

# City & Guilds Level 2 Diploma in Machining (Foundation Knowledge) (1272-02)

Version 2.3 (September 2024)

**Qualification Handbook**

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## Qualification at a glance

<b>Subject area</b>	Manufacturing technologies
<b>City &amp; Guilds number</b>	1272
<b>Age group</b>	16+
<b>Entry requirements</b>	Centres must ensure any pre-requisites stated in the Learner entry requirements section are met
<b>Assessment</b>	Multiple choice; short answer question papers
<b>Grading</b>	Pass/Merit/Distinction
<b>Approvals</b>	Full approval required
<b>Support materials</b>	Qualification handbook Assessor Assessment Pack Candidate Assessment pack
<b>Registration and certification</b>	Consult the Walled Garden/Online Catalogue for last dates

Title and level	City & Guilds qualification number	Regulatory reference number	GLH	TQT
City & Guilds Level 2 Diploma in Machining - (Foundation Knowledge)	1272-02	603/1705/X	360	500

Version and date	Change detail	Section
V 1.0 May 2017	Initial version	All
V2.0 August 2018	Grading information updated Minor formatting issues	Grading Throughout
V2.1 December 2019	Topic 3.1 information added to unit 207	Unit
V2.2 July 2022	Level 2 Diploma in Machining (Foundation Competence) amended to Level 2 Diploma in Machining (Foundation knowledge) Total Qualification Time section wording amended	Structure Total Qualification Time

V2.3 September 2024 Handbook reviewed and quality assurance, access and assessment arrangements updated Throughout

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# 1 Introduction

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

Area	Description
Who is the qualification for?	<p>This qualification is aimed at learners aged 16 and above who would like to gain the basic knowledge required during their initial training to become a Machinist (Advanced Manufacturing Engineering), as part of their Apprenticeship.</p> <p>A learner can also take this qualification as a stand-alone option if they are self-employed as a consultant or on short term contracts that do not support the apprenticeship.</p>
What does the qualification cover?	<p>Learners will develop knowledge of material properties and mathematical concepts needed to be an effective Machinist. They will also learn about how engineering businesses are organised and the business improvement techniques they use.</p> <p>They will learn how to carry out routine engineering workshop tasks and different manual and/or CNC machining operations.</p>
What opportunities for progression are there?	<p>Upon completion of this qualification learners will have developed most of the knowledge required during their foundation phase of the Apprenticeship and can progress to the Development phase.</p>
Who did we develop the qualification with?	<p>This qualification has been developed in collaboration with the Advanced Manufacturing Engineering (Machinist) Trailblazer Group.</p>
Is it part of an apprenticeship framework or initiative?	<p>Yes, this qualification has been developed to be included within the foundation phase of the new Apprenticeship Standard for Advanced Manufacturing Engineering (Machinist).</p>

## Structure

To achieve the City & Guilds Level 2 Diploma in Machining (Foundation Knowledge), learners must achieve

- mandatory unit 203
- mandatory assessment components 021 (Units 201 and 205) and 022 (Units 202 and 204) and
- two optional units from units 206-213.

### Barred combinations:

206 with either 207 or 208

210 with either 211 or 212

City & Guilds unit number	Unit title	GLH
<b>Mandatory units:</b>		
201	Working in an engineering environment	30
202	Engineering techniques	30
203	Engineering maths and science principles	90
204	Fitting and assembly techniques	60
205	Business improvement techniques	30
<b>Optional units:</b>		
206	Principles of milling and turning	90
207	Manual turning techniques	60
208	Manual milling techniques	60
209	Grinding techniques	60
210	Principles of Computer Numerical Control (CNC) machining	90
211	Computer Numerical Control (CNC) turning techniques	60
212	Computer Numerical Control (CNC) milling techniques	60
213	Computer Aided Design (CAD)	60

## Total Qualification Time

Total Qualification Time (TQT) is the number of notional hours which represents an estimate of the total amount of time that could reasonably be expected for a learner to demonstrate the achievement of the level of attainment necessary for the award of a qualification.

TQT is comprised of the following two elements:

- the number of hours that an awarding organisation has assigned to a qualification for guided learning
- an estimate of the number of hours a learner will reasonably 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, unlike guided learning, not under the immediate guidance or supervision of - a lecturer, supervisor, tutor or other appropriate provider of education or training.

Title and level	GLH	TQT
City & Guilds Level 2 Diploma in Machining (Foundation Knowledge)	360	500

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# Centre requirements

## Approval

### Full approval

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the document [Centre Approval Process: Quality Assurance Standards](#) 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.

## 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 area[s] 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.

### Continuing Professional Development (CPD)

Centres must support their staff to ensure that they have current knowledge of the occupational area in order that delivery, mentoring, training, assessment and verification is in line with best practice and that they take account of any national and legislative developments.

### 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. All external quality assurance processes reflect the minimum requirements for verified and moderated assessments, as detailed in the Centre Assessment Standards Scrutiny (CASS), section H2 of Ofqual's General Conditions. For more information on both CASS and City and Guilds Quality Assurance processes visit: the [What is CASS?](#) and [Quality Assurance Standards](#) documents on the City & Guilds website.

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

External quality assurance for the qualification will be provided by City & Guilds EQA process. EQAs are appointed by City & Guilds to approve centres, and to monitor the assessment and internal quality assurance carried out by centres. External quality assurance is carried out to ensure that assessment is valid and reliable, and that there is good assessment practice in centres.

The role of the EQA is to:

- provide advice and support to centre staff
- ensure the quality and consistency of assessments and marking/grading within and between centres by the use of systematic sampling
- provide feedback to centres and to City & Guilds.

## **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.

## **Age restrictions**

This qualification is approved for learners aged 16 or above.

## **Access arrangements and reasonable adjustments**

City & Guilds has considered the design of this qualification and its assessments to best support accessibility and inclusion for all learners. We understand however that individuals have diverse learning needs and may require reasonable adjustments to fully participate. Reasonable adjustments, such as additional time or alternative formats, may be provided to accommodate learners with disabilities and support fair access to assessment.

Access arrangements are adjustments that allow candidates with disabilities, special educational needs, and temporary injuries to access the assessment and demonstrate their skills and knowledge without changing the demands of the assessment. These arrangements must be made before assessment takes place.

Equalities legislation requires City & Guilds to make reasonable adjustments where a disabled person would be at a substantial disadvantage in undertaking an assessment.

It is the responsibility of the centre to ensure at the start of a programme of learning that candidates will be able to access the requirements of the qualification.

Please refer to the Joint Council for Qualifications (JCQ) access arrangements and reasonable adjustments and Access arrangements - when and how applications need to be made to City & Guilds for more information. Both are available on the City & Guilds website.

## 2 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 qualification, their responsibilities as a candidate, and the responsibilities of the centre. This information can be recorded on a learning contract.

### Inclusion and diversity

City & Guilds is committed to improving inclusion and diversity within the way we work and how we deliver our purpose which is to help people and organisations develop the skills they need for growth.

More information and guidance to support centres in supporting inclusion and diversity through the delivery of City & Guilds qualifications can be found here:

[Inclusion and diversity | City & Guilds \(cityandguilds.com\)](https://www.cityandguilds.com)

### Sustainability

City & Guilds are committed to net zero. Our ambition is to reduce our carbon emissions by at least 50% before 2030 and develop environmentally responsible operations to achieve net zero by 2040 or sooner if we can. City & Guilds is committed to supporting qualifications that support our customers to consider sustainability and their environmental footprint.

More information and guidance to support centres in developing sustainable practices through the delivery of City & Guilds qualifications can be found here:

[Our Pathway to Net Zero | City & Guilds \(cityandguilds.com\)](https://www.cityandguilds.com)

Centres should consider their own carbon footprint when delivering this qualification and consider reasonable and practical ways of delivering this qualification with sustainability in mind. This could include:

- reviewing purchasing and procurement processes (such as buying in bulk to reduce the amount of travel time and energy, considering and investing in the use of components that can be reused, instead of the use of disposable or single use consumables)
- reusing components wherever possible

- waste procedures (ensuring that waste is minimised, recycling of components is in place wherever possible)
- minimising water use and considering options for reuse/salvage as part of plumbing activities wherever possible.

