps
- Non-insulated crimps

AC3.3 Containment

- Trunking
- Cable basket work
- Conduit

AC3.5 Surface types

- Wood
- Brick
- Plastic
- Plastic board
- Concrete

AC3.6 Sensors

- Surface mounted contacts on windows and doors including positioning
- Metal foil and take off blocks on glass including the types of interconnection used
- Movement detection sensors including testing

AC3.7 Methods of installing including

- Attaching directly to the surface

- Protection from mechanical damage by hardboard, plywood and metal sheet covering

## Learning outcome

The learner will:

4 Understand procedures for commissioning and handover

## Assessment criteria

The learner can:

4.1 List the typical documentation required to perform system commissioning and system handover

4.2 State the stages and tests involved in electrical installation testing

4.3 Identify test instruments and their purpose

4.4 Describe the procedures for demonstrating and handing over a system to a customer

## Range

AC4.2 Stages and tests

Dead testing (supply not connected)

- Continuity of protective conductors including main and supplementary equipotential bonding
- Continuity of ring final circuit conductors
- Insulation resistance
- Protection by SELV, PELV or electrical separation
- Basic protection by a barrier or enclosure provided during erection
- Insulation resistance/impedance of floors and walls
- Polarity
- Earth electrode resistance

Live testing (supply connected)

- Protection by automatic disconnection of the supply
- Earth fault loop impedance
- Additional protection
- Prospective fault current
- Check of phase sequence
- Functional testing
- Verification of voltage drop

AC4.3 Test instruments

- Multimeter
- Insulation resistance tester
- Mains polarity tester
- Battery tester
- network (Ethernet) cable tester

- Oscilloscope

# Unit 237 Installation of Security Systems

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

The focus of this unit is the installation of security systems including site planning, safety considerations, methods of installation, handover and commissioning procedures.

This links closely with unit 236 where the content is specific to the design aspect of security systems including different types of security system, wiring and transmission paths, installation of components and system testing.

This unit could also be studied either after or concurrently with units 228 and 229, which cover electrical installation methods, circuit inspection and testing and fault diagnosis.

# Unit 238 Project Management in Engineering

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit aim:** | Project management is the skill of being able to plan, co-ordinate and control the tasks involved in turning an idea or activity into a required outcome.<br><br>In this unit learners will understand why project management is important and develop knowledge and understanding of how to plan, monitor and control projects. |

## Learning outcome

The learner will:

1 Understand the importance of project management

## Assessment criteria

The learner can:

1.1 Explain the principles of project management

1.2 Explain the benefits of project management

## Range

AC1.1 Principles

- Defined objectives
- Identification of constraints and resources
- Defined roles and responsibilities
- Resource management
- Management by stages/task
- Management by exception/addressing deviations from plan
- Risk management

AC1.2 Benefits

- Completion on schedule
- Compliance with the requirements of the initial brief
- Efficiency of resource use
- Customer satisfaction
- Improved risk assessment
- Learning from experience
- Development of staff in the project team

## Learning outcome

The learner will:

2 Understand how to plan, monitor and review a project

## Assessment criteria

The learner can:

2.1 Explain the potential constraints to a project
2.2 State the types of resources needed to carry out a project
2.3 Describe the roles and responsibilities within projects
2.4 Explain the methods used to plan projects and their advantages and disadvantages
2.5 Explain risks associated with project management and risk mitigation actions
2.6 Describe methods of monitoring projects
2.7 Explain the reasons for reviewing projects on completion

## Range

AC2.1 Constraints

- Time
- Money
- Materials
- Tools and processes
- Personnel
- Authority
- Competition for resources

AC2.2 Resources

- Time
- Money
- Materials
- Tools and processes
- Personnel

AC2.3 Roles & responsibilities

- Project manager
- Specialist knowledge from different areas of the organisation

