City & Guilds Level 3 Diploma in Machining (Development Knowledge) (1272-03)

Version 2.3 (September 2024)

Qualification Handbook

Qualification at a glance

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

Title and level	City & Guilds qualification number	Regulatory reference number	GLH	TQT
City & Guilds Level 3 Diploma in Machining - (Development Knowledge)	1272-03	603/1706/1	510	750

Version and date	Change detail	Section
V1.0 May 2017	Initial version	All
V2.0 August 2018	Grading information updated Minor formatting issues	Grading Throughout
V2.1 August 2022	Level 3 Diploma in Machining (Development Competence), amended to Level 3 Diploma in Machining (Development Knowledge) Total Qualification Time section wording amended	Structure Total Qualification Time

V2.2 February 2023	GLH for units 301-304, and 315 amended Invigilation wording amended; Assessment title and learning outcome consistency issues amended 301, 308, 309, 310, 311, 314, 317, 318 Qualification grading information clarified Unit 314, topic 2.3 amended Guidance for delivery wording amended Minor spelling and typographical errors amended	Introduction – Qualification structure Test specifications Grading of qualification Unit 314 Unit 318 Throughout
V2.3 September 2024	Handbook reviewed and quality assurance and access statements, updated, and test supervision requirements updated to invigilation	Throughout

Contents

Introduction

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

Area	Description
Who is the qualification for?	This qualification is aimed at learners aged 16 and above who would like to gain the knowledge required for the Development phase of a Machinist (Advanced Manufacturing Engineering) apprenticeship. A learner can also take this qualification as a stand-alone option if they are self-employed or on short-term contracts that do not support the apprenticeship.
What does the qualification cover?	Learners will develop knowledge of material properties and mathematical concepts needed to be an effective Machinist. They will also learn about how engineering businesses take account of health and safety, environmental and communication considerations. They will have the opportunity to learn how to carry out advanced operations using different manual and/or CNC machines as well as concepts related to engineering design, quality inspection, CAD/CAM and organisational efficiency.
What opportunities for progression are there?	Upon completion of this qualification, learners will have developed the knowledge required for the Development phase of the apprenticeship. If all other required qualifications are achieved, they could progress to the end point assessment.
Who did we develop the qualification with?	The qualification has been developed in collaboration with the Advanced Manufacturing Engineering (Machinist) Trailblazer Group.
Is it part of an apprenticeship framework or initiative?	Yes, this qualification has been developed to be included as an on-programme component of the Development phase of the Advanced Manufacturing Engineering (Machinist) apprenticeship.

To achieve the Level 3 Diploma in Machining (Development Knowledge), learners must achieve

- mandatory units 301 – 304
- four optional units from units 305-318.

Barred combinations:

307 with either 305 or 306

310 with either 308 or 309

City & Guilds Unit number	Unit title	GLH
Mandatory units:		
301	Engineering and environmental health and safety	60
302	Communication for machinists/engineers	60
303	Properties and applications of engineering materials	60
304	Engineering maths	90
Optional units:		
305	Advanced turning techniques	60
306	Advanced milling techniques	60
307	Advanced milling and turning techniques	90
308	Advanced manufacturing CNC turning techniques	60
309	Advanced manufacturing CNC milling techniques	60
310	Advanced manufacturing techniques Computer Numerical Control (CNC)	90
311	CNC programming	60
312	Specialist machining	60
313	CAD/CAM	60
314	Precision grinding techniques	60
315	Further maths	60
316	Engineering organisational efficiency and improvement	60
317	Engineering inspection and quality control	60
318	Engineering design process	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 3 Diploma in Machining (Development Knowledge)	510	750

Centre requirements

Approval

Full approval

To offer these qualifications, 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 qualification before designing a course programme.

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 are expected to support their staff in ensuring that their knowledge remains current of the occupational area and of best practice in delivery, mentoring, training, assessment and quality assurance, and that it takes account of any national or 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 in order 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.

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 qualification
- 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[s], 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)

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)

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	www.cityandguilds.com

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Assessment

Summary of assessment methods

Candidates must:

- successfully complete short answer question papers for each mandatory unit (301-304)
- successfully complete the appropriate assessment for each optional unit selected.

Assessment strategy

City & Guilds has written the following assessments~~/assignments~~ 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
- externally set, internally marked assignments.

Assessment Types

Unit	Unit title	Assessment method	Where to obtain assessment materials
301	Engineering and environmental health and safety	Short answer questions	www.cityandguilds.com
302	Communication for machinists/engineers	Short answer questions	www.cityandguilds.com
303	Properties and applications of engineering materials	Short answer questions	www.cityandguilds.com
304	Engineering maths	Short answer questions	www.cityandguilds.com
305	Advanced turning techniques	Short answer questions	www.cityandguilds.com
306	Advanced milling techniques	Short answer questions	www.cityandguilds.com

Unit	Unit title	Assessment method	Where to obtain assessment materials
307	Advanced milling and turning techniques	Short answer questions	www.cityandguilds.com
308	Advanced manufacturing CNC turning techniques	Short answer questions	www.cityandguilds.com
309	Advanced manufacturing CNC milling techniques	Short answer questions	www.cityandguilds.com
310	Advanced manufacturing techniques Computer Numerical Control (CNC)	Short answer questions	www.cityandguilds.com
311	CNC programming	Short answer questions	www.cityandguilds.com
312	Specialist machining	Assignment	www.cityandguilds.com
313	CAD/CAM	Short answer questions	www.cityandguilds.com
314	Precision grinding techniques	Short answer questions	www.cityandguilds.com
315	Further maths	Short answer questions	www.cityandguilds.com
316	Engineering organisational efficiency and improvement	Assignment	www.cityandguilds.com
317	Engineering inspection and quality control	Short answer questions	www.cityandguilds.com
318	Engineering design process	Short answer questions	www.cityandguilds.com

Time constraints

All assessments must be completed within the candidate's period of registration. Each externally set short answer test has a maximum time allocation as stated on the test specifications below and on each test paper.

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 not allowed.

Test specifications

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

Assessment title: Engineering and environmental health and safety
Graded: X/P/M/D

Test: 301	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 301	01: Understand workplace health and safety responsibilities	22	44
	02: Understand how to maintain a safe and healthy workplace	12	24
	03: Understand environmental management requirements of engineering businesses	16	32
	Total	**50**	**100**

Assessment title: Communication for machinists/engineering
Graded: X/P/M/D

Test: 302	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 302	01: Understand how to communicate technical information	26	52
	02: Understand how to communicate general information	24	48
	Total	**50**	**100**

Assessment title: Properties and applications of engineering materials
Graded: X/P/M/D

Test: 303	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 303	01: Understand the properties of materials	16	36
	02: Understand why engineering materials fail	16	36
	03: Understand the suitability of engineering materials	13	28
	Total	**45**	**100**

Assessment title: Engineering maths

Graded: X/P/M/D

Test: 304	Duration: 60 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 304	01: Solve engineering problems using arithmetic	9	22.5
	02: Solve engineering problems using algebraic methods	10	25
	03: Solve engineering problems using trigonometric methods	9	22.5
	04: Solve engineering problems using calculus	8	20
	05 Solve engineering problems using statistics	4	10
	Total	**40**	**100**

Assessment title: Advanced turning techniques
Graded: X/P/M/D

Test: 305	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 305	01: Understand the equipment required for advanced turning operations	16	32
	02: Understand how to produce complex machined components on a lathe	26	52
	03: Understand how to meet quality requirements for advanced turning operations	8	16
	Total	**50**	**100**

Assessment title: Advanced milling techniques
Graded: X/P/M/D

Test: 306	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 306	01: Understand the equipment required for advanced milling operations	16	32
	02: Understand how to produce complex machined components on a mill	26	52
	03: Understand how to meet quality requirements for advanced milling operations	8	16
	Total	**50**	**100**

Assessment title: Advanced milling and turning techniques
Graded: X/P/M/D

Test: 307	Duration: 100 minutes		
Unit 307	**Outcome**	**Number of marks**	**Percentage %**
	01: Understand equipment required for advanced machining operations	26	43
	02: Understand how to produce complex machined components	26	43
	03: Understand how to meet quality requirements for advanced machining operations	8	14
	Total	**60**	**100**

Assessment title: Advanced manufacturing CNC turning techniques

Graded: X/P/M/D

Test: 308	Duration: 90 minutes		
Unit 308	**Outcome**	**Number of marks**	**Percentage %**
	01: Understand equipment required for CNC operations on multi-axis CNC machines	16	32
	02: Understand how to produce complex components on multi-axis CNC lathes	26	52
	03: Understand how to meet quality requirements for advanced CNC turning operations	8	16
	Total	**50**	**100**

Assessment title: Advanced manufacturing CNC milling techniques

Graded: X/P/M/D

Test: 309	Duration: 90 minutes		
Unit 309	**Outcome**	**Number of marks**	**Percentage %**
	01: Understand equipment required for CNC operations on multi-axis CNC milling machines	16	32
	02: Understand how to produce complex components on multi-axis CNC milling machines	26	52
	03: Understand how to meet quality requirements for advanced CNC milling operations	8	16
	Total	**50**	**100**