## Support materials

The following resources are available for these qualifications:

Description	How to access
Assessor Assessment pack Candidate Assessment pack	<a href="http://www.cityandguilds.com">www.cityandguilds.com</a>

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# Assessment

## Summary of assessment methods

### Candidates must:

- successfully complete **one** multiple choice test for unit 203
- successfully complete assessment components 021 and 022 for the mandatory units 201, 202, 204 and 205.
- successfully complete the appropriate assessment for each optional unit selected.

## Assessment strategy

City & Guilds has written the following assessments to use with this/these qualification(s):

- live assignments that can be downloaded from the City & Guilds website (Assessor assessment pack and Candidate assessment pack.)

### Available assessments

City & Guilds has written the following assessments to use with this qualification:

- externally set, internally marked short answer question papers
- evolve multiple choice test to be delivered on-screen.

## Assessment Types

Unit	Unit title	Assessment method	Where to obtain assessment materials
201	Working in an engineering environment	Short answer questions 1272-021	www.cityandguilds.com
202	Engineering techniques	Short answer questions 1272-022	www.cityandguilds.com
203	Engineering maths and science principles	Multiple choice online test 1272-203	www.cityandguilds.com
204	Fitting and assembly techniques	Short answer questions 1272-022	www.cityandguilds.com

<b>Unit</b>	<b>Unit title</b>	<b>Assessment method</b>	<b>Where to obtain assessment materials</b>
205	Business improvement techniques	Short answer questions 1272-021	www.cityandguilds.com
206	Principles of turning and milling	Short answer questions 1272-206	www.cityandguilds.com
207	Manual turning techniques	Short answer questions 1272-207	www.cityandguilds.com
208	Manual milling techniques	Short answer questions 1272-208	www.cityandguilds.com
209	Grinding techniques	Short answer questions 1272-209	www.cityandguilds.com
210	Principles of Computer Numerical Control (CNC) machining/fabrication	Short answer questions 1272-210	www.cityandguilds.com
211	Computer Numerical Control (CNC) turning techniques	Short answer questions 1272-211	www.cityandguilds.com
212	Computer Numerical Control (CNC) milling techniques	Short answer questions 1272-212	www.cityandguilds.com
213	Computer Aided Design (CAD)	Short answer questions 1272-213	www.cityandguilds.com

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### **Time constraints**

All assessments must be completed within the candidate's period of registration.

### **Recognition of prior learning (RPL)**

Recognition of prior learning means using a person's previous experience, or qualifications which have already been achieved, to contribute to a new qualification.

For this qualification, RPL is allowed and is not sector specific.

## Test specifications

The way the knowledge is covered by each test is laid out in the tables below:

**Assessment title:** Assessment component 021

**Graded:** X/P/M/D

Test: 021	Duration: 90 minutes		
	Outcome	Number of marks	Percentage %
<b>Unit 201</b>	01: Understand how engineering businesses are organised	8	13
	02: Understand the effect of change on engineering businesses	8	13
	03: Understand types of communication used in engineering businesses	10	17
<b>Unit 205</b>	01: Understand the importance of continuous improvement to engineering businesses	10	17
	02: Understand the application of continuous improvement techniques	24	40
<b>Total</b>		<b>60</b>	<b>100</b>



**Assessment title:** Assessment component 022

**Graded:** X/P/M/D

<b>Test: 022</b>	<b>Duration: 120 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 202</b>	01: Understand drawings used by engineering businesses	17	20
	02: Understand quality techniques	6	7
<b>Unit 204</b>	01: Understand engineering health and safety requirements	12	14
	02: Understand how to use workshop equipment	24	28
	03: Understand fitting and assembly techniques	26	31
<b>Total</b>		<b>85</b>	<b>100</b>

**Assessment title:** Engineering maths and science principles

**Graded:** X/P/M/D

<b>Test: 203</b>	<b>Duration: 75 minutes</b>		
<b>Unit 203</b>	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
	01: Apply mathematical applications to engineering	25	50
	02: Apply science to engineering	10	20
	03: Understand engineering materials	15	30
	<b>Total</b>	<b>50</b>	<b>100</b>

**Assessment title:** Principles of turning and milling

**Graded:** X/P/M/D

<b>Test: 206</b>	<b>Duration: 120 minutes</b>		
<b>Unit 206</b>	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
	01: Know the equipment required for milling operations	18	22.5
	02: Know the equipment required for turning operations	18	22.5
	03: Understand how to produce machined components	31	39
	04: Understand how to meet quality requirements for machining operations	13	16
<b>Total</b>	<b>80</b>	<b>100</b>	

**Assessment title:** Manual turning techniques

**Graded:** X/P/M/D

<b>Test: 207</b>	<b>Duration: 90 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 207</b>	01: Know the equipment required for turning operations	26	40
	02: Understand how to produce machined components on a lathe	31	48
	03: Understand how to meet quality requirements for turning operations	8	12
<b>Total</b>		<b>65</b>	<b>100</b>

**Assessment title:** Manual milling techniques

**Graded:** X/P/M/D

<b>Test: 208</b>	<b>Duration: 90 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 208</b>	01: Know the equipment required for milling operations	26	40
	02: Understand how to produce machined components on a vertical mill	31	48
	03: Understand how to meet quality requirements for milling operations	8	12
<b>Total</b>		<b>65</b>	<b>100</b>

**Assessment title:** Grinding techniques

**Graded:** X/P/M/D

<b>Test: 209</b>	<b>Duration: 90 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 209</b>	01: Know the equipment required for grinding operations	26	40
	02: Understand how to produce components on grinding machines	31	48
	03: Understand how to meet quality requirements for grinding operations	8	12
<b>Total</b>		<b>65</b>	<b>100</b>

**Assessment title:** Principles of Computer Numerical Control (CNC) machining

**Graded:** X/P/M/D

<b>Test: 210</b>	<b>Duration: 120 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 210</b>	01: Know the equipment required for CNC operations	46	54
	02: Understand how to produce components using CNC machines	31	36
	03: Understand how to meet quality requirements for CNC operations	8	10
<b>Total</b>		<b>85</b>	<b>100</b>

**Assessment title:** Computer Numerical Control (CNC) turning techniques

**Graded:** X/P/M/D

<b>Test: 211</b>	<b>Duration: 90 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 211</b>	01: Know the equipment required for CNC turning operations	26	40
	02: Understand how to produce turned components on a CNC lathe	31	48
	03: Understand how to meet quality requirements for CNC turning operations	8	12
<b>Total</b>		<b>65</b>	<b>100</b>

**Assessment title:** Computer Numerical Control (CNC) milling techniques

**Graded:** X/P/M/D

<b>Test: 212</b>	<b>Duration: 90 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 212</b>	01: Know the equipment required for CNC milling operations	26	40
	02: Understand how to produce milled components on a CNC mill	31	48
	03: Understand how to meet quality requirements for CNC milling operations	8	12
<b>Total</b>		<b>65</b>	<b>100</b>

**Assessment title:** Computer Aided Design (CAD)

**Graded:** X/P/M/D

<b>Test: 213</b>	<b>Duration: 90 minutes</b>		
	<b>Outcome</b>	<b>Number of marks</b>	<b>Percentage %</b>
<b>Unit 213</b>	01: Know the principles of using CAD software	18	40
	02: Understand how to operate CAD software	18	48
	03: Understand the use of CAD/CAM in machining	14	12
	<b>Total</b>	<b>50</b>	<b>100</b>

## Grading

### Grading of individual assessments

Individual assessments will be graded Pass/Merit/Distinction.