AC2.4 Planning methods

- Gantt charts
- Critical path analysis
- Budget planning and control

AC2.5 Risks

- Unrealistic time and cost estimates
- Unexpected costs
- Changing requirements
- Equipment failure/breakdowns
- Safety issues
- Inadequate communication
- Inadequate project management
- Contingency planning

AC2.6 Monitoring methods

- Monitoring of task completion
- Progress reports
- Budget monitoring reports
- Rescheduling uncompleted tasks

AC2.7 Project reviewing

- Compare outcomes against original objectives
- Identify areas for improvement
- Learn from experience
- Improve future projects
- To identify key resources for future projects

# Unit 238 Project Management in Engineering

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

This unit could be taught effectively using a variety of relevant case studies. Learners could also develop understanding by carrying out simulated projects.

# Unit 239 Applied Mathematics in Engineering

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 70 |
| **Unit aim:** | Engineers often use mathematical methods to calculate information needed to design effective products, manufacture parts, and solve engineering problems.<br><br>In this unit learners will apply mathematical principles of algebra, calculus, trigonometry and statistics to solve engineering problems. |

## Learning outcome

The learner will:

1 Apply principles of algebra to solve engineering problems

## Assessment criteria

The learner can:

1.1 Use equations to solve engineering problems requiring calculations

1.2 Manipulate equations and change the subject

1.3 Simplify equations and functions

## Range

AC1.1-AC1.3 Equations

- Compound areas made up of squares, rectangles, triangles, circles
- Volumes and mass of cuboids, cylinders, spheres, compound shapes
- Materials: (calculation of stress, strain, Young's modulus)
- Electrical systems, Ohm's law, electrical power, values of resistors in series and parallel

## Learning outcome

The learner will:

2 Apply principles of calculus and use graphs to solve engineering problems

## Assessment criteria

The learner can:

2.1 Interpret graphs used in engineering systems
2.2 Plot and use graphs to represent variables in engineering systems
2.3 Determine the equation of the relationship shown in a straight-line graph
2.4 Differentiate simple functions
2.5 Determine maximum and minimum values of functions using differentiation

---

## Range

AC2.1-AC2.2
Graphs showing straight line, trigonometrical and exponential relationships

AC2.3
$y = mx + c$

AC2.4-AC2.5
Limited to functions using addition, subtraction, division, multiplication and powers

---

## Learning outcome

The learner will:

3 Apply principles of trigonometry to solve engineering problems

## Assessment criteria

The learner can:

3.1 Apply trigonometric relationships to determine the dimensions in a triangle
3.2 Select and use appropriate principles of trigonometry to solve engineering problems
3.3 Convert between Cartesian and polar co-ordinates

## Range

AC3.1

Tangent, sine and cosine

AC3.2

Tangent, sine, cosine, cosecant, secant, cotangent

AC3.3

Cartesian (x,y) co-ordinates

Polar (r,Θ) co-ordinates where angles are in degrees

## Learning outcome

The learner will:

4 Apply statistics to solve engineering problems

## Assessment criteria

The learner can:

4.1 Determine averages and standard deviation for data sets

4.2 Explain how statistical data is used in quality control

4.3 Explain the benefits and limitations of using statistical process control, relative to quantity of parts being manufactured

## Range

AC4.1

Mean, median and modal averages, cumulative frequency and standard deviation

AC4.2-AC4.3

Statistical process control

Nominal values, upper and lower action (warning) limits, upper and lower control limits

# Unit 239 Applied Mathematics in Engineering

Supporting Information

## *Unit guidance*

Centres may provide a formula sheet to support the assessment for this unit.