Assessment title: Advanced manufacturing techniques Computer Numerical Control (CNC)

Graded: X/P/M/D

310	Duration: 90 minutes		
Unit 310	**Outcome**	**Number of marks**	**Percentage %**
	01: Know the equipment required for CNC operations on multi-axis CNC machines	16	32
	02: Understand how to produce complex components on multi-axis CNC machines	26	52
	03: Understand how to meet quality requirements for advanced CNC operations	8	16
	Total	**50**	**100**

Assessment title: CNC programming
Graded: X/P/M/D

Test: 311	Duration: 60 minutes		
	Outcome	**Number of marks**	**%**
Unit 311	01: Understand equipment required for CNC machining	8	20
	02: Understand how to produce programs for CNC machining	32	80
	Total	**40**	**100**

Assessment title: CAD/CAM
Graded: X/P/M/D

Test: 313	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 313	01: Understand the application of Computer Aided Engineering (CAE)	14	28
	02: Understand how to operate CAD software to produce complex designs	22	44
	03: Understand the use of CAD/CAM in machining	14	28
	Total	**50**	**100**

Assessment title: Precision grinding techniques
Graded: X/P/M/D

Test: 314	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 314	01: Know equipment required for precision grinding	16	32
	02: Understand how to produce complex components with precision grinding machines	26	52
	03: Understand how to meet quality requirements for precision grinding operations	8	16
	Total	**50**	**100**

Assessment title: Further maths
Graded: X/P/M/D

Test: 315	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 315	01: Solve engineering problems using algebraic methods	19	38
	02: Solve engineering problems using trigonometric methods	15	30
	03: Solve engineering problems using calculus	16	32
	Total	**50**	**100**

Assessment title: Engineering inspection and quality control
Graded: X/P/M/D

Test: 317	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 317	01: Understand the principles and applications of quality management systems	18	30
	02: Understand the application of measurement techniques	22	37
	03: Understand the application of Statistical Process Control (SPC) to manage product quality	20	33
	Total	**60**	**100**

Assessment title: Engineering design process
Graded: X/P/M/D

Test: 318	Duration: 90 minutes		
	Outcome	**Number of marks**	**Percentage %**
Unit 318	01: Understand the design process	18	36
	02: Understand the factors considered when designing a product	15	30
	03: Understand how manufacturing processes influence design	17	34
	Total	**50**	**100**

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/marking 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 **eight** 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	2
Merit	3
Distinction	4

- Grade points for each of the **eight** assessments need to be added together in line with the qualification structure, and the overall qualification grade determined, using the following conversion table:

Total grade points	Overall qualification grade
16 -20	Pass
21 - 27	Merit
28 - 32	Distinction

- Overall grade calculation must include the four mandatory and four optional units only, as shown in the example below. If any additional optional units are taken the four highest scoring optional units must be used in the overall grade calculation.

Example
Learner A has achieved the following:

Assessment	Grade achieved	Grade points
Mandatory		
1273-301	Pass	2
1273-302	Pass	2
1273-303	Pass	2
1273-304	Merit	3
Optional		
1273-3xx	Distinction	4

1273-3xx	Pass	2
1273-3xx	Merit	3
1273-3xx	Merit	3
	Total grade points	**21**
	Overall qualification grade	**Merit**

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

  904 Pass
  905 Merit
  906 Distinction

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 301 Engineering and environmental health and safety

Unit level:	Level 3
GLH:	60

What is this unit about?

The aim of this unit is for learners to develop their knowledge of their health and safety responsibilities when working in an engineering business. They will learn about health and safety legislation and how the business' activities could impact on the environment. They will also learn about the types of documentation require to adhere to Health and safety policies.

Learning outcomes

In this unit, learners will be able to

1 Understand workplace health and safety responsibilities
2 Understand how to maintain a safe and healthy workplace
3 Understand environmental management requirements of engineering businesses

Scope of content

Learning outcome

1 Understand workplace health and safety responsibilities

Topics

1.1 Responsibilities under legislation
1.2 Roles of key people involved in workplace health and safety
1.3 Roles of organisations involved in workplace health and safety

Topic 1.1

Key responsibilities of employers and employees under legislation:

- Health and Safety at Work etc Act
- Management of Health and Safety at Work Regulations
- Control of Substances Hazardous to Health (COSHH)
- Provision and Use of Work Equipment Regulations (PUWER)
- Personal Protective Equipment Regulations
- Manual Handling Operations Regulations
- Lifting Operations and Lifting Equipment Regulations (LOLER)
- Noise at Work Regulations
- Vibration at Work Regulations
- Electricity at Work Regulations
- The Health and Safety (Display Screen Equipment) Regulations
- Reportable Diseases and Dangerous Occurrences Regulations (RIDDOR).

Topic 1.2

Roles of key health and safety personnel in a workplace and how they may differ depending on the type of organisation:

- Health and safety representatives
- Environmental health officers
- Health and Safety Executive Inspectors
- First aiders
- Fire marshalls/wardens.

Topic 1.3

Roles of organisations involved in workplace health and safety and actions that can be taken in specific situations:

- Health and Safety Executive (HSE)
- Local authorities
- Environmental health agency
- Fire authority
- Trade unions.

Learning outcome

2 Understand how to maintain a safe and healthy workplace

Topics

2.1 Organisational safety requirements
2.2 Risk assessment

Topic 2.1

Procedures and supporting documentation for workplace health and safety:

- For fire prevention
- For emergency evacuation
- For near misses
- For accidents
- For machining operations
- For maintenance
- For storage of materials
- For movement of materials.

Topic 2.2

Requirements and procedures involved in producing a risk assessment:

- Hierarchy of control and how it is applied in different situations (elimination, substitution, controls, safe systems of work, personal protective equipment)
- Hazard, likelihood, severity, risk rating, who affect and how
- Review process.

Learning outcome

3 Understand environmental management requirements of engineering businesses

Topics

3.1 Key requirements of environmental legislation and standards
3.2 Relationship between human and environmental conditions in the workplace
3.3 Energy and waste

Topic 3.1

Key requirements of environmental legislation and standards:

- Environmental Protection Act
- Pollution Prevention and Control Act
- Clean Air Act
- Radioactive Substances Act
- Waste Regulations
- Dangerous Substances and Preparations and Chemicals Regulations
- ISO14001.

Topic 3.2

Relationship between human and environmental conditions in the workplace and how they are controlled:

- Human conditions (lack of management control, carelessness, improper behaviour and dress, lack of training, supervision and experience, fatigue, drug-taking, alcohol)
- Environmental conditions (unguarded or faulty machinery, equipment and tools, inadequate ventilation, untidy, dirty, overcrowded workplace, inadequate lighting).

Topic 3.3

- Sources of energy and their environmental impact (fossil, renewable, nuclear)
- Types and likely causes of industrial emissions and methods used for mitigation
- Requirements for the safe disposal and recycling of waste
- Procedures required for energy audits and implications of findings.

Guidance for delivery

This is a theory unit that provides opportunities for learners to input on their own experiences when working in an engineering environment. The use of case studies from a range of different types of business would enable learners to grasp the scale and scope that health and safety has on the industry. Case studies can also be used to consider the impact of an engineering activities on the environment.

Gaining an understanding of health, safety and the environment can be developed through practical activities where learners complete documentation related to real machining tasks.

There are opportunities to work with employers who can provide case studies of how policies and procedures have prevented incidents. They can also provide examples of real documentation used in their business.

Unit 302 Communication for machinists/engineers

Unit level:	Level 3
GLH:	60

What is this unit about?

The aim of this unit is for learners to develop their understanding of how to communicate with an engineering business. They will learn about communicating with both general and technical information. This will include research methodologies and understanding engineering drawings. They will also learn about the types of documentation required to effectively communicate within their business.

Learning outcomes

In this unit, learners will be able to

1 Understand how to communicate technical information
2 Understand how to communicate general information

Scope of content

Learning outcome

1 Understand how to communicate technical information

Topics

1.1 Research methods
1.2 Sources of technical information
1.3 Diagrammatic representation of technical information

Topic 1.1

Process for obtaining primary and secondary information:

- Identify requirements
- Gather
- Record sources
- Collate
- Evaluate
- Synthesise.

Types of information:

- Qualitative
- Quantitative.

Criteria for evaluating information:

- Credibility
- Bias
- Assumptions
- Validity
- Sufficiency
- Currency.

Topic 1.2

Characteristics of sources of technical information:

- Characteristics (information provided, location)
- Types of technical information (manufacturers' specifications, technical manuals, engineering drawings, schematics, reference books, standard operating procedures (SOPs), method statements, job cards).

Suitability of sources for different engineering problems:

- Technical problems (materials, processes, equipment, skills)
- Commercial problems (finance, time, risk/reward).

