City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) (2145-12)

Version 1.0 (January 2025)

Qualification Handbook

Qualification at a glance

Subject area	Engineering
City & Guilds number	2145
Age group approved	16–19, 19+
Entry requirements	N/A
Assessment	Theory exam Practical assignment
Grading	Pass/Fail
Approvals	Full approval required
Support materials	Sample assessments materials (SAMs), Qualification handbook
Registration and certification	Consult Walled Garden/Online Catalogue for last dates
Occupational Standard(s)	ST0537 Engineering Operative ST0349 Welder

Title and level	City & Guilds qualification number	Regulatory reference number	GLH	TQT
City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma)	2145-12	610/4541/X	360	470

Version and date	Change detail	Section
1.0 January 2025	Initial version	All

Contents

1 Introduction

What is this qualification about?

Area	Description
Who is the qualification for?	The qualification is for 16–19-year-old learners wishing to enter an engineering sector or possibly progress onto an accelerated apprenticeship or employment. Learners will develop the knowledge, skills, and behaviours (KSBs) within the associated occupational standards (ref ST0537/ST0349). The qualification will provide occupational entry competence and will require learners to undertake further learning/training to reach full competence. This qualification is suitable for those aged 16 years old or over.
What does the qualification cover?	Learners will develop the knowledge, skills, and behaviours within the associated occupational standards (ref ST0537/ST0349). The qualification will provide occupational entry competence and will require learners to undertake further learning/training to reach full competence.
What opportunities for progression are there?	From the pathways included there are progression routes available into the majority of subsectors within the industry: • manufacturing • maintenance • fabrication • welding.
Why choose this qualification?	This qualification has been designed with the involvement of a range of technical subject matter experts and employers, to ensure it meets the needs of the occupation. The qualification aligns to the ST0537 Engineering Operative and ST0349 Welder occupational standards and will provide employers with reliable evidence of a learner's attainment against occupational standard knowledge, skills, and behaviours, which form the minimum requirements for entry into occupation.

2 Content coverage and mapping

Occupational standards

This qualification has been developed to cover as many of the Knowledge, Skills and Behaviours (KSBs) in the relevant Occupational Standard as it may be reasonable to attain by undertaking a course of education or training. Where KSBs in a relevant occupation standard cannot reasonably be obtained within a course of education or training in an educational setting, City & Guilds seeks validation from credible employers to ensure that the qualification is fit for purpose.

The knowledge and skills content within this qualification has been amplified to reflect the KSBs. High-level mapping to the KSBs in the Occupational Standard can be found in the Qualification Structure section. Detailed mapping at unit level can be found in Appendix 1.

The table below shows the Occupational Standards the qualification aligns to:

Qualification	Occupational Standard reference/title
City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) The qualification has three pathways: • Maintenance • Production Engineering (Manufacturing) • Fabrication and Welding.	ST0537 Engineering Operative ST0349 Welder

3 Employer engagement

City & Guilds would like to take this opportunity to thank all the employers, trade associations, professional bodies, providers, subject matter experts and consultants who have dedicated time to review and validate this qualification. These stakeholders have been used throughout the development and validation of this qualification to ensure that it meets the requirements of the Occupational Standard and the needs of the industry. Employer validation recognises the demand or likely demand for learners who have completed the City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma). This collaborative work is to ensure that a learner studying the City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) has the best opportunities available to them as they progress through their career with a solid base as a starting point.

4 Qualification structure

Structure

The City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) has three pathways:

- Maintenance
- Production Engineering (Manufacturing)
- Fabrication and Welding.

The following tables detail what learners must achieve for each pathway:

To achieve the **City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) – Maintenance**, learners must achieve units 201–206.

City & Guilds unit number	Unit title	GLH
201	Principles of engineering	60
202	Engineering workshop practice	60
203	Working in engineering	60
204	Maintenance principles	60
205	Engineered systems	60
206	Carrying out planned maintenance	60

To achieve the **City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) – Production Engineering (Manufacturing)**, learners must achieve units 201–203 plus 207 and 208.

City & Guilds unit number	Unit title	GLH
201	Principles of engineering	60
202	Engineering workshop practice	60
203	Working in engineering	60
207	Manufacturing principles	90
208	Manufacturing products	90

To achieve the **City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) – Fabrication and Welding**, learners must achieve units 201–203 plus 209 and 210.

City & Guilds unit number	Unit title	GLH
201	Principles of engineering	60
202	Engineering workshop practice	60
203	Working in engineering	60
209	Fabrication principles and processes	90
210	Welding principles and processes	90

Total Qualification Time (TQT)

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 comprises the following two elements:

1) 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 hours (GLH), not under the immediate guidance or supervision of – a lecturer, supervisor, tutor or other appropriate provider of education or training.