# Unit 240 Leading an Engineering Team

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | In this unit, learners will develop an understanding of the approaches used in leading a team and the roles of team members. They will also understand the importance of effective communication and conflict resolution. |

## Learning outcome

The learner will:

1 Understand approaches to leading a team

## Assessment criteria

The learner can:

1.1 Describe the roles and responsibilities of a team leader
1.2 Explain different leadership styles and their advantages and disadvantages
1.3 Explain the different roles that exist within a team
1.4 Explain how to work effectively within a team

## Range

AC1.1 Roles and responsibilities

- Setting objectives
- Resource allocation
- Managing workloads
- Motivating staff
- Conflict resolution
- Monitoring performance
- Communication
- Problem solving
- Meeting health and safety requirements

AC1.2 Leadership styles

- Autocratic
- Participative
- Delegative

AC1.3 Team roles as defined by Belbin

- Co-ordinator
- Shaper
- Completer/finisher
- Implementer
- Monitor evaluator
- Plant
- Resource investigator
- Specialist
- Team worker

AC 1.4 Work effectively

- Personal development
- Participation in group discussions and decision making
- Suggesting solutions to problems
- How to give and receive constructive criticism
- When to be assertive
- Respond to feedback from others
- Time management

## Learning outcome

The learner will:

2 Understand types of communication used in engineering businesses

## Assessment criteria

The learner can:

2.1 Explain the principles of communication
2.2 Describe types of business documentation and their typical uses
2.3 Describe types of ICT applications

## Range

AC2.1 Principles of communication

- Two-way process
- Types of communication (oral, written, non-verbal)
- Formal/informal

AC2.2 Types of business documentation

- Gantt charts
- Bill of Materials (BoM)
- Technical Reports

- Job cards
- Risk assessments
- Emails

AC2.3 ICT applications

- Word processing
- Spreadsheets
- Databases
- Presentation
- CAD/CAM
- Mobile apps

---

## Learning outcome

The learner will:

3 Understand how to resolve problems and conflict in the workplace

## Assessment criteria

The learner can:

3.1 Explain the difference between the root cause and symptoms of a problem
3.2 Describe methods used to resolve problems and conflict
3.3 Explain the reasons for conflict in work situations and ways to avoid them

---

## Range

AC3.2 Methods

- Negotiation
- Persuasion
- Compromise
- Mediation
- Arbitration

AC3.3 Reasons for conflict

- Differences of opinion
- Unpopular team leader decisions
- Working within time constraints
- Team member aspirations and/or ambitions
- Individual skill levels
- Team member personalities

Avoid conflict situations by:

- Enquiring politely

- Timeliness when seeking advice or assistance
- Avoiding conflict and knowing when to withdraw from the situation
- Listening carefully
- Following reasonable requests from supervisors
- Offering help when colleagues are in need of assistance

# Unit 240 Leading an Engineering Team

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 241 Engineering Manufacturing Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | This unit will provide learners with an understanding of how to prepare for manufacturing operations processes, types of manufacturing operation and how these are monitored. They will also understand the factors that affect the efficiency of manufacturing. |

## Learning outcomes

The learner will:

1. Understand how to prepare for manufacturing operations

## Assessment criteria

The learner can:

1.1 Explain considerations for preparing and maintaining work areas
1.2 Describe checks required on receipt of materials
1.3 Describe methods of material handling
1.4 Describe safety factors when handling materials

## Range

AC1.1 Prepare and maintain work areas

- Health and safety requirements
  - Identify and check equipment prior to use
  - Housekeeping
  - Protecting others
- Identify and check availability of materials
- Waste disposal

AC1.2 Checks

- Materials are as specified on the documentation

- Materials are stored safely
- Materials are in a suitable condition

AC1.3 Methods to transfer materials

- Manual
- Hand operated e.g. pallet trucks, push conveyors
- Power operated e.g. power operated cranes, forklift trucks

AC1.4 Safety factors

- Manual handling methods and restrictions
- Load does not exceed the safe lifting capacity of the equipment
- Load is secure
- There are no restrictions or obstacles preventing handling of materials

---

## Learning outcome

The learner will:

2 Understand the principles of manufacturing operations

## Assessment criteria

The learner can:

2.1 Describe the types of manufacturing process
2.2 Describe the different scales of production
2.3 Describe the types of instructions used to undertake manufacturing operations
2.4 Describe ways of monitoring and controlling the manufacturing processes

---

## Range

AC2.1 Types

- Wasting
- Forming
- Shaping
- Additive
- Finishing
- Joining

AC2.2 Scales of production

- One off/prototype
- Batch
- Mass
- Continuous/flow

AC2.3 Instructions

- Job cards
- Engineering drawings
- Process planning documentation
- Manufacturers' instructions

AC2.4 Monitoring and controlling

- Quality of finished product
- Dimensional accuracy
- Raw material use
- Consumable material use
- Machinery condition
- Equipment or tool condition
- Output/production targets

## Learning outcome

The learner will:

3 Understand factors that affect the efficiency of manufacturing

## Assessment criteria

The learner can:

3.1 Describe the "Eight Wastes" that affect manufacturing
3.2 Describe methods of minimising the "Eight Wastes"
3.3 Explain manufacturing issues and ways in which they may be minimised

## Range

AC3.1 Eight wastes

- Defects
- Overproduction
- Waiting
- Motion
- Transporting
- Extra-processing
- Inventory
- Untapped human potential

AC3.3 Issues

- Productivity
- Material faults
- Material use
- Operation safety
- Quality of product
- Shortages

# Unit 241 Engineering Manufacturing Techniques

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 242 Engineering Design Techniques

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | In this unit learners will learn about the factors that influence the design of new products. They will understand the key information included within design briefs and product design specifications and the stages that make up both linear and iterative approaches to designing products. Learners will understand strategies and techniques used to develop design solutions and how these are evaluated. |

## Learning Outcome

The learner will:

1. Understand the factors that affect the development of a product design specification (PDS)

## Assessment Criteria

The learner can:

1.1 Describe the information included in a design brief

1.2 Describe factors that influence new designs

1.3 Describe the stages of the linear design process

1.4 Describe the stages of the iterative design process

1.5 Describe the information included in a PDS

## Range

AC1.1 Information in a design brief

- Purpose of the product
- User/client
- Constraints (manufacturing methods, functional properties)
- User wants (material, size, weight, shape)
- Quantity to be produced
- Environmental impact
- Cost

AC1.2 Factors

- Market pull
- Technology push
- Changes in legislation and standards
- Sustainability
- Avoiding design fixation

AC1.3 Stages of the linear design process

- Analyse brief
- Research
- Specification
- Ideas generation
- Ideas development
- Production planning
- Production
- Testing
- Evaluation

AC1.4 Stages of the iterative design process

- Modelling and prototyping
- Testing
- Evaluating
- Refining/creating a new iteration
- Repeating stages in a cyclical process

AC1.5 Information included in a PDS

- Product function
- Size, weight, physical dimensions
- Environmental factors
- Costs
- Health & Safety requirements
- Maintenance requirements
- Aesthetics
- Ergonomics
- Relevant industry standards
- Materials
- Manufacturing methods
- Sustainability requirements

## Learning outcome

The learner will:

2. Understand strategies and techniques used to develop design solutions

## Assessment criteria

The learner can:

2.1 Describe the characteristics and applications of different design strategies
2.2 Explain how ergonomics influence the design of products
2.3 Explain modelling techniques and their benefits/limitations

## Range

AC2.1 Design strategies

- User-centred design (UCD)
- Inclusive design
- Systems approach
- Collaborative design

AC2.3 Modelling techniques

- Virtual modelling
- Block modelling
- Rapid prototyping
- Using modular kits
- Breadboarding – electrical circuits

## Learning outcome

The learner will:

3. Understand the factors that affect the evaluation of a product design

## Assessment criteria

The learner can:

3.1 Describe techniques used to evaluate designs
3.2 Explain the considerations when evaluating a final design from proposals

## Range

AC3.1 Techniques

- Feasibility study
- Design matrix
- Market research
- Product analysis
- Comparison with brief and specification

AC3.2 Considerations

- Product design specification
- Cost
- Quality requirements
- Availability of materials
- Manufacturing processes
- Environmental impact

# Unit 242 Engineering Design Techniques

Supporting Information

### *Unit guidance*

This unit should be delivered within a classroom/training environment. Learners could be given access to case studies of existing products to analyse how they were designed and the approaches/strategies used.