Topic 1.3

Interpretation of different types of diagrammatic representation:

- Types of diagrammatic representation (sketches, drawings, models, graphs)
- Interpret (symbols, geometric dimensioning and tolerancing (GDT), dimensions, tolerances, different views, imperial and metric systems of measurement, labels, data, axes, lines).

Creation of diagrammatic representation:

- Use conventions and standards (sketches, drawings, models, graphs)

- Views and layouts.

Learning outcome

2 Understand how to communicate general information

Topics

2.1 Principles of communication
2.2 Business documentation
2.3 Barriers to communication
2.4 Information Communication Technology (ICT) applications
2.5 Information security

Topic 2.1

Principles of communication:

- Two way process
- Content (language, structure, organisation, legal requirements/constraints, relevance)
- Presentation (house style, tone, style)
- Context (audience, location, purpose, timescale)
- Types (oral, non-verbal, written).

Topic 2.2

Conventions and suitability of different types of communication records:

- Conventions (layout, format, structure, content)
- Types of communication records (policies, protocols, contracts, notes, minutes, emails, letters, websites, social media, images, texts).

Topic 2.3

Characteristics of barriers to communication and how these can be overcome:

- Physical
- Technical
- Emotional
- Attitude.

Topic 2.4

Characteristics of ICT applications and their suitability for communicating different types of information:

- Word-processing
- Spreadsheets
- Databases
- Presentation.

Topic 2.5

Security of information records:

- Threats to security of information records (digital, physical)
- Procedures used to minimise security risks
- Commercial and personal consequences of non-compliance
- Key requirements of data protection legislation.

Procedures for managing information records and their application:

- Storage
- Retrieval
- Archiving
- Retention
- Classification
- Labelling/indexing
- Version control
- Internal controls.

Guidance for delivery

This is a theory unit that provides opportunities for learners to input on their own experiences when communicating in an engineering environment. The use of case studies from a range of different types of business would enable learners to understand the uses of different types of communication. Case studies can also be used to demonstrate best practice of communication by machinists.

Gaining an understanding of technical information can be developed through practical activities where learners research and interpret engineering information from a range of sources related to real machining tasks.

There are opportunities to work with employers who can provide case studies and examples of engineering technical information. They can also provide examples of real documentation used in their business communications.

Unit 303 Properties and applications of engineering materials

Unit level:	Level 3
GLH:	60

What is this unit about?

The purpose of this unit is for learners to understand the behaviours and properties of 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 complex components for a range of specific situations. This also supports the learner in selecting and testing the most appropriate materials to satisfy the requirements for different types of application.

Learning outcomes

In this unit, learners will be able to

1 Understand the properties of materials
2 Understand why engineering materials fail
3 Understand the suitability of engineering materials

Scope of content

Learning outcome

1 Understand the properties of materials

Topics

1.1 Properties of materials
1.2 Structure of materials
1.3 Effects of processing on the properties of materials

Topic 1.1

Properties of materials:

- Mechanical (strength (compressive, shear, tensile), hardness, toughness, ductility, durability, malleability, elasticity, plasticity)
- Physical (conductivity (thermal, electrical), density, melting temperature, permeability, thermal expansion, corrosion resistance).

Classification of materials:

- Metals (cast iron, aluminium alloys, titanium, steels, copper)
- Natural (natural polymers, rubber, wood, stone)
- Synthetic (neoprene, thermoplastics, thermosets, composites)
- Engineering ceramics (tungsten carbide, silicon carbide, alumina).

Topic 1.2

Relationship between material structures and properties:

- Periodic table
- Atomic structure
- Molecular structure
- Bonding mechanisms
- Structure (lattice, grain, crystals)
- Cross linking of polymers.

Topic 1.3

Effects of processing on material properties:

- Cutting
- Forming (rolling, forging, moulding)
- Welding
- Sintering
- Coating
- Heat treatments (case hardening, annealing, quenching, tempering, precipitation hardening)
- Hot working
- Cold working.

Learning outcome

2 Understand why engineering materials fail

Topics

2.1 Causes of engineering materials failure
2.2 Symptoms of engineering materials failure
2.3 Methods of testing for engineering materials failure

Topic 2.1

Causes of engineering materials failure:

- Chemical
- Physical
- Design
- Manufacture.

Topic 2.2

Symptoms of engineering materials failure:

- Fracture
- Fatigue
- Creep.

Topic 2.3

Methods of testing:

- Destructive (tensile, shear, hardness, corrosion, wear resistance, impact)
- Non-destructive (visual, penetrant, radiographic, magnetic powder, ultrasonic).

Learning outcome

3 Understand the suitability of engineering materials

Topics

3.1 Factors affecting selection of engineering materials
3.2 Criteria from engineering information

Topic 3.1

Factors affecting selection of engineering materials:

- Application
- Properties
- Environment
- Availability
- Sustainability
- Costs.

Topic 3.2

Use engineering information to determine criteria for suitability of engineering materials:

- Standard (British Standards (BS), European Standards (EN), International Standards (ISO))
- Manufacturers' information (data sheets, catalogues, websites).
- Specifications.

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, selecting appropriate materials for machining based on their mechanical properties. Practical activities involving machining different types of materials can be used to discuss the atomic structure of these materials, as learners experience the ease and/or difficulty of working with them in different applications.

Employers can be engaged to support delivery with examples of activities where the theory can be applied e.g. costing materials for specific applications.

Unit 304 Engineering maths

Unit level:	Level 3
GLH:	90

What is this unit about?

The purpose of this unit is for learners to understand the principles of mathematics and apply these to solve engineering problems. They will learn the principles of arithmetic, trigonometry, calculus, algebraic methods and statistics and how these can be applied in a range of engineering contexts.

Learning outcomes

In this unit, learners will be able to

1 Solve engineering problems using arithmetic
2 Solve engineering problems using algebraic methods
3 Solve engineering problems using trigonometric methods
4 Solve engineering problems using calculus
5 Solve engineering problems using statistics

Scope of content

Learning outcome

1 Solve engineering problems using arithmetic

Topics

1.1 Apply arithmetic methods
1.2 Apply standard formulae

Topic 1.1

Apply arithmetic methods

- Addition, subtraction, multiplication, division
- Order of operation
- Decimal places
- Significant figures
- SI units (metric) and prefixes
- Ratio, proportions
- Transposition
- Fractions.

Topic 1.2

Apply standard formulae:

- Area of simple and compound 2D shapes
- Surface area and volume of simple and compound 3D shapes
- Calculating density and mass.

Learning outcome

2 Solve engineering problems using algebraic methods

Topics

2.1 Solve problems using equations
2.2 Solve problems using rules of indices
2.3 Solve problems using logarithms

Topic 2.1

Solve problems using equations:

- Simplifying equations and functions
- Manipulating equations to change the subject.

Topic 2.2

Solve problems using rules of indices.

Topic 2.3

Solve problems with logarithms:

- Laws of logarithms
- Use of natural logarithms
- Changing the base.

Learning outcome

3 Solve engineering problems using trigonometric methods

Topics

3.1 Use trigonometry on right angled triangles
3.2 Apply sine and cosine rules to engineering problems
3.3 Radian measure

Topic 3.1

Use trigonometry on right angled triangles:

- Calculate
- Length of unknown side from two other sides
- Length of unknown side from a known angle and length
- Unknown angle from two lengths.

Topic 3.2

Apply sine and cosine rules to solve engineering problems:

- Solution of triangles, by applying sine and cosine rules.

Topic 3.3

Radian measure:

- Using radians
- Convert angles between radians and degrees.

Learning outcome

4 Solve engineering problems using calculus

Topics

4.1 Solving problems relating to graphs
4.2 Solving problems using differentiation and integration

Topic 4.1

Solving problems relating to graphs:

- Interpret changes in an engineering system from a graph
- Express equations of a straight line using a graph.

Topic 4.2

Solving problems using differentiation and integration:

- Standard integrals
- Calculation of turning points maximum, minimum and optimal values.

Learning outcome

5 Solve engineering problems using statistics

Topics

5.1 Calculation of averages
5.2 Central tendency and dispersion

Topic 5.1

Calculation of averages:

- Mean
- Median
- Mode.

Topic 5.2

Central tendency and dispersion:

- Cumulative frequency and variance
- Standard deviation.

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 polar coordinates for machining operations. Gear ratios can be applied when setting up speeds and feeds on machines. Statistical methods can be used to produce an SPC analysis.

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 305 Advanced turning techniques

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit enables the learner to acquire the essential knowledge and understanding needed to develop advanced turning skills. This unit provides the learner with knowledge of the tools, equipment and machinery used to create complex turned components. They will learn how to set up, operate and plan the use of machinery to create complex turned components safely and efficiently. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a complex turned component against a specification.

Learning outcomes

In this unit, learners will be able to

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

Scope of content

Complex turned components require the combination of a number of different types of features.