For a unit to be achieved, candidates must achieve a minimum Pass in the assessment, as per the marking scheme provided.

A Pass reflects the minimum requirements that are expressed in the unit, with Merit and Distinction showing progression in the depth and breadth of the learner's knowledge, as well as in the type of cognitive operations they demonstrate.

Individual assessments will be graded Pass/Merit/Distinction where indicated.

The grade boundaries for Pass, Merit and Distinction for each assessment have been set through a judgemental process using technical experts, aimed at defining what the grades for each assessment should mean in practice. The following descriptors are based on that process.

For the units to be achieved, candidates must achieve a minimum of Pass in the assessments. The descriptors given here simply provide a baseline against which Merit and Distinction grades can be understood and should **not** be used for grading/markings the assessments.

### Pass

The candidate has a solid understanding of the unit key concepts. Some understanding may be simplistic, narrow or shallow. Individual topics are dealt with separately but understanding is clear. Recall of the unit content is generally accurate, without serious misapprehensions or gaps. Recall may be slow or show signs of difficulty/uncertainty and minor misapprehensions may occur.

Indicators:

- explanations may be a little incoherent or incomplete but the meaning is on the whole accurate
- the use of illustrations/examples are mostly relevant to the explanation
- relationships between concepts are missing
- reasoning shows comprehension of the main facts
- analyses or evaluations are simplistic but relevant
- sources, when used, are limited but relevant
- main facts are stated accurately
- definitions and descriptions are accurate, but somewhat limited
- diagrams, when used, are mostly correctly annotated, with some minor errors eg spelling.

### **Merit**

The candidate has a sound understanding of the breadth/depth of the relevant concepts. Topics are dealt with in relation to each other and communicated clearly. The breadth and depth of the unit content are recalled in an accurate and complete manner. Recall is confident.

Indicators:

- explanations are coherent, complete and accurate
- use of illustrations/examples which accurately and clearly add to/support the explanation
- relationships are made between concepts
- reasoning is plausible and conventional
- analyses and evaluations are methodical and plausible
- information is drawn from a range of appropriate sources and used appropriately
- facts are accurate and cover the breadth and depth of the unit
- definitions and descriptions are clear
- technical language is accurate

### **Distinction**

The candidate has a well-developed understanding of the relevant concepts. Relationships between topics are highly developed and may be set in context; interactions between topics are clearly expressed. There is evidence of understanding of some facts/knowledge which go beyond the requirements of the unit. Recall is automatic and can be brought together making useful connections.

Indicators:

- explanations are well thought out, thorough and well-argued/justified
- well-chosen illustrations/ examples, which accurately and precisely clarify explanations
- relationships are brought together to show an understanding of the bigger picture
- reasoning is justified, well-argued and may be creative
- analyses and evaluations are thorough, well-developed
- sourced information is critically evaluated, showing awareness of its importance or relevance
- evidence of interest beyond the scope of the unit
- descriptions and definitions are detailed
- use of knowledge is consistently high and second nature.



## Grading of the qualification

The Employer Group has taken the decision to grade this qualification Pass/Merit/Distinction, through the aggregation of the individual assessments graded Pass/Merit/Distinction.

Grading can be of use both as a motivational tool within the learning environment and also to learners presenting evidence of their knowledge to prospective employers.

All assessments must be achieved at a minimum of Pass for the qualification to be awarded. All assessments graded Pass/Merit/Distinction contribute equally to the overall qualification grade.

Centres will need to calculate the qualification grade as follows:

- The grade achieved by a learner will need to be converted into points as follows:

Individual assessment grade	Grade points
Pass	1
Merit	2
Distinction	3

- Grade points for each assessment need to be added together and the overall qualification grade determined using the following conversion table:

Total grade points	Overall qualification grade
5 - 7	Pass
8 - 11	Merit
12 - 15	Distinction

Overall qualification grades must be entered using **one** of the following overall grading modules on the Walled Garden:

- 901 Pass
- 902 Merit
- 903 Distinction

## Example

Learner A has achieved the following:

Assessment	Grade achieved	Grade points
<b>Mandatory</b>		
203	Merit	2
021	Pass	1
022	Pass	1
<b>Optional</b>		
210	Merit	2
213	Distinction	3
<b>Total grade points</b>		<b>9</b>
<b>Overall qualification grade</b>		<b>Merit</b>

Overall qualification grade (merit) must be entered using the following grading module on the Walled Garden:

- 902 Merit

# Units

## Structure of the units

These units each have the following:

- City & Guilds reference number
- Title
- Level
- Guided learning hours (GLH)
- Learning outcomes
- Topics and associated range content

Centres must deliver the full breadth of the range.

# Unit 201 Working in an engineering environment

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	30
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## What is this unit about?

The aim of this unit is to introduce learners to basic principles of working in engineering business. They will learn basic business concepts relating to organisation charts and functional areas and how change impacts on business. They will also learn about the types of documentation used in business and what they are used for.

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## Learning outcomes

In this unit, learners will be able to

- 1 Understand how engineering businesses are organised
- 2 Understand the effect of change on engineering businesses
- 3 Understand types of communication used in engineering businesses

## Scope of content

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### Learning outcome

- 1 Understand how engineering businesses are organised
- 

### Topics

- 1.1 Characteristics of types of engineering business
- 1.2 Functional areas of engineering businesses
- 1.3 Stakeholders of engineering businesses

#### Topic 1.1

Characteristics of engineering businesses of different:

- Sizes
- Geographical operation (local, national, international)
- Sectors.

Characteristics of how engineering businesses are organised:

- Levels of responsibility
- Lines of communication
- Organisation charts.

#### Topic 1.2

Characteristics of and job roles within different functional areas:

- Support
- Sales and marketing
- Engineering
- Manufacturing
- Quality.

#### Topic 1.3

Expectations of different types of stakeholders:

- Existing clients/users
- Potential clients/users
- Board of Directors
- External shareholders
- Standards bodies
- Regulator for that industry.

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## Learning outcome

2 Understand the effect of change on engineering businesses

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### Topics

2.1 Causes of changes

2.2 Effects of changes

#### Topic 2.1

Characteristics of factors causing change in engineering businesses:

- Internal (finance, efficiency, quality, skills)
- External (legislation, technology, market forces).

#### Topic 2.2

Effects of change:

- On industry
  - On businesses
  - On employees.
- 

## Learning outcome

3 Understand types of communication used in engineering businesses

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### Topics

3.1 Principles of communication

3.2 Types of business documentation

3.3 ICT applications

#### Topic 3.1

Principles of communication:

- Two way process
- Types of communication (oral, written, non-verbal)
- Formal/informal.

#### Topic 3.2

Types of, purpose and conventions for completion of business documentation:

- Gantt charts
- Bill of Materials (BoM)
- Technical Reports
- Job cards
- Emails.

#### Topic 3.3

Characteristics of ICT software applications:

- Word processing
  - Spreadsheets
  - Databases
  - Presentation
  - CAD
  - CAM
-

- Mobile apps.

## Guidance for delivery

This is a theory unit that provides opportunities for learners to input on their own experiences when working in engineering businesses. The use of case studies from a range of different types of business would enable learners to grasp the scale and scope of the industry. Case studies can also be used to consider the impact of external factors on the business and ways they have dealt with change.

Gaining and understanding of communication and principles and types of business communication can be developed through practical activities where learners complete documentation related to real machining tasks planned or completed.

There are opportunities to work with employers who can provide case studies of responses to change and provide examples of real documentation used in business.



# Unit 202 Engineering techniques

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	30
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## What is this unit about?

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 developed to meet national and international standards. They will learn the difference between quality control and quality assurance and how these are applied in business.

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## Learning outcomes

In this unit, learners will be able to

- 1 Understand drawings used by engineering businesses
- 2 Understand quality techniques

## Scope of content

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### Learning outcome

1 Understand drawings used by engineering businesses

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### Topics

- 1.1 Types of engineering drawing
- 1.2 Information on engineering drawings
- 1.3 Mechanical symbols used on engineering drawings

#### Topic 1.1

Types of engineering drawings:

- Part
- General assembly
- General arrangement.