Title and level	GLH	TQT
City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma)	360	470

5 Centre requirements

Approval

Full approval

To offer this qualification, new centres will need to gain both centre and qualification approval. Please refer to the document Centre Approval Process: Quality Assurance Standards for further information.

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

Resource requirements

Centre staffing

Staff delivering this qualification 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 in terms 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.

Physical resources

Centres must be able to demonstrate that they have access to the equipment and technical resources required to deliver this qualification and its assessment.

All pathways

Hand tools:

- rules
- tapes
- scribers
- centre punch
- internal, external callipers
- combination sets
- engineer's square
- micrometers
- verniers
- spirit level
- protractors
- socket sets: metric and imperial
- torque wrench
- taps and dies (metric and imperial)
- hammers and mallets
- files: flat, diamond point and half round
- cold chisels
- clamps: G-clamps, mole grips, ratchet, carver and sash clamps
- spanners: open ended, combination, podger and adjustable (metric and imperial)
- Allen keys (metric and imperial)
- screwdriver sets: cross and flat head
- pliers: combination, snipe nose, circlip
- hacksaws/junior hacksaw
- tin snips/hand shears
- crimping tools/pliers
- battery-operated drills, screwdrivers etc
- drill bits
- battery-operated angle grinder
- compressed air tools: impact wrench, air screwdriver, air drills, air die grinder, air angle grinder
- hand and angle grinders
- electric nibbler – shears

Standing machine equipment:

- pistol, bench, pillar and radial drills
- band and circular saws
- welding equipment
- guillotine
- box pan folder
- bench/pedestal grinder
- bench shears
- lathes
- millers

- surface grinders
- plasma cutter
- oxy-fuel cutting equipment

Maintenance pathway

Documentation:

- specifications, documentation and information required for the maintenance operation
- planned preventative maintenance schedules
- corrective maintenance schedules

Tools and equipment:

- rules
- tapes
- internal, external callipers
- combination sets
- squares
- micrometers
- telescopic gauges
- vernier callipers, protractors, height gauge
- protractors
- socket sets (metric and imperial): depending on equipment being maintained
- torque wrench
- gauges: feeler, plug, gap, ring, radius, thread
- taps and dies (metric and imperial)
- hammers and mallets, wedges
- files: flat, diamond point and half round
- cold chisels
- clamps: G-clamps, mole grips, ratchet, carver and sash clamps
- spanners: open ended, combination, podger and adjustable (metric and imperial)
- Allen keys (metric and imperial)
- screwdriver sets: cross and flat head
- pliers: combination, snipe nose, circlip
- hacksaws
- crimping tools/pliers
- desoldering tools
- soldering iron
- battery-operated drills, screwdrivers etc
- compressed air tools: impact wrench, air screwdriver, air drills, air die grinder, air angle grinder
- portable toolkit station
- torch

Consumables:

- degreaser
- lubrication
- emery cloth
- cotton rags

Access to:

- pistol, bench, pillar and radial drills
- band and circular saws
- hand and angle grinders
- surface tables and plates
- V-blocks
- straight edges
- jacks
- spirit level
- laser alignment equipment
- lathes and milling machines
- welding and cutting equipment

Replacement component/parts:

- nuts and bolts, gaskets and seals etc

Production Engineering (Manufacturing) pathway

Turning:

Machine and machining tools/equipment:

- centre lathe
- work holding equipment
- cutting tools
- callipers, rule, micrometers, dial test indicator (DTI), surface finish comparison gauges
- suitable computer numerical control (CNC) software
- V-blocks
- 3-jaw chuck
- 4-jaw chuck
- live, dead/revolving centres
- plain mandrel
- machine vice
- drive plate
- centres
- dial test indicator
- collet chuck
- chuck key
- Allen keys

Cutting tools:

- high-speed steel (HSS), tungsten carbide
- roughing
- turn and facing
- knife
- parting
- grooving
- centre drill
- boring
- knurling

- slab, face and end mill
- slot drill
- side and face cutter
- angle cutter
- chamfer
- gear cutter
- centre drill
- twist drills
- stock
- die
- taps and tap wrench
- hacksaw
- emery cloth
- files

Hand tools:

- square
- scriber
- protractor/combination set
- callipers
- rule
- micrometers
- dial test indicators
- verniers
- vernier height gauge
- comparison gauge
- surface finish comparison gauges
- wrenches and Allen keys

Milling:

Machine and machine tooling:

- milling machine (horizontal and vertical)
- suitable CNC software
- Work-holding equipment
- milling machine vice
- clamps, T-slot nuts/bolts
- V-blocks
- edge/centre finder
- collets
- angle plate
- parallel strip

Cutting tools:

HSS and carbide tipped cutting tools to include:

- slab mill
- face mill
- end mill
- slot drill

- ball cutter
- side and face cutter
- angle cutter
- slitting saw
- drill bits

Hand tools:

- squares comparison gauges
- surface finish comparison gauges
- vernier callipers
- rule
- micrometers
- dial test indicator
- square
- wrenches, Allen keys
- emery cloth
- files

Fabrication and Welding pathway

Hand tools:

- Steel rule (300mm/500mm/1000mm/2000mm straight edge)
- cord rule
- steel tape
- scriber/French chalk
- centre punch
- combination square
- engineer's square
- plate square
- back mark
- sliding bevel
- protractor
- dividers wing/calliper
- trammel head set and bar
- verniers (depending on integrity of tolerance)
- marking blue/layout fluid
- spirit level
- welding magnets
- engineer's hammer, ball-pein, cross-pein, planishing
- steel head mallet/hide head mallet
- bench stakes and mandrels
- cold chisels
- hacksaw
- files flat/round/triangle/square
- tin snips – straight, curved and combination
- clamping – G-clamps, carver clamps, sash clamps, ratchet clamps and mole grips
- spanners – open ended, combination, adjustable, podgers, drifts and wedges
- screwdrivers/pliers
- angle grinder (accessories) – grinding disc, cutting disc and flap disc (polishing)

- pistol drills – drill bits
- nibbler/rotary shears
- flame-cutting equipment (oxy fuel)
- portable straight-line oxy-fuel cutter (quickie)
- portable plasma cutter

Machine equipment:

- bench, pillar and radial drills
- circular saw, band saw
- pedestal grinder
- cut off saw
- manual and powered pyramid and pinch rolling equipment (CNC)
- manual and powered swing beam, box pan folder
- up and down stroking press brakes (CNC)
- manual and powered guillotines
- bench shears
- manual and powered punches
- universal steelworkers
- CNC plasma/laser cutter

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 & 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 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 this qualification. However, centres must ensure that candidates have the potential and opportunity to gain the qualification successfully.

Initial assessment and induction

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

- if the learner has any specific training needs
- support and guidance they may need when working towards their qualification
- any units they have already completed or credit they have accumulated which is relevant to the qualification
- the appropriate type and level of qualification.

City & Guilds recommends that centres provide an induction programme, so the learner fully understands the requirements of the qualification, their responsibilities as a learner and the responsibilities of the centre. This information can be recorded on a learning contract.

Age restrictions

This qualification is approved for learners aged 16 or above.

Access to assessment and special consideration

City & Guilds has considered the design of this qualification and its assessments in order to best support accessibility and inclusion for all learners. City & Guilds understands 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.

The Equality Act 2010 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 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: http://www.cityandguilds.com/delivering-our-qualifications/centre-development/centre-document-library/policies-and-procedures/access-arrangements-reasonable-adjustments

6 Delivering the qualification

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)

Support materials

The following resources are available for this qualification.

Description	How to access
Sample assessments	www.cityandguilds.com
Qualification handbook	www.cityandguilds.com

7 Assessment

Summary of assessment methods

For the City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) – Maintenance pathway, candidates must successfully complete:

Assessment component	Assessment method	Description and conditions
2145-201	Externally marked theory exam	This assessment covers units 201, 202 and 203. The short-answer question assessment is externally set and externally marked and will be delivered as a paper-based assessment. The exam is designed to assess the candidate's depth and breadth of understanding across the theoretical content in the qualification at the end of the period of learning, using short-answer questions. It will be sat under invigilated examination conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations The test specification shows the coverage of the assessment across the unit content. Sample assessment materials can be downloaded from the City & Guilds website.
2145-251	Practical assignment (Maintenance)	This assessment covers units 204, 205 and 206. The practical assignment is externally set and internally marked, with external verification. The assignment is designed to assess the candidate's depth and breadth of knowledge, skills and understanding from across content in the qualification, at the end of their period of learning. It will be completed under invigilated, controlled assessment conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations The test specification shows the coverage of the assessment across the qualification content. Assignment material availability will be communicated through the publication of a key date schedule.