Learning outcome

1 Understand equipment required for advanced turning operations

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Topics

1.1 Parts of a lathe
1.2 Workholding devices
1.3 Cutting tools

Topic 1.1

Characteristics, function and considerations of parts of a lathe and how they interact to achieve machining operations:

- Safety features
- Tool holding devices
- Mechanical parts
- Electrical/electromechanical parts (controls, digital readout).

Topic 1.2

Characteristics, function and considerations for the use of workholding devices:

- Chucks (3 jaw, 4 jaw, collet)
- Face plates
- Between centres
- Steadies (travelling steadies, fixed steadies, self-centering steadies).

Topic 1.3

Characteristics, functions and limitations of cutting tools:

- Tool types (roughing and finishing, turning, boring, grooving, undercutting, parting, forming, chamfering, reaming, tapping, threading, drilling)
- Characteristics (tool angles (rake and clearance, approach), materials, ISO Coding for indexable inserts)
- Tool posts (fixed, indexable)
- Materials (tungsten carbide, ceramic coatings)
- Effects of cutting fluids and compounds.

Learning outcome

2 Understand how to produce complex turned components on a lathe

Topics

2.1 Safety issues
2.2 Information required to produce turned features
2.3 Techniques for the use of workholding devices
2.4 Techniques for mounting cutting tools
2.5 Calculations required for turning operations
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

Information required to create different types of features:

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, multi-start, square).

Information:

- Datum
- Sizes
- Material
- Tooling
- Measuring instruments
- Speeds and feeds.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

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 cutting tools:

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

Topic 2.5

Calculations required for turning operations in different machining conditions:

- Speeds
- Feeds
- Counterweight position
- Power requirements
- Tapers using precision balls.

Topic 2.6

Principles of planning turning operations:

- Critical path
- Sequence of operations.

Learning outcome

3 Understand how to meet quality requirements for advanced turning operations

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 (Coordinate Measuring Machine (CMM), trial cuts, dimensions and tolerances of workpiece, surface finish, condition of tools, time, effects of temperature, cost).

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 is beneficial for learners to have prior knowledge of the use of lathes. If this is not the case it may be advantageous for learners to undertake introductory sessions related to basic turning techniques.

This unit is designed to be delivered alongside practical workshop or real work 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 complex turned component presented 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 306 Advanced milling techniques

Unit level:	Level 3
GLH:	60

What is this unit about?

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

Learning outcomes

In this unit, learners will be able to

1 Understand equipment required for advanced milling operations
2 Understand how to produce complex machined components on a milling machine
3 Understand how to meet quality requirements for advanced milling operations

Scope of content

Complex machined components require the combination of a number of different types of features.

Learning outcome

1 Understand equipment required for advanced milling operations

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Topics

1.1 Parts of a milling machine
1.2 Workholding devices
1.3 Cutting tools

Topic 1.1

Characteristics, function and considerations of parts of a vertical and horizontal milling machine and how they interact to achieve machining operations:

- Safety features
- Tool holding devices
- Mechanical parts (slides, lead screws, spindles, arbours)
- Electrical/electromechanical parts (drives, pumps, motors, controls).

Topic 1.2

Characteristics, function and considerations for the use of workholding devices:

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

Topic 1.3

Characteristics, functions and limitations of cutting tools:

- Tool types (end mill, slot drill, shell cutter, bullnose cutter, face mill, fly cutter, dovetail cutter, drills, reamers, taps, woodruff cutter)
- Characteristics (tool angles, materials, ISO Coding for indexable inserts)
- Materials (Tungsten carbide, ceramic, high speed steel, coatings)
- Effects of cutting fluids and compounds.

Learning outcome

2 Understand how to produce complex machined components on a milling machine

Topics

2.1 Safety issues
2.2 Information required to produce machined features
2.3 Techniques for the use of workholding devices
2.4 Techniques for mounting cutting tools
2.5 Calculations required for milling operations
2.6 Principles of planning milling operations

Topic 2.1
Safety issues associated with the use of a milling machine and how they are controlled:

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

Topic 2.2
Information required to create different types of features:

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.

Information:

- Datum
- Sizes
- Material
- Tooling
- Measuring instruments
- Speeds and feeds.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

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 cutting tools:

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

Topic 2.5
Calculations required for milling operations in different machining conditions:

- Speeds
- Feeds
- Power requirements
- Pitch Circle Diameters (PCDs)
- Dividing head (40:1).

Topic 2.6
Principles of planning milling operations**:**

- Critical path
- Sequence of operations.

Learning outcome

3 Understand how to meet quality requirements for advanced milling operations

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 (CMM, trial cuts, dimensions and tolerances of workpiece, surface finish, condition of tools, time, effects of temperature, cost).

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 alongside practical workshop or real work 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 complex components. Learners can then consider the operational requirements and processes that will deliver the complex milled component presented 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 complex components that are manufactured in the engineering environment.

Unit 307 Advanced milling and turning techniques

Unit level:	Level 3
GLH:	90

What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create complex machined components. They will learn how machinery is set up and operated safely and the processes to be followed to create complex machined components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a complex machined component against a specification.

Learning outcomes

In this unit, learners will be able to

1 Understand equipment required for advanced machining operations
2 Understand how to produce complex machined components
3 Understand how to meet quality requirements for advanced machining operations

Scope of content

The content of this unit relates to both milling and turning operations.

Complex machined components require the combination of a number of different types of features.

Learning outcome

1 Understand equipment required for advanced machining operations

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Topics

1.1 Parts of a milling machine
1.2 Parts of a lathe
1.3 Workholding devices
1.4 Cutting tools

Topic 1.1
Characteristics, function and considerations of parts of a milling machine and how they interact to achieve machining operations:

- Safety features
- Tool holding devices
- Mechanical parts
- Electrical/electromechanical parts (drives, pumps, motors, controls).

Topic 1.2
Characteristics, function and considerations of parts of a lathe and how they interact to achieve machining operations:

- Safety features
- Tool holding devices
- Mechanical parts
- Electrical/electromechanical parts (digital readouts, controls).

Topic 1.3
Characteristics, function and considerations for the use of workholding devices:

- Machine vice (fixed, swivel, hydraulic)
- Dividing head
- Between centres
- Steadies (travelling steadies, fixed steadies)
- Fixtures
- Chucks (3 jaw, 4 jaw, collet).

Topic 1.4
Characteristics, functions and limitations of cutting tools:

- Tool types (end mill, slot drill, shell cutter, bullnose cutter, drills, reamers, taps, roughing and finishing, parting, chamfering, reaming, threading, boring)
- Characteristics (tool angles (rake and clearance, approach), materials, ISO Coding for indexable inserts)
- Effects of cutting fluids and compounds.

Learning outcome

2 Understand how to produce complex machined components

Topics

2.1 Safety issues
2.2 Information required to produce machined features
2.3 Techniques for the use of workholding devices
2.4 Techniques for mounting cutting tools
2.5 Calculations required for machining operations
2.6 Principles of planning machining operations

Topic 2.1

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

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

Topic 2.2

Information required to create different types of features:

Types of features:

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

Information:

- Datum
- Sizes
- Material
- Tooling
- Measuring instruments
- Speeds and feeds.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

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 cutting tools:

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

Topic 2.5

Calculations required for machining operations in different machining conditions:

- Speeds
- Feeds
- Tapers using precision balls
- Counterweight positions
- Pitch Circle Diameters (PCDs)
- Dividing head (40:1).

Topic 2.6

Principles of planning machining operations:

- Critical path
- Sequence of operations.

Learning outcome

3 Understand how to meet quality requirements for advanced machining operations

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 (Coordinate Measuring Machine (CMM), trial cuts, dimensions and tolerances of workpiece, surface finish, condition of tools, time, effects of temperature, cost).

Topic 3.2

Evaluating machined 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 for using milling machines and lathes. It can be delivered alongside practical workshop or real work 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 complex components. Learners can then consider the operational requirements and processes that will deliver the complex machined component presented 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 complex components that are manufactured in the engineering environment.

Unit 308 Advanced manufacturing CNC turning techniques

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create complex components on multi-axis CNC lathes. They will learn how machinery is set up and operated safely and the processes to be followed to create complex components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a complex component against a specification.

Learning outcomes

In this unit, learners will be able to

1 Understand equipment required for CNC operations on multi-axis CNC machines
2 Understand how to produce complex components on multi-axis CNC lathes
3 Understand how to meet quality requirements for advanced CNC turning operations

Scope of content

Complex machined components require the combination of a number of different features.

Learning outcome

1 Understand equipment required for CNC operations on multi-axis CNC machines

Topics

1.1 CNC lathe parts
1.2 Material loading and workholding devices
1.3 Tooling on multi-axis machines

Topic 1.1

Characteristics, function and considerations of multi-axis CNC lathe parts and how they interrelate to achieve machining operations:

- Safety devices
- Tool holding devices
- Mechanical parts
- Electrical/electronic parts (DC and AC drives, controls).

Topic 1.2

Characteristics, function and considerations for the use of material loading and workholding devices:

- Bar feeders/pullers
- Face drivers
- Robots
- Hydraulic chucks (hard jaw, soft jaw).