Difference between first and third angle projection.

Characteristics and advantages of using different views:

- Orthographic
- Isometric
- Exploded
- Section
- Detail
- Breakout
- Auxiliary.

Difference between drawings and sketches.

#### Topic 1.2

Information:

- Zones
- Title block
- Scale
- Paper size
- Revision
- Status
- Dimensions
- Line types
- Associated drawings
- Bill of Materials (BoM)/parts list.

BS, EN and ISO drawing standards.

### **Topic 1.3**

#### **Mechanical symbols:**

- Balloon
- Diameter
- Counterbore
- Countersink
- Depth
- Centre mark
- Centre line.

#### Geometric Dimensioning and Tolerancing (GDT) symbols:

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

#### Surface finishing symbols:

- Roughness (Ra Value)
- Surface type.

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### **Learning outcome**

2 Understand quality techniques

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### **Topics**

2.1 Characteristics of quality

2.2 Quality inspections

### **Topic 2.1**

#### Characteristics of quality control:

- Measurement of finished products
- Documentation (inspection reports, test results).

#### Characteristics of quality assurance:

- Measurement of components during manufacture
- Right first time – prevention of defects.

### **Topic 2.2**

#### Characteristics of and suitability of quality criteria:

- Functionality
- Tolerances
- Specification
- Dimensions
- Output.

## Guidance for delivery

This is a theory unit. The learning outcome related to drawing techniques could be addressed through practical activities where learners create drawings to meet national and international standards. It is recommended that this is through the use of CAD software. Learners could produce drawings from images of existing products, provided by employers. They could also produce sketches to appreciate the difference between sketches and engineering drawings. The theory can also be applied through interpreting drawings. This may be through carrying out machining activities from drawings provided.

The quality learning outcome can also be applied to practical activities. The concepts would apply with all components machined or produced.

The unit provides opportunities to engage with employers. Employers can provide examples of products and/or engineering drawings. They can present drawings with errors and/or omissions to be identified by the learner. Employers can also give presentations on their quality assurance and quality control processes.

# Unit 203 Engineering maths and science principles

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	90
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## What is this unit about?

The purpose of this unit is for learners to understand the basic principles of mathematics, science and materials that are important wherever they work in engineering. By learning these topics, they will better understand their importance in the process that allows engineers to design and manufacture components for a range of specific situations.

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## Learning outcomes

In this unit, learners will be able to

- 1 Apply mathematical applications to engineering
- 2 Apply science to engineering
- 3 Understand engineering materials

## Scope of content

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### Learning outcome

- 1 Apply mathematical applications to engineering
- 

### Topics

- 1.1 General mathematical principles
- 1.2 Calculate areas and volumes of shapes
- 1.3 Use trigonometric functions
- 1.4 Solve different types of equations
- 1.5 Create different types of graphs

#### Topic 1.1

Apply general mathematical principles in engineering:

- Addition, subtraction, multiplication, division
- Order of operation (BODMAS)
- Decimal places
- Significant figures
- Approximation
- Degrees of accuracy
- SI units (metric) and prefixes, imperial units
- Averages (mean, median, mode)
- Unit conversions
- Ratio and proportion
- Fractions
- Angles of shapes
- Power and roots
- Transposition of formulae
- Use of scientific calculator.

#### Topic 1.2

Calculate areas of shapes:

- Squares
- Rectangles
- Circles
- Triangles
- Compound shapes.

Calculate surface areas and volumes of shapes:

- Cubes
- Rectangular prisms
- Cylinders
- Cones
- Spheres.

#### Topic 1.3

Use trigonometry on right angle triangles to calculate:

- Length of unknown side from two given lengths
- Length of unknown side from a known length and angle

- Unknown angle from two lengths.

#### **Topic 1.4**

Use graphical and mathematical methods to solve different types of equations:

- Linear
- Quadratic
- Simultaneous.

#### **Topic 1.5**

Create different types of graph:

- Straight line graphs
- Curved graphs.

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### **Learning outcome**

2 Apply science to engineering

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### **Topics**

2.1 Definitions of scientific principles

2.2 Apply engineering principles in engineering situations

#### **Topic 2.1**

Definitions and formulae of scientific principles:

- Force
- Power
- Energy
- Work
- Moments
- Efficiency
- Friction
- Heat (latent, specific, transfer methods, coefficient of expansion)
- Ohm's law
- Watt's law
- Magnetism.

#### **Topic 2.2**

Apply engineering principles in engineering situations:

- Work done by a simple machine
- Power
- Energy
- Gear ratios
- Classification of levers (class one, class two, class three)
- Moments of force
- Efficiency of a device (electrical efficiency, mechanical advantage)
- Heat (latent, specific heat capacity, coefficient of expansion)
- Ohm's law
- Resistance in series and parallel circuits.

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## Learning outcome

### 3 Understand engineering materials

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#### Topics

- 3.1 Types of engineering materials
- 3.2 Properties of engineering materials
- 3.3 Corrosion of engineering materials
- 3.4 Heat treatment of metals
- 3.5 Suitability of materials for engineering applications

#### Topic 3.1

Types of engineering materials, characteristics and their forms of supply:

- Metallic
- Ferrous metals
- Non-ferrous metals
- Non-metallic
- Composites.

#### Topic 3.2

Characteristics of material properties of different types of material:

- Physical (specific heat capacity, latent heat, thermal conductivity, density, corrosion resistance, electrical conductivity, resistivity)
- Mechanical (hardness, strength, ductility, malleability, elasticity, plasticity, toughness, creep resistance).

#### Topic 3.3

Causes of corrosion:

- Pitting
- Galvanic
- Oxidation.

Suitability of different types of corrosion prevention and retarding for an application:

- Coating
- Cathodic
- Anodic.

#### Topic 3.4

Effects of different types of heat treatments on materials:

- Annealing
- Normalising
- Hardening
- Tempering.

#### Topic 3.5

Suitability of materials for different engineering applications against a range of criteria:

- Ease of manufacture
- Application
- Aesthetics
- Environment
- Sustainability
- Availability



- Properties.

## Guidance for delivery

This is a theoretical unit that is best taught through applied activities related to engineering contexts.

There are many opportunities to link the learning in this unit with practical machining activities. For example, calculating missing dimensions from drawings. Practical activities involving machining different types of materials can be used to discuss the properties of these materials, as learners experience the ease and/or difficulty of working with them. Gear ratios can be applied when setting up speeds and feeds on machines.

Employers can be engaged to support delivery with examples of activities where the theory can be applied eg with engineering drawings or case studies.

## Unit 204 Fitting and assembly techniques

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	60
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### What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create components. 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 they can evaluate the quality of a component against a specification

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### Learning outcomes

In this unit, learners will be able to

- 1 Understand engineering health and safety requirements
- 2 Understand how to use workshop equipment
- 3 Understand fitting and assembly techniques

## Scope of content

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### Learning outcome

- 1 Understand engineering health and safety requirements
- 

### Topics

- 1.1 Legislation affecting health and safety in engineering
- 1.2 Safe working practices in engineering
- 1.3 Classification of safety signs
- 1.4 Risk assessment process

#### Topic 1.1

Employer responsibilities under health and safety legislation:

- Health and Safety at Work Act 1974
- Provision and Use of Work Equipment Regulations 1998 (PUWER)
- Personal Protective Equipment Regulations 1992
- Control of Substances Hazardous to Health Regulations 2002 (COSHH)
- Manual Handling Operations Regulations 1992
- Reporting of Diseases and Dangerous Occurrence Regulations 2013
- Electricity at Work Regulations 1989.

#### Topic 1.2

Procedures for safe working practices:

- Safe isolation of energy sources
- Prepare self and area to be in a safe condition to carry out work
- Work safely whilst carrying out activities
- Ensure self and area are left in a safe condition upon completion of the activities.