# Unit 243 Marketing Engineered Products

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 50 |
| **Unit aim:** | In this unit the learners will understand the principles of marketing, the main considerations when marketing an engineered product and method of communicating with potential customers. |

## Learning Outcome

The learner will:

1. Understand the principles of marketing

## Assessment Criteria

The learner can:

1.1 Explain the difference between marketing and sales
1.2 Explain what is meant by a “market” and “market segments”
1.3 Explain the basic concept of marketing
1.4 State the advantages and disadvantages of establishing a brand identity
1.5 Explain how the 5Cs of marketing influence the marketing of products

## Range

AC 1.3 Concept

- Message
- Branding
- Position

AC 1.5 The 5C’s

- Company
- Customers
- Competitors
- Collaborators
- Climate

## Learning outcome

The learner will:

2. Understand the marketing process for an engineered product

## Assessment criteria

The learner can:

2.1 Explain the reasons for developing a new product
2.2 Describe what is meant by a unique selling proposition (USP)
2.3 Explain the stages of a product lifecycle and their effect on marketing
2.4 Describe the key considerations in a marketing plan

## Range

AC2.1 Reasons for new product

- Profit
- Technology push
- Market pull
- Changes to legislation and standards

AC2.3 Stages of a product lifecycle

- Introduction
- Growth
- Maturity
- Decline

AC2.4 Marketing plan: 7P's

- Product
- Price
- Promotion
- Place
- Positioning
- Packaging
- People

## Learning outcome

The learner will:

3. Understand marketing as a communication method

## Assessment criteria

The learner can:

3.1 Describe communication methods used for marketing

3.2 Describe types of marketing materials

---

## Range

AC3.1 Communication methods

- Word of mouth
- Print media
- Television and radio
- Trade shows
- Telesales
- Direct
- Social media
- Email/letters
- Meetings
- Websites

AC3.2 Materials

- Product data sheets
- Brochures
- Advertisements
- Mailshots
- Leaflets

---

# Unit 243 Marketing Engineered Products

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

This unit can be taught using a range of case studies of engineered products.

# Unit 244 Additive Manufacturing (3D Printing)

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 40 |
| **Unit aim:** | Additive manufacturing processes, such as 3D printing, are revolutionising how products are designed and manufactured. With the push of a button, anyone can make a physical prototype from a CAD model.<br><br>In this unit learners will understand the principles of additive manufacturing, the range of processes available and their advantages and limitations. In particular, they will develop knowledge and understanding of the operation of 3D printing. |

## Learning outcome:

The learner will:

1. Understand the principles of additive manufacturing

## Assessment criteria

The learner can:

1.1 Explain the difference between additive and subtractive approaches to manufacturing
1.2 Describe the method by which additive manufacturing processes make products
1.3 Describe different types of additive manufacturing processes
1.4 Explain the advantages and limitations of additive manufacturing

## Range

AC1.3 Types of additive manufacturing processes

- 3D printing/fused deposition modelling
- Selective laser sintering
- Stereolithography

AC1.4 Advantages and limitations relating to:

- Shape and internal geometry of the product
- Materials used
- Mechanical and physical properties
- Product dimensions
- Processing times

- Sustainability

## Learning outcome

The learner will:

2. Understand the set-up and operation of 3D printing

## Assessment criteria

The learner can:

2.1 Describe the main parts of a 3D printer and their functions
2.2 Describe the materials that can be used with a 3D printer
2.3 Explain the design limitations on the CAD model to be used for 3D printing
2.4 Explain the methods used to communicate a 3D CAD model to a 3D printer
2.5 Explain the safety considerations needed when 3D printing
2.6 Describe the manufacture of a product using a 3D printer
2.7 Explain the effect of the process parameters on the features and properties of the manufactured item
2.8 Explain defects that arise when 3D printing and how they may be resolved
2.9 Explain maintenance requirements for a 3D printer

## Range

AC2.1 Parts of a 3D printer

- Controller board
- Print head
- Stepper motors
- Threaded rod
- Belts
- End stops
- Power supply unit
- Print bed
- Feeder system
- Bed levelling system
- Filament
- Casing

AC2.2 Materials

- Polylactic acid (PLA)
- Acrylonitrile butadiene styrene (ABS)
- Polyamide (nylon)
- Glass filled polyamide

AC2.3 Design limitations

- Bridging
- Overhangs
- Need for support structures
- Infill density and form

AC2.4 Methods of communication

- .stl file
- USB cable
- SD card
- USB flash drive
- Ethernet

AC2.5 Safety considerations

- Fume and vapours
- Hot parts and components
- Entanglement in mechanical parts
- Use of a cabinet
- Electrical safety

AC2.7 Process parameters

- Layer thickness
- Build orientation
- Raster width
- Print speed

AC2.8 Defects

- Poor surface finish
- Layer misalignment
- Stringing (filaments bridging empty spaces)
- Warping
- Z-wobble
- Excessive base layer
- Product not attaching to print bed
- Voids
- Delaminations or separations in the surface

AC2.9 Maintenance

- Cleaning the nozzle
- Levelling and cleaning the print platform
- Preheating the bed and nozzle
- Checking that belts and screws are tight
- Lubrication requirements

# Unit 244 Additive Manufacturing (3D Printing)

Supporting Information

## *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

# Unit 245 Effective Working Practices in an Engineering Environment when Working on Military Vehicles and Equipment

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 30 |
| **Unit aim:** | This unit will provide the knowledge and understanding required to work on military vehicles and equipment. Learners will develop an understanding of how to plan and execute a variety of maintenance tasks on military vehicles and equipment, drawing on a range of technical drawings and support documentation. |

## Learning outcome

The learner will:

1 Understand the procedures for carrying out an engineering activity on military vehicles and equipment.

## Assessment criteria

The learner can:

1.1 Describe task requirements for an engineering activity
1.2 Describe a works programme for specific tasks
1.3 Describe the procedure for completion of an engineering activity
1.4 Describe how to complete appropriate documentation to organisational requirements

## Range

AC1.1 Task requirements

- Identify sources of information
- Information from single or multiple sources
- Task details
- Task outputs

AC1.2 Works programme

- Identify key stages

- Produce a scope of works
- Identify quality control measures

  For engineering activities

## Learning outcome

The learner will:

2 Understand data used for engineering activities

## Assessment criteria

The learner can:

2.1 Describe sources of documentation and / or data to complete engineering tasks
2.2 Describe required documentation and / or data to meet task outputs
2.3 Describe how to use correct data for an engineering activity
2.4 Describe how to interpret engineering drawings
2.5 Identify technical support structure

## Range

AC2.1 Sources of documentation e.g.

- Army Equipment Support publications (AESP)
- Manufacturers publications
- Technical literature
- Drawings, sketches and components
- Written briefings
- Verbal briefings

AC2.4 Engineering drawings could include

- engineering drawing standards
- essential drawing information
  - Scales
  - Dimensions
  - Issue number
  - Tolerances
  - Symbols
  - Notes
  - Materials
  - Parts list
- different projection types
  - Oblique

    - Isometric
    - Orthographic
    - 1st angle
    - 3rd angle
- drawing layouts
    - Freehand sketches
    - Sectional view
    - Component drawings
    - Exploded views
    - General assembly
    - Schematic
- datums

---

## Learning outcome

The learner will:

3 Understand the importance of quality control

## Assessment criteria

The learner can:

3.1 Describe the procedures for record keeping
3.2 Describe the potential consequence of not following quality procedures
3.3 Identify the procedure for reporting faults

---

## Range

AC3.1 Record keeping procedures

- equipment documentation
    - Data recording and Corrective Action Systems
    - Job cards
    - Who can sign off lob cards as complete and to standard required
- user documentation and details required
    - Oil / lubricants used
    - Fuel consumption / drawn
    - Hours run

AC3.3 Fault reporting procedures

- Following organisation specific processes
- Using organisation specific forms

# Unit 245 Effective Working Practices in an Engineering Environment when Working on Military Vehicles and Equipment

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required.

Assessment of outcomes could be through presentation of documents used when carrying out tasks and by short written answers.

# Unit 246 Principles of Military Vehicle and Equipment Maintenance

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 60 |
| **Unit aim:** | This unit will provide the knowledge and understanding of the principles required to carry out maintenance on military vehicles and equipment. Learners will understand the types of maintenance and the reasons for them and they will learn how to prepare and carry out a maintenance activity safely |

## Learning outcome

The learner will:

1 Understand the different types of maintenance

## Assessment criteria

The learner can:

1.1 Explain the purpose of maintenance
1.2 Describe different types of maintenance
1.3 Describe types of routine maintenance
1.4 Explain time and usage maintenance
1.5 Explain special maintenance
1.6 Explain the Health and Safety considerations when planning and undertaking maintenance tasks on Military vehicles and equipment

## Range

AC1.1 Purpose of maintenance

- To rectify faults to return equipment to service
- To service components to prolong service life of equipment
- To prevent breakdowns

AC1.2 Types of maintenance

- Planned maintenance
- Reactive maintenance

AC1.3 Types of routine maintenance

- Pre and post use checks
- Planned or scheduled maintenance

AC1.4 Time and usage
- Hours run
- Time bound
- Operating environment

AC1.6 Health and Safety considerations
- COSHH
- Hydraulic pressure
- Manual handling
- Lifting equipment
- Other equipment fitted to vehicle

---

## Learning outcome

The learner will:

2 Understand the procedures for maintenance on military equipment in line with the technical literature available

## Assessment criteria

The learner can:

2.1 Describe how to prepare for maintenance activities
2.2 Describe how maintenance activities are undertaken
2.3 Describe how post maintenance functional tests are carried out
2.4 Describe the handover procedure following completion of maintenance activities

---

## Range

AC2.1 Preparation
- Establish resource requirements
- Conduct a risk assessment for task
- Establish a safe working area

AC2.3 Post maintenance functional tests to confirm functionality in line with technical literature
- Off load tests
- On load tests

## Learning outcome

The learner will:

3 Understand the procedure for removing and replacing components

## Assessment criteria

The learner can:

3.1 Describe the procedure for removing and replacing components

3.2 Explain the extent of own authority and reporting procedures for problems that cannot be resolved

## Range

AC3.1 Procedure

- Support publication requirements
- Manufacturers technical literature

# Unit 246 Principles of Military Vehicle and Equipment Maintenance

Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on engineering information such as engineering drawings and specifications from which learners can interpret the information presented and consider the appropriate tools, equipment and machinery required to create the components. Learners can then consider the operational requirements and processes to carry out the activities.