Topic 1.3

Function and limitations of different types of tooling used on multi-axis CNC lathes:

- Cutting tools
- Live tooling
- Sister tooling
- Preset tooling
- Qualified tooling
- Through coolant tooling.

Types of indexing:

- Materials
- Coding.

Learning outcome

2 Understand how to produce complex components on multi-axis CNC lathes

Topics

2.1 Safety issues
2.2 Component features
2.3 Mounting tools
2.4 CNC programs
2.5 Planning CNC operations

Topic 2.1

Safety issues associated with the use of multi-axis CNC lathes and how they are controlled:

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

Topic 2.2

Information required to create different types of complex component features:

Features:

- Faces (datum, flat, perpendicular, parallel, tapered)
- Diameters (internal, external, bored, tapered, concentric, eccentric)
- Holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, tapered)
- Non-standard threads (multi-start, acme, square, non-standard pitch)
- Complex profiles.

Information:

- Datum (datum shift)
- Coordinates
- Tooling
- Order of indexing.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

Topic 2.3

Techniques for mounting tools:

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

Topic 2.4

Use machine codes:

- Rapid motion
- Linear motions
- Circular motions
- Coolant
- Tool change
- Spindle start
- Spindle stop
- Program stop.

Use preparatory function codes:

- Absolute programming
- Incremental programming
- Feed per revolution
- Feed per minute
- Speed per revolution
- Speed per minute
- Metric
- Imperial.

Determine machine axes:

- Primary
- Secondary
- Auxiliary.

Determine coordinates:

- Absolute
- Incremental
- Polar
- Cartesian.

Define terminology:

- Part programs
- Word address
- Conversational
- Lead in
- Lead out
- Sub-routine/labels
- Canned cycles/process pages.

Limitations of methods of inputting program:

- Manual
- USB flash drive
- Intranet
- Direct Numerical Control (DNC).

Suitability of methods of proving part programs:

- Proof read
- Graphic simulation
- Single block
- Rapid override.

Topic 2.5

Principles of planning CNC operations:

- Critical path
- Sequence of operations
- Tooling collision
- Optimisation.

Learning outcome

3 Understand how to meet quality requirements for advanced CNC turning operations

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 (probing, trial cuts, dimensions and tolerances of workpiece, surface finish of workpiece, condition of tools, timing, repeatability, effects of temperature).

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 is beneficial for learners to have prior knowledge of the use of CNC machines and/or basic machining operations. If this is not the case it may be advantageous for learners to undertake introductory sessions related to basic machining techniques.

This unit is designed to be delivered alongside practical workshop or real work 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 complex 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 programs which can be reviewed.

Unit 309 Advanced manufacturing CNC milling techniques

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create complex components on multi-axis CNC milling machines. They will learn how machinery is set up and operated safely and the processes to be followed to create complex components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a complex component against a specification.

Learning outcomes

In this unit, learners will be able to

1 Understand equipment required for CNC operations on multi-axis CNC milling machines
2 Understand how to produce complex components on multi-axis CNC milling machines
3 Understand how to meet quality requirements for advanced CNC milling operations

Scope of content

Complex machined components require the combination of a number of different features.

Learning outcome

1 Understand equipment required for CNC operations on multi-axis CNC milling machines

Topics

1.1 CNC milling machine parts
1.2 Material loading and workholding devices
1.3 Tooling on multi-axis machines

Topic 1.1

Characteristics, function and considerations of multi-axis CNC milling machine parts and how they interrelate to achieve machining operations:

- Safety devices
- Tool holding devices
- Mechanical parts
- Electrical/electronic parts (DC and AC drives, controls).

Topic 1.2

Characteristics, function and considerations for the use of material loading and workholding devices:

- Robots
- Pallet changers
- Tooling columns (tombstones)
- Hydraulic vices
- Fixtures.

Topic 1.3

Function and limitations of different types of tooling used on multi-axis CNC milling machines:

- Cutting tools
- Sister tooling
- Preset tooling
- Qualified tooling
- Through coolant tooling.

Types of indexing:

- Materials
- Coding.

Learning outcome

2 Understand how to produce complex components on multi-axis CNC milling machines

Topics

2.1 Safety issues
2.2 Component features
2.3 Mounting tools
2.4 CNC programs
2.5 Planning CNC operations

Topic 2.1

Safety issues associated with the use of multi-axis CNC milling machines and how they are controlled:

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

Topic 2.2

Information required to create different types of complex component features:

Features:

- Faces (datum, flat, perpendicular, parallel, tapered)
- Slots (open, enclosed, helical, blind, through)
- Pockets (regular, complex, blind, through)
- Holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, tapered)
- Complex profiles.

Information:

- Datum (datum shift)
- Coordinates
- Tooling
- Order of indexing.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

Topic 2.3

Techniques for mounting tools:

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

Topic 2.4

Use machine codes:

- Rapid motion
- Linear motions
- Circular motions
- Coolant
- Tool change
- Spindle start
- Spindle stop
- Program stop.

Use preparatory function codes:

- Absolute programming
- Incremental programming
- Feed per revolution
- Feed per minute
- Speed per revolution
- Speed per minute
- Metric
- Imperial.

Determine machine axes:

- Primary
- Secondary
- Auxiliary.

Determine coordinates:

- Absolute
- Incremental
- Polar
- Cartesian.

Define terminology:

- Part programs
- Word address
- Conversational
- Lead in
- Lead out
- Sub-routine/labels
- Canned cycles/process pages.

Limitations of methods of inputting program:

- Manual
- USB flash drive
- Intranet
- Direct Numerical Control (DNC).

Suitability of methods of proving part programs:

- Proof read
- Graphic simulation
- Single block
- Rapid override.

Topic 2.5

Principles of planning CNC operations:

- Critical path
- Sequence of operations
- Tooling collision
- Optimisation.

Learning outcome

3 Understand how to meet quality requirements for advanced CNC milling operations

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 (probing, trial cuts, dimensions and tolerances of workpiece, surface finish of workpiece, condition of tools, timing, repeatability, effects of temperature).

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 is beneficial for learners to have prior knowledge of the use of CNC machines and/or basic machining operations. If this is not the case it may be advantageous for learners to undertake introductory sessions related to basic machining techniques.

This unit is designed to be delivered alongside practical workshop or real work 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 complex 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 programs which can be reviewed.

Unit 310 Advanced manufacturing techniques Computer Numerical Control (CNC)

Unit level:	Level 3
GLH:	90

What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create complex components on multi-axis CNC machines. They will learn how machinery is set up and operated safely and the processes to be followed to create complex components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a complex component against a specification.

Learning outcomes

In this unit, learners will be able to

1 Know equipment required for CNC operations on multi-axis CNC machines
2 Understand how to produce complex components on multi-axis CNC machines
3 Understand how to meet quality requirements for advanced CNC operations

Scope of content

The unit requires learning to be focussed on multi-axis CNC lathes and multi-axis CNC milling machines.

Complex machined components require the combination of a number of different types of features.

Learning outcome

1 Know equipment required for CNC operations on multi-axis CNC machines

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Topics

1.1 CNC machine parts
1.2 Material loading and workholding devices
1.3 Tooling on multi-axis machines

Topic 1.1

Characteristics, function and considerations of multi-axis CNC machine parts and how they interrelate to achieve machining operations:

- Safety devices
- Tool holding devices
- Mechanical parts (beds, slideways, lead screws, conveyors)
- Electrical/electronic parts (DC and AC drives, controls).

Topic 1.2

Characteristics, function and considerations for the use of material loading and workholding devices:

- Bar feeders/pullers
- Face drivers
- Robots
- Pallet changers
- Tooling columns (tombstones)
- Hydraulic vices
- Fixtures.

Topic 1.3

Function and limitations of different types of tooling used on multi-axis CNC machines:

- Cutting tools
- Live tooling
- Sister tooling
- Preset tooling
- Qualified tooling
- Through coolant tooling.

Types of materials:

- Tungsten carbide
- Ceramic
- Coatings.

Types of indexing:

- Materials
- Coding.

Learning outcome

2 Understand how to produce complex components on multi-axis CNC machines

Topics

2.1 Safety issues
2.2 Component features
2.3 Mounting tools
2.4 CNC programs
2.5 Planning CNC operations

Topic 2.1

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

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

Topic 2.2

Information required to create different types of complex component features:

Features:

- Faces (datum, flat, perpendicular, parallel, tapered)
- Diameters (internal, external, bored, tapered, concentric, eccentric)
- Slots (open, enclosed, helical, blind, through)
- Pockets (regular, complex, blind, through)
- Holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, tapered)
- Non-standard threads (multi-start, acme, square, non-standard pitch)
- Complex profiles.

Information:

- Datum (datum shift)
- Coordinates
- Tooling
- Order of indexing.

Topic 2.3

Techniques for mounting tools:

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

Topic 2.4

Use machine codes:

- Rapid motion
- Linear motions
- Circular motions
- Coolant
- Tool change
- Spindle start
- Spindle stop
- Program stop.