#### Topic 1.3

How shape and colour are used to classify different types of safety signs:

- Warning
- Mandatory
- Safe condition
- Prohibition.

#### Topic 1.4

Process undertaken when carrying out risk assessments:

- Identification of hazards
- Evaluation of risk (severity, likelihood, number affected, risk rating)
- Recommendation of control measures.

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## Learning outcome

2 Understand how to use workshop equipment

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## Topics

- 2.1 Engineering workshop tools
- 2.2 Marking out techniques
- 2.3 Measuring instruments
- 2.4 Technical information used for engineering activities

### Topic 2.1

Applications and techniques for use of workshop tools:

- Hacksaws
- Files
- Chisels
- Drills
- Taps and dies
- Tin snips
- Screwdrivers
- Reamers
- Spanners
- Hammers
- Pliers
- Torque wrenches.

### Topic 2.2

Applications of marking out equipment:

- Rules
- Dividers
- Scribes
- Surface plates
- Punches
- Scribing blocks
- Squares
- Protractors
- Chalk lines
- Vernier instruments
- Marking out tables
- Angle plates.

Marking out techniques for:

- Datum/centre lines
- Square/rectangular profiles
- Circles
- Radial profiles
- Hole positions (linear, PCD)
- Angles/angular profiles.

### **Topic 2.3**

Applications and suitability of measuring instruments:

- Micrometres (external, internal, depth)
- Tape measures
- Vernier calliper
- Comparison plates
- Rules
- Squares
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measurement Machine (CMM).

### **Topic 2.4**

Extract information from different information sources in order to carry out engineering workshop activities:

Technical information:

- Materials
- Components
- Dimensions
- Tolerances
- Finishes
- Quantity
- Function.

Information sources:

- Technical manuals
- Specifications
- Engineering drawings
- Standards (national, international).

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## Learning outcome

3 Understand fitting and assembly techniques

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### Topics

- 3.1 Planning workshop activities
- 3.2 Equipment required for fitting and assembly
- 3.3 Fitting and assembly operations
- 3.4 Quality checks for fitting and assembly operations

#### Topic 3.1

Considerations when planning engineering workshop activities:

- Health and safety
- Materials
- Equipment
- Tools
- Time
- Quality checks
- Tolerances
- Calculate speeds and feeds
- Order of operations.

#### Topic 3.2

Characteristics and limitations of equipment required for fitting and assembly operations:

- Workholding devices
- Cutting tools
- Tool holders
- Measuring equipment.

#### Topic 3.3

Processes and tools used in techniques for fitting operations:

- Filing
- Scraping
- Lapping
- Polishing
- Blue bedding
- Drilling
- Threading.

Processes and tools used in techniques for assembly operations:

- Permanent (brazing, soldering, welding, adhesives, riveting)
- Semi-permanent (fastening, bolt locking).

#### Topic 3.4

Monitoring work performance:

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

Evaluating components against specification:

- Identify quality criteria (tolerance, surface finish, parallelism) from engineering information (drawings, standards)

- Application of inspection techniques (measurement, visual).



## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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 component in the engineering information.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

## Unit 205 Business improvement techniques

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	30
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### What is this unit about?

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.

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### Learning outcomes

In this unit, learners will be able to

- 1 Understand the importance of continuous improvement to engineering businesses
- 2 Understand the application of continuous improvement techniques

## Scope of content

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### Learning outcome

- 1 Understand the importance of continuous improvement to engineering businesses
- 

### Topics

- 1.1 Categories of work
- 1.2 Categories of waste
- 1.3 Importance of continuous improvement

#### Topic 1.1

Definitions and examples of categories of work in engineering businesses:

- Value added
- Non-value added
- Waste.

#### Topic 1.2

Characteristics of different types of waste:

- Defects
- Overproduction
- Overprocessing
- Transportation
- Waiting
- Motion
- Inventory
- Talent.

#### Topic 1.3

Importance of continuous improvement to an engineering business:

- Survival
- Efficiency
- Profit
- Growth
- Customer satisfaction
- Legislation.

---

## Learning outcome

2 Understand the application of continuous improvement techniques

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### Topics

- 2.1 Workplace organisation
- 2.2 Visual management
- 2.3 Problem solving
- 2.4 Characteristics of the Deming cycle

#### Topic 2.1

Characteristics and examples of 6S as a method of workplace organisation in engineering businesses:

- Sort
- Set
- Shine
- Standardise
- Safety
- Sustain.

Contribution of 6S to workplace organisation and continuous improvement.

#### Topic 2.2

Purpose of visual management:

- To make people aware of information
- To control how people carry out tasks.

How visual management is used in engineering businesses:

- Work instructions
- Performance data
- Status of issues and actions
- Schedule of activities
- Processes
- Area information/boundaries.

#### Topic 2.3

Difference between symptoms, cause and root cause of a problem.

How to prevent recurrence of problem:

- Changes to management systems
- Operating systems and procedures
- Identification of opportunities for improvement.

Characteristics of tools used to verify root cause of problems and their suitability for engineering problems:

- Brainstorming
- 5 Whys?
- Cause and effect diagrams
- Testing decisions
- Verification techniques

- Root cause paths.

#### **Topic 2.4**

Characteristics and applications of each stage in the Deming cycle:

- Plan
- Do
- Check
- Act.

## **Guidance for delivery**

This is a theory unit, which is best delivered in the context of real or realistic case studies. Learners can use examples of their own employer practices and the application of any business improvement techniques that are used. Learners can also relate the concepts presented through this unit to machining operations.

There are opportunities to use employers to give masterclasses on particular techniques and to present details of typical problems encountered by engineering businesses.

# Unit 206 Principles of turning and milling

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	90
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## What is this unit about?

This unit enables the learner to acquire the essential knowledge and understanding needed to develop manual milling and turning skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create milled and turned components. They will learn how machinery is set up and operated safely and the processes to be followed to create milled and turned components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a component against a specification.

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## Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for milling operations
- 2 Know the equipment required for turning operations
- 3 Understand how to produce machined components
- 4 Understand how to meet quality requirements for machining operations

## Scope of content

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### Learning outcome

- 1 Know the equipment required for milling operations
- 

### Topics

- 1.1 Characteristics and function of parts of a vertical mill
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of cutting tools

#### Topic 1.1

Characteristics and function of parts of a vertical mill:

- Isolators
- Speed control
- Feed control
- Emergency stops
- Coolant system
- Turret/head
- Guards and interlocks
- Tool holding device.

#### Topic 1.2

Characteristics, function and limitations of workholding devices:

- Machine vice (fixed, swivel)
- T slot and clamps.

#### Topic 1.3

Characteristics and limitations of cutting tools:

- Tool types (end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, drills, reams, taps)
- Characteristics (tool angles, materials)
- Effects of cutting fluids.



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## Learning outcome

2 Know the equipment required for turning operations

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## Topics

2.1 Characteristics and function of parts of a lathe

2.2 Characteristics, function and limitations of workholding devices

2.3 Characteristics and limitations of cutting tools

### Topic 2.1

Characteristics and function of parts of a lathe:

- Isolators
- Speed control
- Feed control
- Chuck
- Emergency stops
- Coolant system
- Tail stock
- Head stock
- Guards and interlocks
- Compound slide
- Taper turning attachment
- Tool holding device.

### Topic 2.2

Characteristics, function and limitations of workholding devices:

- 3 jaw chucks
- 4 jaw chucks
- Between centres.

### Topic 2.3

Characteristics and limitations of cutting tools:

- Tool types (roughing and finishing, turning, boring, grooving, undercutting, parting, forming, reaming, tapping, threading, drilling, end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, flycutter, dovetail cutter)
- Characteristics (tool angles (rake and clearance, approach), materials)
- Effects of cutting fluids.