# Unit 247 Procedures and Processes for Fault Identification on Military Vehicles and Mechanical Systems

| | |
|---|---|
| **Unit level:** | Level 2 |
| **GLH:** | 70 |
| **Unit aim:** | This unit will provide the knowledge and understanding required to describe the major components of a military vehicle or system. Learners will be able to describe the purpose of major components and their function.<br>They will be able to identify faults on these components using a range of methods and information sources and identify how to rectify the fault and carry out functional tests before returning the equipment to service |

## Learning outcome

The learner will:

1 Understand the function of military vehicles and mechanical systems

## Assessment criteria

The learner can:

1.1 Describe the purpose of the main components of vehicle systems

1.2 Describe the operation of vehicle systems

## Range

AC1.1 Components/systems

- Power source
- Transmission
- Wheels
- Tracks
- Hydraulic systems
- Engine
- Cooling
- Steering system
- Braking system
- Electrical system

- Organisation specific equipment mounted on vehicle

AC1.2 Operation of vehicle systems

- Power source could include:
  - Petrol engine (Spark Ignition)
  - Diesel Engine (Compression Ignition)
- Transmission could include:
  - Mechanical
  - Hydraulic

---

## Learning outcome

The learner will:

2 Understand how to identify the symptoms of a fault

## Assessment criteria

The learner can:

2.1 Explain how sensory methods are used to identify faults
2.2 Describe the system instruments / gauges available to identify faults
2.3 Describe symptoms that indicate the system is faulty
2.4 Explain the process for identification and location of faults

---

## Range

AC2.1 Sensory methods

- Sight
- Touch
- Smell
- Sound

AC2.2 System instrument gauges

- Vehicle specific warning lamps
- Alarms and gauges
- Diagnostic equipment supplied with the vehicle (if applicable)

AC2.3 Symptoms

- Reduced performance
- Breakdown

AC2.4 Identification process

- User report
- Malfunction indicator lamp / alarm

- On board diagnostics
- Data link
- Sensory evidence
    - Visual
    - Sound
    - Smell

To include faults on one or more of the following components/systems:

- Engine
- Cooling
- Transmission
- Hydraulics
- Tracks
- Wheels
- Steering system
- Braking system
- Electrical system
- Organisation specific equipment mounted on vehicle

---

## Learning outcome

The learner will:

3 Understand procedures for rectifying / remedying faults

## Assessment criteria

The learner can:

3.1 Describe the procedures for rectifying / remedying faults
3.2 Describe the different levels of repair tasks as stipulated in the equipment supporting documentation
3.3 Explain who is authorised to carry out different levels of repair

---

## Range

AC3.2 Levels of repair tasks

- User maintenance / pre use checks e.g. lights, oil, fluid levels (level 1)
- Field Maintenance / repair (level 2)
- Workshop maintenance / repair (level 3)
- Base workshop repair (level 4)

## Learning outcome

The learner will:

4 Understand the process for testing / checking the function of equipment following repair

## Assessment criteria

The learner can:

4.1 Describe the process for testing / checking equipment for serviceability
4.2 Explain the extent of own authority and reporting procedures for problems that cannot be resolved
4.3 Identify functional test requirements to be carried out before handover in accordance with organisational procedures

# Unit 247 Procedures and Processes for Fault Identification on Military Vehicles and Mechanical Systems

## Supporting Information

### *Unit guidance*

This is a theory unit intended to underpin the development of practical skills. It can be delivered as part of an apprenticeship programme in the workshop through the completion of practical activities. The combination of theory and practice is more likely to reinforce the learning required.

It is recommended that learning is based on practical activities on vehicles or equipment where learners can use available information from a range of sources to identify faults and how to rectify them

# Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centre document library** on **www.cityandguilds.com** or click on the links below:

**Centre Handbook: Quality Assurance Standards**

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

**Centre Handbook: Quality Assurance Standards**

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

**Access arrangements: When and how applications need to be made to City & Guilds** provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **Centre document library** also contains useful information on such things as:

- conducting examinations
- registering learners
- appeals and malpractice.

**Useful contacts**

Please visit the Contact us section of the City & Guilds website, **Contact us**

## City & Guilds

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We partner with our customers to deliver work-based learning programmes that build competency to support better prospects for people, organisations and wider society. We create flexible learning pathways that support lifelong employability because we believe that people deserve the opportunity to (re)train and (re)learn again and again – gaining new skills at every stage of life, regardless of where they start.

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