Use preparatory function codes:

- Absolute programming
- Incremental programming
- Feed per revolution
- Feed per minute
- Speed per revolution
- Speed per minute
- Metric
- Imperial.

Determine machine axes:

- Primary
- Secondary
- Auxiliary.

Define terminology:

- Word address
- Conversational
- Lead in
- Lead out
- Sub-routine/labels
- Canned cycles/process pages
- Tool locations.

Limitations of methods of inputting programs:

- Manual
- USB flash drive
- Intranet
- Direct Numerical Control (DNC).

Suitability of methods of proving part programs:

- Proof read
- Graphic simulation
- Single block
- Rapid override.

Topic 2.5

Principles of planning CNC operations:

- Critical path
- Sequence of operations
- Tooling collision
- Optimisation.

Learning outcome

3 Understand how to meet quality requirements for advanced CNC operations

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 (probing, trial cuts, dimensions and tolerances of workpiece, surface finish of workpiece, condition of tools, timing, repeatability, effects of temperature).

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

The unit requires learning to be focussed on multi axis CNC lathes and multi axis CNC milling machines.

This is a theory unit intended to underpin the development of practical skills. It is beneficial for learners to have prior knowledge of the use of CNC machines and/or basic machining operations. If this is not the case it may be advantageous for learners to undertake introductory sessions related to basic machining techniques.

This unit is designed to be delivered alongside practical workshop or real work 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 complex 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 programs that can be reviewed.

Unit 311 CNC programming

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create components with CNC machines. They will learn how machinery is set up and operated safely and the processes to be followed to create components. Learners will learn about the information required to create a CNC program. Learners will also develop an understanding of quality requirements and how they can evaluate the quality of a milled and turned component against a specification.

Learning outcomes

In this unit, learners will be able to

1 Understand equipment required for CNC machining
2 Understand how to produce programs for CNC machining

Scope of content

This unit relates to the programming of a minimum three axis CNC milling and turning machines.

Learning outcome

1 Understand equipment required for CNC machining

Topics

1.1 Machine parts
1.2 Equipment required

Topic 1.1

Characteristics, function and considerations of multi-axis CNC machine parts and how they interrelate to achieve machining operations:

- Safety devices
- Tool holding devices
- Mechanical parts
- Electrical/electronic parts.

Topic 1.2

Characteristics, function and considerations for the use of additional equipment for machines:

- Workholding
- Material loading
- Tools.

Learning outcome

2 Understand how to produce programs for CNC machining

Topics

2.1 Safety issues
2.2 Component features
2.3 CNC programming
2.4 Planning CNC operations

Topic 2.1

Safety issues and how they are controlled by the program:

- Tool collision
- Tool change location
- Feed and speeds.

Topic 2.2

Features:

- Faces (datum, flat, perpendicular, parallel, tapered)
- Diameters (internal, external, bored, tapered, concentric, eccentric)
- Slots (open, enclosed, helical, blind, through)
- Pockets (regular, complex, blind, through)
- Holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, tapered)
- Non-standard threads (multi-start, acme, square, non-standard pitch)
- Complex profiles (2D geometry).

Information:

- Datum (datum shift)
- Coordinates
- Tooling
- Feeds
- Speeds
- Material.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

Topic 2.3

Create programs:

- Sequence of operations
- Position (eg axis coordinates (x, y, z), absolute, incremental)
- Tooling and workholding (eg position, direction, amount of movement)
- Rates of change (eg feed rates, spindle rates)
- Preparatory functions (eg metric/imperial units, tool selection, cutting fluids, workpiece loading and holding, tool changing, safety).

Methods used to prove/evaluate the program:

- Data transfer
- Simulation
- Single block.
- Rapid override.

Topic 2.4

Principles of planning CNC operations:

- Critical path
- Sequence of operations
- Tooling collision
- Optimisation
- Safety.

Guidance for delivery

The unit requires learning to be focussed on two different types of machines from the following:

- CNC lathes
- CNC mills.

This is a theory unit intended to underpin the development of practical skills. It can be delivered alongside practical workshop or real work 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 programming 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 examples CNC programs that are used for milled and turned components.

Unit 312 Specialist machining

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit provides the learner with knowledge of the tools, equipment and machinery used to create complex components on specialist machines. They will learn how machinery is set up and operated safely and the processes to be followed to create complex components. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a complex component against a specification.

Learning outcomes

In this unit, learners will be able to

1 Understand equipment required for specialist machining
2 Understand how to produce complex components using specialist machines
3 Understand how to meet quality requirements for advanced specialist machine operations

Scope of content

Learners must develop understanding relating to one example specialist CNC machine from the following categories:

- Forming (press brakes, tube bending, spinning)
- Profiling (punch presses, laser, water, plasma, oxy-gas, broaching)
- EDM (spark eroding, wire eroding).

Complex components require the combination of a number of different types of features.

Learning outcome

1 Understand equipment required for specialist machining

Topics

1.1 Specialist machine parts
1.2 Equipment required

Topic 1.1

Characteristics, function and considerations of specialist machine parts and how they interrelate to achieve machining operations:

- Safety devices
- Tool holding devices
- Mechanical parts
- Electrical/electronic parts.

Topic 1.2

Characteristics, function and considerations for the use of additional equipment required for manufacturing processes

- Material loading
- Workholding devices
- Tools.

Learning outcome

2 Understand how to produce complex components using specialist machines

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Topics

2.1 Safety issues
2.2 Component features
2.3 Machining techniques
2.4 Planning machining operations

Topic 2.1

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

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

Topic 2.2

Information required to create different types of component features:

Features:

- Faces
- Diameters
- Slots
- Pockets
- Holes
- Bends
- Profiles.

Information:

- Datum (datum shift)
- Coordinates
- Tooling
- Bend allowance
- Feeds
- Material.

Information sources:

- Engineering drawings
- Tables and charts
- International standards
- Calculations.

Topic 2.3

Techniques for machine operation:

- Checking equipment is fit for purpose
- Workholding
- Material loading
- Operating activities
- Securing workpiece
- Quality criteria.

Topic 2.4

Principles of planning machine operations:

- Sequence of operations
- Critical path
- Optimisation (time, material, safety, cost)
- Tooling collision
- Safety.

Learning outcome

3 Understand how to meet quality requirements for advanced specialist machine operations

Topics

3.1 Monitoring machine performance
3.2 Evaluating components against specification

Topic 3.1

Monitoring machine performance:

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

Topic 3.2

Evaluating components against specification:

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

Guidance for delivery

The unit requires learning to be focussed on one specialist CNC machine from one of the following categories:

- Bending
- Profiling
- EDM.

This is a theory unit intended to underpin the development of practical skills. This unit will develop learners' knowledge of a range of specialist machining equipment, such as press brakes, water jet cutters and EDMs.

This unit is designed to be delivered alongside practical workshop or real work 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 specialist machinery required to create 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 specialist machinery and components.

Unit 313 CAD/CAM

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit enables the learner to acquire the essential understanding of the importance of Computer Aided Engineering (CAE) and how to use Computer Aided Design (CAD) to create and analyse models of complex components. Learners will understand the relationship between CAD and Computer Aided Manufacture (CAM).

Learning outcomes

In this unit, learners will be able to

1 Understand the application of Computer Aided Engineering (CAE)
2 Understand how to operate CAD software to produce complex designs
3 Understand the use of CAD/CAM in machining

Scope of content

Complex designs are those that combine a range of features that are not classed as primitives eg box, cylinder, sphere.

Learning outcome

1 Understand the application of Computer Aided Engineering (CAE)

Topics

1.1 Importance of a safe CAD working environment
1.2 Purpose, benefits and limitations of CAD/CAE
1.3 Importance of data management

Topic 1.1

Implications of the Health and Safety (Display Screen Equipment) Regulations:

- To employees
- To employers.

Risk assessments associated with the use of CAD/CAE in different environments:

- Office environments
- Workshop environments.

Topic 1.2

Purpose, benefits and limitations of CAD/CAE:

- Modelling (surface, solid, organic/freeform)
- Drawing
- Analysis (Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), Multi Body System (MBS))
- Visualisation (rendering, animation)
- Links to CAM.

Topic 1.3

Importance of CAD data management procedures:

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

Learning outcome

2 Understand how to operate CAD software to produce complex designs

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
2.4 Process and features used to analyse components

Topic 2.1

Process and features used in part modelling:

- Visual analysis (section, Zebra)
- Create geometry (extrude, revolve, loft, sweep, rib)
- Modify geometry (Boolean operations, shell, split (face, body))
- Constraints (coincident, concentric, parallel perpendicular, tangent).

Topic 2.2

Process and features used in assembly modelling:

- Visual analysis (section, Zebra, interference)
- Assemble part models (constraints, joints, position).