---

## Learning outcome

3 Understand how to produce machined components

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### Topics

- 3.1 Safety issues associated with the use of machines
- 3.2 Characteristics of machined features
- 3.3 Techniques for the use of workholding devices
- 3.4 Techniques for mounting cutting tools
- 3.5 Techniques for setting speeds and feeds
- 3.6 Principles of planning machining operations

The content in this learning outcome relates to both milling and turning operations.

#### Topic 3.1

Safety issues associated with the use of a machine and how they are controlled:

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

#### Topic 3.2

Characteristics of different types of features:

- Faces (datum, flat, perpendicular, parallel, tapered)
- Steps/shoulders
- Slots (enclosed, open ended)
- Grooves/undercuts
- Diameters (internal, external, bored)
- Holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed)
- Threads (internal, external).

#### Topic 3.3

Techniques for the use of workholding devices:

- Mounting, alignment and removal of workholding device into/from machine
- How to mount, secure and align the workpiece.

#### Topic 3.4

Techniques for mounting cutting tools:

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Aligning/orientate tool.

#### Topic 3.5

Techniques for setting speeds and feeds:

- Calculate speeds in different conditions
- Setting speed on machine
- Setting feed on machine.

#### Topic 3.6

Principles of planning machining operations:

- Critical path

- Sequence of operations.
- 

## Learning outcome

4 Understand how to meet quality requirements for machining operations

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## Topics

- 4.1 Characteristics and limitations of measuring equipment
- 4.2 Monitoring machine performance
- 4.3 Evaluating machined components against specification requirements

### Topic 4.1

Characteristics and limitations of measuring equipment:

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

### Topic 4.2

Monitoring machine performance:

- Potential defects (symptoms, causes, resolution)
- In-process checks (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools).

### Topic 4.3

Evaluating machined components against specification:

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

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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 machined component in the engineering information.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

# Unit 207 Manual turning techniques

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	60
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## What is this unit about?

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.

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## Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for turning operations
- 2 Understand how to produce turned components on a lathe
- 3 Understand how to meet quality requirements for turning operations

## Scope of content

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### Learning outcome

- 1 Know the equipment required for turning operations
- 

### Topics

- 1.1 Characteristics and function of parts of a lathe
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of cutting tools
- 1.4 Characteristics and limitations of measuring equipment

#### Topic 1.1

Characteristics and function of parts of a lathe:

- Isolators
- Speed control
- Feed control
- Chuck
- Emergency stops
- Coolant system
- Tail stock
- Head stock
- Bed
- Saddle
- Apron
- Guards and interlocks
- Compound slide
- Lead screw
- Feed shaft
- Taper turning attachment
- Tool holding device.

#### Topic 1.2

Characteristics, function and limitations of workholding devices:

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

#### Topic 1.3

Characteristics and limitations of 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)
- Effects of cutting fluids and compounds

## Topic 1.4

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).

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## Learning outcome

2 Understand how to produce turned components on a lathe

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## Topics

- 2.1 Safety issues associated with the use of a lathe
- 2.2 Characteristics of turned features
- 2.3 Techniques for the use of workholding devices
- 2.4 Techniques for mounting cutting tools
- 2.5 Techniques for setting speeds and feeds
- 2.6 Principles of planning turning operations

## Topic 2.1

Safety issues associated with the use of a lathe and how they are controlled:

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

## Topic 2.2

Characteristics of different types of features:

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

## Topic 2.3

Techniques for the use of workholding devices:

- Mounting and removal of workholding device into/from machine
- How to mount, secure and align the workpiece

## Topic 2.4

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.

### **Topic 2.5**

Techniques for setting speeds and feeds:

- Calculate speeds in different conditions
- Setting speed on machine
- Setting feed on machine.

### **Topic 2.6**

Principles of planning turning operations:

- Critical path
- Sequence of operations.

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## **Learning outcome**

3 Understand how to meet quality requirements for turning operations

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## **Topics**

3.1 Monitoring machine performance

3.2 Evaluating turned components against specification requirements

### **Topic 3.1**

Monitoring machine performance:

- Potential defects (symptoms, causes, resolution)
- In-process checks (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools).

### **Topic 3.2**

Evaluating turned components against specification:

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



## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

# Unit 208 Manual milling techniques

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	60
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## What is this unit about?

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.

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## Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for milling operations
- 2 Understand how to produce turned components on a lathe
- 3 Understand how to meet quality requirements for milling operations

## Scope of content

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### Learning outcome

- 1 Know the equipment required for milling operations
- 

### Topics

- 1.1 Characteristics and function of parts of a mill
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of cutting tools
- 1.4 Characteristics and limitations of measuring equipment

#### Topic 1.1

Characteristics and function of parts of a vertical mill:

- 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.

#### Topic 1.2

Characteristics, function and limitations of workholding devices:

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

#### Topic 1.3

Characteristics and limitations of cutting tools:

- Tool types (end mill, slot drill, shell cutter, bullnose cutter, ballnose cutter, face mill, fly cutter, dovetail cutter, drills, reams, taps)
- Characteristics (tool angles, materials)
- Effects of cutting fluids.

## Topic 1.4

Characteristics and limitations of measuring equipment:

- Micrometres (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Slip gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM).

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## Learning outcome

2 Understand how to produce turned components on a lathe

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## Topics

- 2.1 Safety issues associated with the use of a mill
- 2.2 Characteristics of milled features
- 2.3 Techniques for the use of workholding devices
- 2.4 Techniques for mounting cutting tools
- 2.5 Techniques for setting speeds and feeds
- 2.6 Principles of planning milling operations

## Topic 2.1

Safety issues associated with the use of a mill and how they are controlled:

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

## Topic 2.2

Characteristics of different types of features:

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

## Topic 2.3

Techniques for the use of workholding devices:

- Mounting, alignment and removal of workholding device into/from machine
- How to mount, secure and align the workpiece.

## Topic 2.4

Techniques for mounting cutting tools:

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

### **Topic 2.5**

Techniques for setting speeds and feeds:

- Calculate speeds in different conditions
- Setting speed on machine
- Setting feed on machine.

### **Topic 2.6**

Principles of planning milling operations:

- Critical path
- Sequence of operations.

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## **Learning outcome**

3 Understand how to meet quality requirements for milling operations

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## **Topics**

3.1 Monitoring machine performance

3.2 Evaluating milled components against specification requirements

### **Topic 3.1**

Monitoring machine performance:

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

### **Topic 3.2**

Evaluating milled components against specification:

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

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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 milled component in the engineering information.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

## Unit 209 Grinding techniques

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	60
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### What is this unit about?

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.

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### Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for grinding operations
- 2 Understand how to produce components on grinding machines
- 3 Understand how to meet quality requirements for grinding operations

## Scope of content

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### Learning outcome

- 1 Know the equipment required for grinding operations
- 

### Topics

- 1.1 Characteristics and function of parts of grinding machines
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of abrasive wheels
- 1.4 Characteristics and limitations of measuring equipment

#### Topic 1.1

Parts of grinding machines:

- Isolators
- Peripheral control
- Wheels
- Table control
- Emergency stops
- Coolant system
- Guards and interlocks
- Local Extraction and Ventilation (LEV) system.

Types of grinding machines:

- Cylindrical (internal, external)
- Surface (horizontal, vertical)
- Universal.

#### Topic 1.2

Characteristics, function and limitations of workholding devices:

- Chucks (scroll, magnetic, collet)
- Vices (fixed, swivel, universal)
- V block and clamps
- Mandrels.

#### Topic 1.3

Characteristics and limitations of abrasive wheels:

- Wheel types (straight, cylinder, single taper, double taper, single concaved, straight cup)
- Characteristics (material, bond type, grain size, hardness/grade, density/structure, treatment)
- Effects of grinding fluids.

#### Topic 1.4

Characteristics and limitations of measuring equipment:

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



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## Learning outcome

2 Understand how to produce components on grinding machines

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### Topics

- 2.1 Safety issues associated with the use of grinding machines
- 2.2 Characteristics of features
- 2.3 Techniques for the use of workholding devices
- 2.4 Techniques for mounting abrasive wheels
- 2.5 Techniques for maintaining abrasive wheels
- 2.6 Principles of planning grinding operations

Learners should gain understanding in respect of cylindrical, surface and universal grinding machines.

#### Topic 2.1

Safety issues associated with the use of a grinding machine and how they are controlled:

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

#### Topic 2.2

Characteristics of different types of features:

- Faces (datum, flat, perpendicular, parallel, angular)
- Diameters (internal, external)
- Steps
- Tapers
- Grooves/undercuts
- Slots/profiles.

#### Topic 2.3

Techniques for the use of workholding devices:

- Mounting and removal of workholding device into/from machine
- How to mount, secure and align the workpiece.

#### Topic 2.4

Techniques for mounting abrasive wheels:

- Checking wheels are fit for purpose (speed, material, grade, size, condition)
- Securing abrasive wheels in machine spindle
- Balancing the wheel
- Testing the mounted wheel.

#### Topic 2.5

Techniques for maintaining the abrasive wheel:

- Trueing the wheel
- Dressing the wheel
- Forming the wheel.

## Topic 2.6

Principles of planning grinding operations:

- Critical path
- Sequence of operations.

---

## Learning outcome

3 Understand how to meet quality requirements for grinding operations

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## Topics

3.1 Monitoring machine performance

3.2 Evaluating ground components against specification requirements

### Topic 3.1

Monitoring machine performance:

- Potential defects (symptoms, causes, resolution)
- In-process checks (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of wheel).

### Topic 3.2

Evaluating components against specification:

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

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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 component in the engineering information.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

# Unit 210 Principles of Computer Numerical Control (CNC) machining/fabrication

<b>Unit level:</b>	Level 2
<b>GLH:</b>	90

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## What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create components with CNC milling machines and CNC lathes. 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 they can evaluate the quality of a component against a specification.

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## Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for CNC operations
- 2 Understand how to produce components using CNC machines
- 3 Understand how to meet quality requirements for CNC operations

## Scope of content

This unit relates to CNC milling machines and CNC lathes.

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## Learning outcome

- 1 Know the equipment required for CNC operations
- 

## Topics

- 1.1 Characteristics and function of CNC machines
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of tools
- 1.4 Characteristics and limitations of measuring equipment

### Topic 1.1

Characteristics and function of CNC machine parts:

- Isolators
- Emergency stops
- Guards and interlocks
- Tool holding device
- Controls
- Open loop control
- Closed loop control
- Servo motors/stepper motors
- Positional transducers.

### Topic 1.2

Characteristics, function and limitations of workholding devices:

- Chucks
- Vices
- Fixtures.

### Topic 1.3

Function and limitations of tools used on CNC machines:

- Cutting tools.

### Topic 1.4

Characteristics and limitations of measuring equipment:

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

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## Learning outcome

2 Understand how to produce components using CNC machines

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### Topics

- 2.1 Safety issues associated with the use of CNC machines
- 2.2 Characteristics of component features
- 2.3 Techniques for the use of workholding devices
- 2.4 Techniques for mounting tools
- 2.5 CNC programs
- 2.6 Principles of planning CNC operations

#### Topic 2.1

Safety issues associated with the use of CNC machines and how they are controlled:

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

#### Topic 2.2

Characteristics of different types of component features:

- Faces (datum, flat, perpendicular, parallel, tapered)
- Diameters (internal, external, bored, tapered, concentric, eccentric)
- Shoulders
- Grooves/undercuts
- Holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed)
- Threads (internal, external).
- Steps
- Recesses
- Slots (enclosed, open ended, tee).

#### Topic 2.3

Techniques for the use of workholding devices:

- Mounting and removal of workholding device into/from machine
- How to mount, secure and align.

#### Topic 2.4

Techniques for mounting tools:

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Set tool offset.

#### Topic 2.5

CNC programs:

- Interpret key command codes (program start, linear motions, circular motions, absolute programming, incremental programming, tool change, coolant, program stop, machine axes)
- Terminology (part programs, word address, conversational, absolute, incremental)
- 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)

### **Topic 2.6**

Principles of planning CNC operations:

- Critical path
- Sequence of operations.

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## **Learning outcome**

3 Understand how to meet quality requirements for CNC operations

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## **Topics**

3.1 Monitoring machine performance

3.2 Evaluating components against specification requirements

### **Topic 3.1**

Monitoring machine performance:

- Potential defects (symptoms, causes, resolution)
- In-process checks (trial cuts, size of workpiece, surface finish of workpiece, condition of tools).

### **Topic 3.2**

Evaluating components against specification:

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

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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 component in the engineering information.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.



# Unit 211 Computer Numerical Control (CNC) turning techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60

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## What is this unit about?

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.

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## Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for CNC turning operations
- 2 Understand how to produce turned components on a CNC lathe
- 3 Understand how to meet quality requirements for CNC turning operations

## Scope of content

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### Learning outcome

- 1 Know the equipment required for CNC turning operations
- 

### Topics

- 1.1 Characteristics and function of parts of a CNC lathe
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of cutting tools
- 1.4 Characteristics and limitations of measuring equipment

#### Topic 1.1

Characteristics and function of parts of a CNC lathe:

- Isolators
- Emergency stops
- Coolant system
- Tail stock
- 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.

#### Topic 1.2

Characteristics, function and limitations of workholding devices:

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

#### Topic 1.3

Characteristics and limitations of cutting equipment:

- Tool types (roughing, finishing, grooving, parting, reaming, tapping, threading, drilling, profiling)
- Classification of ISO coding for indexable inserts
- Characteristics of cutting tools (shape, size, tip radius, rake angle, cutter length, ISO Coding for indexable inserts)
- Tool holder characteristics (handing, approach angle, clamping system, insert shape and size)
- Effects of cutting fluids.

#### Topic 1.4

Characteristics and limitations of measuring equipment:

- Micrometres (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules

- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM).

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## Learning outcome

2 Understand how to produce turned components on a CNC lathe

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### Topics

- 2.1 Safety issues associated with the use of a CNC lathe
- 2.2 Characteristics of turned features
- 2.3 Techniques for the use of workholding devices
- 2.4 Techniques for mounting cutting tools
- 2.5 CNC programs
- 2.6 Principles of planning CNC turning operations

#### Topic 2.1

Safety issues associated with the use of a CNC lathe and how they are controlled:

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

#### Topic 2.2

Characteristics of different types of features:

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

#### Topic 2.3

Techniques for the use of workholding devices:

- Mounting and removal of workholding device into/from machine
- How to mount, secure and align the workpiece.

#### Topic 2.4

Techniques for mounting cutting tools:

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Set tool offset.

#### Topic 2.5

CNC programs:

- Coding (machine axes, Cartesian coordinates, machine management (spindle start/stop, coolant on/off, tool change, end of program, optional stop)
- Terminology (part programs, word address, conversational, absolute, incremental)
- 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)

### **Topic 2.6**

Principles of planning CNC turning operations:

- Critical path
- Sequence of operations.

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### **Learning outcome**

3 Understand how to meet quality requirements for CNC turning operations

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### **Topics**

3.1 Monitoring machine performance

3.2 Evaluating turned components against specification requirements

### **Topic 3.1**

Monitoring machine performance:

- Potential defects (symptoms, causes, resolution)
- In-process checks (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools).

### **Topic 3.2**

Evaluating turned components against specification:

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

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

## Unit 212 Computer Numerical Control (CNC) milling techniques

<b>Unit level:</b>	Level 2
<b>GLH:</b>	60

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### What is this unit about?

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.