Topic 2.3

Process and features used to create drawings in CAD software:

- Create templates
- Use line types, styles and colour
- View placement (auxiliary, section, detail, break, breakout)
- Bill of Materials (BoM)
- Annotate (surface symbols, geometric dimensioning tolerancing (GDT) symbols, balloon, dimensions, tolerance, datum, hole tables, revision cloud/tag/table).

Topic 2.4

Process and features used to analyse individual components:

- Create a study(for FEA, CFD, MBS)
- Export a report.

Learning outcome

3 Understand the use of CAD/CAM in machining

Topics

3.1 Applications of CAM
3.2 Suitability of using CAM in machining
3.3 Key functions of CAM software

Topic 3.1

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

- Subtractive manufacturing (CNC machines, cutters)
- Additive manufacturing (Fusion Deposition Modelling (FDM), Stereo Lithography (SLA), Selective Laser Sintering (SLS), Multi Jet Modelling (MJM)).

Topic 3.2

Suitability of using CAM in machining:

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

Topic 3.3

Operation of CAM functions:

- Tool path generation
- Post processing
- Data transfer
- Simulation.

Guidance for delivery

This is a theory unit intended to underpin the development of practical skills. It is recommended that learners have already studied and used CAD at an introductory/basic level before commencing this unit.

The unit can be 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 302 where learners gain knowledge of drawing standards. CAD operation can help learners gain knowledge of those standards.

Learning about CAD/CAE/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.

Unit 314 Precision grinding techniques

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit enables the learner to acquire the essential knowledge and understanding needed to develop precision grinding skills. This unit provides the learner with knowledge of the equipment and machinery used to create complex and precise components using a grinding machine. They will learn how to set up, operate and plan the use of grinding machinery to create precise components safely and efficiently. Learners will develop an understanding of quality requirements and how they can evaluate the quality of a precise component, produced using a grinding machine, against a specification.

Learning outcomes

In this unit, learners will be able to

1 Know equipment needed for precision grinding
2 Understand how to produce complex components with grinding machines
3 Understand how to meet quality requirements for precision grinding operations

Scope of content

Complex components require the combination of a number of different features.

Learning outcome

1 Know equipment needed for precision grinding

Topics

1.1 Parts of grinding machines
1.2 Workholding devices
1.3 Abrasive wheels

Topic 1.1

Characteristics, function and considerations of parts of different types of grinding machines:

Types of grinding machines:

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

Machine parts:

- Safety features
- Grinding wheel mounts
- Mechanical parts (bed, slides, spindles, arbours)
- Hydraulic parts.

Topic 1.2

Characteristics, function and considerations for the use of workholding devices:

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

Topic 1.3

Characteristics, function and limitations of abrasive wheels:

- Wheel types (straight, cylinder, single taper, double taper, single concaved, straight cup)
- Characteristics (structure, grade, grit, shape, construction, material, bond type, treatment, classification)
- Effects of grinding fluids.

Learning outcome

2 Understand how to produce complex components with grinding machines

Topics

2.1 Safety issues associated with the use of grinding machines
2.2 Information required to create different types of features with grinding machines
2.3 Techniques for preparing grinding machines for use
2.4 Techniques for maintaining abrasive wheels
2.5 Calculations required for grinding operations in different conditions
2.6 Principles of planning grinding operations

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, machine guards).

Topic 2.2

Features:

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

Information

- Datum
- Sizes
- Material
- Wheel
- Measuring instruments
- Speeds and feeds.

Information sources

- Engineering drawings
- Tables and charts
- International standards
- Calculations
- Approved code of practice.

Topic 2.3

Techniques for preparing grinding machines for use:

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

Topic 2.4

Techniques for maintaining abrasive wheels:

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

Topic 2.5

Calculations required for grinding operations in different conditions:

- Speeds
- Feeds
- Depth of cut.

Topic 2.6

Principles of planning grinding operations:

- Critical path
- Sequence of operations
- Optimisation.

Learning outcome

3 Understand how to meet quality requirements for precision grinding operations

Topics

3.1 Monitoring machine performance

3.2 Evaluating components against specification requirements

Topic 3.1

Monitoring machine performance:

- Symptoms, causes and resolution of defects (wheel chatter, rough finish, wheel loading, short wheel life
- Effects of heat when grinding and possible remedies
- In-process checks (trial cuts, backlash, dimensions and tolerances of workpiece, surface finish of workpiece, condition of wheel).

Topic 3.2

Evaluating machined components against specification:

- Identify quality criteria (tolerance, flatness, squareness, 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 is beneficial for learners to have prior knowledge of grinding techniques. If this is not the case it may be advantageous for learners to undertake introductory sessions related to basic grinding techniques.

This unit is designed to be delivered alongside practical workshop or real work 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 equipment and machinery required to create precise components. Learners can then consider the operational requirements and processes that will deliver the precise 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 315 Further maths

Unit level:	Level 3
GLH:	60

What is this unit about?

The purpose of this unit is for learners to understand the principles of further mathematics and apply these to solve engineering problems. They will learn the principles of trigonometry, calculus and algebra and how these can be applied in a range of engineering contexts.

Learning outcomes

In this unit, learners will be able to

1 Solve engineering problems using algebraic methods
2 Solve engineering problems using trigonometric methods
3 Solve engineering problems using calculus

Scope of content

Learning outcome

1 Solve engineering problems using algebraic methods

Topics

1.1 Solve problems using equations
1.2 Solve problems using non-linear graphs
1.3 Solve engineering problems using complex numbers

Topic 1.1

Solve problems using equations:

- Resolving simultaneous equations
- Using quadratic equations.

Topic 1.2

Solve problems using non-linear graphs:

- Express equations of exponential and logarithmic functions using a graph
- Use formulae to determine numbers in a sequence or series (arithmetic, geometric, Progression rules).

Topic 1.3

Solve engineering problems using complex numbers:

- Definition of complex numbers
- Addition and subtraction of complex numbers
- Convert between coordinates (Polar and Cartesian).

Learning outcome

2 Solve engineering problems using trigonometric methods

Topics

2.1 Use trigonometric functions to solve problems
2.2 Use trigonometric identities to solve engineering problems
2.3 Identify characteristics of a sine wave
2.4 Express equations of simple trigonometric functions using a graph

Topic 2.1

Use trigonometric functions to solve problems:

- Inverse trigonometric functions
- Compound angles.

Topic 2.2

Use trigonometric identities to solve engineering problems:

- tan = sin/cos
- cot = 1/tan
- sec = 1/cos
- cosec = 1/sin.

Topic 2.3

Identify characteristics of a sine wave:

- Amplitude
- Periodic time
- Frequency.

Topic 2.4

Express equations of simple trigonometric functions using a graph:

- sin, cos, tan
- Degrees, radians.

Learning outcome

3 Solve engineering problems using calculus

Topics

3.1 Rules of differentiation

3.2 Rules of integration

Topic 3.1

Apply rules of differentiation:

- Simple trigonometric functions (sin, cos, tan)
- Calculations involving a second derivative
- Product rule.

Topic 3.2

Apply rules of integration:

- Simple trigonometric functions (sin, cos, tan)
- Integration by substitution.

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 forces involved with machining activities.

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 316 Engineering organisational efficiency and improvement

Unit level:	Level 3
GLH:	60

What is this unit about?

The purpose of this unit is for learners to gain an understanding of the key factors affecting organisational efficiency. They will gain an understanding of production management and the importance of human resources to effective production processes. Learners will develop an understanding of business improvement techniques and how they can be applied to improve the efficiency of production processes.

Learning outcomes

In this unit, learners will be able to

1 Understand production management
2 Understand the application of business improvement techniques to production management
3 Understand the relationship between human resources and production management

Scope of content

Learning outcome

1 Understand production management

Topics

1.1 Methods of production
1.2 Stages of production
1.3 Production planning

Topic 1.1

Characteristics, considerations and suitability of types/methods of production for different scales of manufacture:

- One-off / Bespoke
- Batch
- Mass
- Continuous.

Topic 1.2

Activities involved and factors affecting efficiency in different stages of production:

- Design/Engineering
- Design for manufacture (DFM)/ Design for Assembly (DFA)
- Manufacturing
- Fabricating and assembling
- Finishing
- Quality.

Topic 1.3

How production planning affects efficient operations:

- Processes and layouts
- Tools and documentation
- Staffing involved
- Timescales
- Monitoring
- Health and safety
- Quality controls
- Scheduling.

Learning outcome

2 Understand the application of business improvement techniques to production management

Topics

2.1 Business improvement techniques
2.2 Quality control and quality assurance

Topic 2.1

Characteristics, application and suitability of business improvement tools and techniques for production management:

Techniques:

- Lean
- Kaizen
- 6 sigma
- TQM.

Tools:

- Kanban
- JIT
- 6S
- Visual management
- Quick changeover (SMED)
- Value stream mapping.

Topic 2.2

- Purpose of quality standards
- Difference between quality assurance and quality control
- Effectiveness of quality management systems
- Roles and responsibilities of the Quality Manager.

Learning outcome

3 Understand the relationship between human resources and production management

Topics

3.1 Characteristics, advantages and disadvantages of techniques for developing others
3.2 Team working
3.3 Leadership
3.4 Employee rights and responsibilities

Topic 3.1

Characteristics, advantages and disadvantages of techniques for developing others:

- Coaching
- Mentoring
- Performance reviews
- Training.

Topic 3.2

Characteristics and benefits of an effective team:

Characteristics:

- Clear team goals
- Clear roles
- Clear lines of authority and decision making
- Group norms set for working together
- Trained and skilled members
- Good communication.

Benefits:

- Increased efficiency
- Sharing of expertise
- Identification and development of talent
- Increased motivation
- Fostering innovation.

Topic 3.3

Characteristics of different leadership styles and their impact on:

- The business
- The leader
- Staff
- Other stakeholders.

Leadership styles:

- Behavioural
- Participative
- Autocratic.

Topic 3.4

Key legislation and statutory entitlements:

- Health and safety
- Equality and diversity
- Leave entitlement (holiday, sickness, maternity, paternity)
- Working hours
- Payment
- Union membership.

Impact of statutory entitlements on the business and employees.

Guidance for delivery

This is a theory-based unit that is best delivered in the context of real or realistic case studies. It is designed to be delivered once learners are working in a real manufacturing environment so that they can experience the implementation of business improvement techniques.

Working with employers would enhance the delivery of the unit. This could be through presentation of a problem and an exploration, with the employer, of how the use of business improvement techniques could improve efficiency.

Unit 317 Engineering inspection and quality control

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit provides learners with an understanding of quality management systems and the associated roles and activities for inspection, measurement and statistical process control (SPC).

Learning outcomes

In this unit, learners will be able to

1 Understand the principles and applications of quality management systems
2 Understand the application of measurement techniques
3 Understand the application of Statistical Process Control (SPC) to manage product quality

Scope of content

Learning outcome

1 Understand the principles and applications of quality management systems

Topics

1.1 Effects of quality management systems
1.2 ISO9001
1.3 Principles of inspection and measurement

Topic 1.1

Effects of quality management systems on:

- The workforce
- Costs
- Efficiency/productivity
- Monitoring and identifying out of tolerance/rejected work
- Product performance.

Topic 1.2

ISO9001:

- General requirements
- Application and processes
- Criteria and methods
- Availability of resources and information
- Monitoring, measuring and analysis of processes
- Continual improvement of processes.

Topic 1.3

Principles of inspection and measurement:

- Quality assurance
- Quality control
- Quality Manager
- Variation
- Repeatability
- Reproducibility
- Accuracy
- Tolerance
- Comparison
- Precision
- Gauging
- Limits and fits
- Capability of a measuring system
- Total system capability.

Learning outcome

2 Understand the application of measurement techniques

Topics

2.1 Capabilities, suitability and applications of types of measuring instruments
2.2 Application of techniques used in inspection and measurement

Topic 2.1

Capabilities, suitability and applications of types of measuring instruments:

- Gauge types
- Comparator types
- Mechanical measurement types.

Topic 2.2

Application of techniques used in inspection and measurement

- Linear measurement
- Surface texture measurement
- Straightness, squareness, flatness measurement
- Concentricity, eccentricity measurement
- Angular measurement.

Learning outcome

3 Understand the application of Statistical Process Control (SPC) to manage product quality

Topics

3.1 SPC
3.2 Normal distribution curve
3.3 Process capability measures

Topic 3.1

SPC:

- Typical applications
- Advantages and disadvantages of SPC for managing quality.

Topic 3.2

Normal distribution curve:

- Characteristics of a normal distribution curve
- Determine the mean, variance and standard deviation.

Topic 3.3

Process capability measures:

- Calculate the values Cp, Cpk, Cpm
- understand the meaning of values
- setting tolerance bands.

Guidance for delivery

This is a theory unit developing an understanding of quality assurance and quality control processes in engineering. It is best delivered when learners have experience of working in advanced manufacturing engineering and have grasped some of the concepts and processes.

The unit is designed to be delivered alongside practical workshop or real work activities. The combination of theory and practice is more likely to reinforce learning.

Working with employers would enhance the delivery of the unit. Employers can present case studies of quality assurance issues and how they were resolved and sample products that can be inspected and measured.

Unit 318 Engineering design process

Unit level:	Level 3
GLH:	60

What is this unit about?

This unit gives an overview of the design process and explores the different factors that can influence design. Learners will learn the main stages in the design process and the importance of a good product specification. They will also learn how ergonomics and functional considerations affect the design of a product. Learners will gain knowledge of different manufacturing processes and their suitability for meeting different design requirement.

Learning outcomes

In this unit, learners will be able to

1 Understand the design process
2 Understand the factors considered when designing a product
3 Understand how manufacturing processes influence design

Scope of content

Learning outcome

1 Understand the design process

Topics

1.1 The design brief
1.2 Product specifications
1.3 Developing design ideas

Topic 1.1

The design brief:

- Reasons for developing new or improved products (market pull, technology push)
- Purpose of the design brief
- Analysis of the design brief (identifying customer, customer requirements, design constraints).

Topic 1.2

Product specification:

- Purpose of the product specification
- Types of product requirements, the reasons for their inclusion in a product specification and how they can be evaluated (function, form, physical dimensions, aesthetics, cost, environmental considerations, safety).

Topic 1.3

Developing design ideas:

- Methods of presenting design ideas and their advantages and disadvantages (freehand sketches, virtual modelling, physical modelling)
- Produce freehand sketches to address product specification requirements
- Techniques used to evaluate designs against a specification
- Suitability of methods used to communicate final design solution.

Learning outcome

2 Understand the factors considered when designing a product

Topics

2.1 How properties affect the selection of a material for a design
2.2 How ergonomics affect the design of a product
2.3 How mechanical requirements contribute to the design

Topic 2.1

How physical properties affect the selection of a material for a design:

- Density
- Mass
- Conductivity (thermal, electrical)
- Thermal expansion and contraction
- Corrosion resistance.

How mechanical properties affect the selection of a material for a design:

- Resistance to wear
- Mechanical strength (tensile, compressive, shear)
- Fatigue life
- Factor of safety.

Make calculations:

- Linear expansion and contraction
- Strength
- Factor of safety.

Topic 2.2

How ergonomic factors affect the design of a product:

- Meaning of ergonomics and human factors
- How anthropometric data influences design
- Safety considerations.

Topic 2.3

Characteristics of different types of movement:

- Linear
- Rotary
- Oscillating
- Reciprocating.

Methods of changing the direction of transmitted motion:

- Gears (simple and compound gear trains, spur, bevel, worm, rack and pinion)
- Cams (pear, eccentric, snail)
- Levers and linkages
- Chains and belt drives
- Pulley systems.

Learning outcome

3 Understand how manufacturing processes influence design

Topics

3.1 Shaping processes
3.2 Forming processes
3.3 Joining processes

Topic 3.1

Characteristics and suitability of shaping processes:

- Casting
- Forging
- Extrusion
- Injection moulding.

Topic 3.2

Characteristics and suitability of forming processes:

- Vacuum forming of plastics
- Bending and piercing of sheet metal.

Topic 3.3

Characteristics and suitability of joining processes:

- Welding
- Soldering
- Mechanical fixings.

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 activities such as product analysis, discussing products and design and different manufacturing processes, building on unit 303 Properties and applications of engineering materials.

Employers can be engaged to support delivery with examples of activities where the theory can be applied eg using different methods of manufacture or materials to see the results – good or bad.

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.

Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centre document library** on **www.cityandguilds.com** or click on the links below:

Centre Handbook: Quality Assurance Standards

This document is for all approved centres and provides guidance to support their delivery of our qualifications. It includes information on:

- centre quality assurance criteria and monitoring activities
- administration and assessment systems
- centre-facing support teams at City & Guilds/ILM
- centre quality assurance roles and responsibilities.

The Centre Handbook should be used to ensure compliance with the terms and conditions of the centre contract.

Centre Assessment: Quality Assurance Standards

This document sets out the minimum common quality assurance requirements for our regulated and non-regulated qualifications that feature centre-assessed components. Specific guidance will also be included in relevant qualification handbooks and/or assessment documentation.

It incorporates our expectations for centre internal quality assurance and the external quality assurance methods we use to ensure that assessment standards are met and upheld. It also details the range of sanctions that may be put in place when centres do not comply with our requirements or actions that will be taken to align centre marking/assessment to required standards. Additionally, it provides detailed guidance on the secure and valid administration of centre assessments.

Access arrangements: When and how applications need to be made to City & Guilds provides full details of the arrangements that may be made to facilitate access to assessments and qualifications for candidates who are eligible for adjustments in assessment.

The **Centre document library** also contains useful information on such things as:

- conducting examinations
- registering learners
- appeals and malpractice.

Useful contacts

Please visit the **Contact us** section of the City & Guilds website.

City & Guilds

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Published by City & Guilds, a registered charity established to promote education and training.

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