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### Learning outcomes

In this unit, learners will be able to

- 1 Know the equipment required for CNC milling operations
- 2 Understand how to produce components on a CNC mill
- 3 Understand how to meet quality requirements for CNC milling operations

## Scope of content

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### Learning outcome

- 1 Know the equipment required for CNC milling operations
- 

### Topics

- 1.1 Characteristics and function of parts of CNC mills
- 1.2 Characteristics, function and limitations of workholding devices
- 1.3 Characteristics and limitations of cutting tools
- 1.4 Characteristics and limitations of measuring equipment

#### Topic 1.1

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.

#### Topic 1.2

Characteristics, function and limitations of workholding devices:

- Machine vice
- Fixtures.

#### Topic 1.3

Characteristics and limitations of cutting equipment:

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

#### Topic 1.4

Characteristics and limitations of measuring equipment:

- Micrometres (internal, external, depth)
- Vernier calliper
- Comparison plates
- Rules
- Protractors
- Gauges
- Dial Test Indicator (DTI)
- Set square

- Coordinate Measuring Machine (CMM).

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## Learning outcome

2 Understand how to produce components on a CNC mill

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### Topics

- 2.1 Safety issues associated with the use of a CNC mill
- 2.2 Characteristics of milled features
- 2.3 Techniques for the use of workholding devices
- 2.4 Techniques for mounting cutting tools
- 2.5 CNC programs
- 2.6 Principles of planning CNC milling operations

#### Topic 2.1

Safety issues associated with the use of a CNC mill and how they are controlled:

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

#### Topic 2.2

Characteristics of different types of features:

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

#### Topic 2.3

Techniques for the use of workholding devices:

- Mounting and removal of workholding device into/from machine
- How to mount, secure and align the workpiece.

#### Topic 2.4

Techniques for mounting cutting tools:

- Checking tools are fit for purpose
- Securing cutting tools in tool holding devices
- Set tool offset.

#### Topic 2.5

CNC programs:

- Coding (machine axes, Cartesian coordinates, machine management (spindle start/stop, coolant on/off, tool change, end of program, optional stop)
- Terminology (part programs, word address, conversational, absolute, incremental)
- 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).



## Topic 2.6

Principles of planning CNC milling operations:

- Critical path
- Sequence of operations.

---

## Learning outcome

3 Understand how to meet quality requirements for CNC milling operations

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## Topics

3.1 Monitoring machine performance

3.2 Evaluating milled components against specification requirements

### Topic 3.1

Monitoring machine performance:

- Potential defects (symptoms, causes, resolution)
- In-process checks (trial cuts, backlash, size of workpiece, surface finish of workpiece, condition of cutting tools).

### Topic 3.2

Evaluating milled components against specification:

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

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before learners go into a workshop or employer environment and develop skills. Alternatively, 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.

It is recommended that 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 milled component in the engineering information.

Working with employers would enhance the delivery of the unit. This could be through the presentation of engineering information or presentations on the types of machinery and components.

# Unit 213 Computer Aided Design (CAD)

<b>Unit level:</b>	Level 2
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<b>GLH:</b>	60
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## What is this unit about?

This unit provides the learner with knowledge of the equipment required and how to operate CAD software. They will learn about different uses of CAM and the importance of CAD to CAM operations. .

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## Learning outcomes

In this unit, learners will be able to

- 1 Know the principles of using CAD software
- 2 Understand how to operate CAD software
- 3 Understand the use of CAD/CAM in machining

## Scope of content

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### Learning outcome

- 1 Know the principles of using CAD software
- 

### Topics

- 1.1 Characteristics of a safe CAD working environment
- 1.2 Characteristics of CAD equipment
- 1.3 Applications of CAD software
- 1.4 Procedures for data management

#### Topic 1.1

Key responsibilities under the Health and Safety (Display Screen Equipment) Regulations:

- Of employees
- Of employers.

Hazards associated with the use of CAD in different environments:

- Office environments
- Workshop environments.

#### Topic 1.2

Equipment requirements for CAD:

- Minimum hardware requirements
- Peripherals
- Operating system requirements
- Software.

Characteristics of CAD user interfaces (UI):

- Toolbars
- Navigation in 3D
- Customisation.

#### Topic 1.3

Applications of CAD software:

- Modelling
- Drawing
- Analysis
- Visualisation (rendering/animation)
- Links to CAM.

#### Topic 1.4

Purpose and procedures for CAD data management:

- Labelling/file name conventions
- File format
- Version control
- Indexing
- Storage

- Security.

---

## Learning outcome

2 Understand how to operate CAD software

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## Topics

- 2.1 Process and features used in part modelling
- 2.2 Process and features used in assembly modelling
- 2.3 Process and features used to create drawings with CAD software

### Topic 2.1

Process and features used in part modelling:

- Navigation
- Create geometry
- Modify geometry
- Dimension.

### Topic 2.2

Process and features used in assembly modelling:

- Navigation
- Assemble part models (constraints, position).

### Topic 2.3

Process and features used to create drawings in CAD software:

- Navigation
- Use of pre-designed templates
- Use line types, styles and colour
- View placement
- Annotate (dimension, text, symbols).

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## Learning outcome

3 Understand the use of CAD/CAM in machining

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## Topics

3.1 Applications of Computer Aided Manufacturing (CAM)

3.2 Suitability of using CAM in machining

3.3 Key functions of CAM software

3.4 Relationship between CAD and CAM

### Topic 3.1

Applications of different types of CAM equipment and how they work:

- CNC machines (mills, lathes, cutters)
- Robotics
- Additive manufacturing (3D printers, laser sintering).

### Topic 3.2

Suitability of using CAM in machining:

- Speed
- Accuracy
- Repeatability
- Form complexity
- Links to CAD
- Equipment required.

### Topic 3.3

Characteristics of CAM functions:

- Tool path generation
- Post processing
- Data transfer.

### Topic 3.4

The importance of CAD for CAM and related future developments.

Future developments

- Generative design
- Topology optimisation (latticing).

## Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It can be delivered as an introduction before using CAD software but it is recommended that it is delivered 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 unit 202 where learners gain knowledge of drawing standards. CAD operation can help learners gain knowledge of those standards.

Learning about CAD/CAM operations would also benefit from practical activities, for example using CNC equipment in machining. This would allow learners to appreciate the importance of CAD to CAM operations.

Working with employers would enhance the delivery of the unit. This could be through masterclasses on the use of CAD software or opportunities to observe CAM equipment operating.

## Relationships to other qualifications

### Links to other qualifications

This qualification is part of a suite that contributes to the on-programme assessment of the Machinist (Advanced Manufacturing Engineering) apprenticeship. The qualifications are:

- 1272-02 Level 2 Diploma in Machining (Foundation Knowledge)
- 1272-03 Level 3 Diploma in Machining (Development Knowledge)
- 1271-02 Level 2 Diploma in Advanced Manufacturing Engineering (Foundation Competence)
- 1271-03 Level 3 Diploma in Advanced Manufacturing Engineering (Development Competence) - Machining.

### Literacy, language, numeracy and ICT skills development

These qualifications can develop skills that can be used in the following qualifications:

- Functional Skills (England) – see [City & Guilds Functional Skills](#)
- Essential Skills (Northern Ireland) – see [City & Guilds Essential Skills NI](#)
- Essential Skills Wales – see [City & Guilds Essential Skills Wales](#)



## 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:

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 Assessment**

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.

## City & Guilds

For over 140 years, we have worked with people, organisations and economies to help them identify and develop the skills they need to thrive. We understand the life-changing link between skills development, social mobility, prosperity and success. Everything we do is focused on developing and delivering high-quality training, qualifications, assessments and credentials that lead to jobs and meet the changing needs of industry.

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.

The City & Guilds community of brands includes Gen2, ILM, Intertrain, Kineo and The Oxford Group.

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City & Guilds reviews its Qualifications on a regular basis to ensure they remain current, relevant, and meet industry and learner needs.

This Qualification Handbook however may contain references to historic information, such as former organisations, obsolete frameworks, codes or standards, or retired units and qualifications. This information is included for reference purposes only.

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