For the City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) – Production Engineering (Manufacturing) pathway, candidates must successfully complete:

Assessment component	Assessment method	Description and conditions
2145-201	Externally marked theory exam	This assessment covers units 201, 202 and 203. The short-answer question assessment is externally set and externally marked and will be delivered as a paper-based assessment. The exam is designed to assess the candidate's depth and breadth of understanding across the theoretical content in the qualification at the end of the period of learning, using short-answer questions. It will be sat under invigilated examination conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations The test specification shows the coverage of the assessment across the unit content. Sample assessment materials can be downloaded from the City & Guilds website.
2145-252	Practical assignment (Production Engineering)	This assessment covers units 207 and 208. The practical assignment is externally set and internally marked, with external verification. The assignment is designed to assess the candidate's depth and breadth of knowledge, skills and understanding from across content in the qualification, at the end of their period of learning. It will be completed under invigilated, controlled assessment conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations The test specification shows the coverage of the assessment across the qualification content. Assignment material availability will be communicated through the publication of a key date schedule.

For the City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) – Fabrication and Welding pathway, candidates must successfully complete:

Assessment component	Assessment method	Description and conditions
2145-201	Externally marked theory exam	This assessment covers units 201, 202 and 203. The short-answer question assessment is externally set and externally marked and will be delivered as a paper-based assessment. The exam is designed to assess the candidate's depth and breadth of understanding across the theoretical content in the qualification at the end of the period of learning, using short-answer questions. It will be sat under invigilated examination conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations The test specification shows the coverage of the assessment across the unit content. Sample assessment materials can be downloaded from the City & Guilds website.

Assessment component	Assessment method	Description and conditions
2145-253	Practical assignment (Fabrication and Welding)	This assessment covers units 209 and 210. The practical assignment is externally set and internally marked, with external verification. The assignment is designed to assess the candidate's depth and breadth of knowledge, skills and understanding from across content in the qualification, at the end of their period of learning. It will be completed under invigilated, controlled assessment conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations The test specification shows the coverage of the assessment across the qualification content. Assignment material availability will be communicated through the publication of a key date schedule.

Scheme of assessment overview

For City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) – Maintenance pathway, candidates must successfully complete:

Candidates must complete all assessment components					
Assessment component	**Method**	**Duration**	**Marks**	**Marking approach**	**Grading**
2145-201	Dated entry, paper-based theory exam	2 hours	60	Externally set and externally marked	Pass/Fail
2145-251	On-demand practical assignment	14 hours	N/A	Externally set, internally marked and externally verified	Pass/Fail

For City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) – Production Engineering (Manufacturing) pathway, candidates must successfully complete:

Candidates must complete all assessment components					
Assessment component	**Method**	**Duration**	**Marks**	**Marking approach**	**Grading**
2145-201	Dated entry, paper-based theory exam	2 hours	60	Externally set and externally marked	Pass/Fail
2145-252	On-demand practical assignment	18 hours	N/A	Externally set, internally marked and externally verified	Pass/Fail

For City & Guilds Level 2 Extended Technical Occupational Engineering (Diploma) – Fabrication and Welding pathway, candidates must successfully complete:

Candidates must complete all assessment components					
Assessment component	**Method**	**Duration**	**Marks**	**Marking approach**	**Grading**
2145-201	Dated entry, paper-based theory exam	2 hours	60	Externally set and externally marked	Pass/Fail
2145-253	On-demand practical assignment	18 hours	N/A	Externally set, internally marked and externally verified	Pass/Fail

Assessment specifications

The assessment specifications outlined in the tables below highlight, at a high level, the way that the qualification content will be assessed within the assessment components.

Assessment component: 2145-201

Test: 2145-201	**Duration: 2 hours**		
Unit	**Outcome**	**Number of marks**	**Percentage %[1]**
201 Principles of engineering	LO1 Understand the application of maths in engineering	8	13
	LO2 Understand the application and principles of science in engineering	8	13
	LO3 Understand engineering materials	10	17
202 Engineering workshop practice	LO1 Understand engineering health and safety requirements	12	20
	LO2 Understand how to prepare for engineering workshop activities		
	LO3 Understand hand tools and skills in engineering	8	13
	LO4 Understand quality control procedures in engineering	3	5
203 Working in engineering	LO1 Know how engineering businesses are organised	5	8
	LO2 Understand business communications		
	LO3 Understand approaches to business improvement		
	LO4 Understand technical drawings used by engineering businesses	6	10
	Total	60	100%

Permitted materials: 2145-12 Source document: formula sheet, non-programmable scientific calculator

Graded: Pass/Fail

[1] Rounded to whole numbers

To achieve a Pass, a candidate will be able to:

- understand the fundamental theories of engineering, including mathematics, engineering materials, tools and techniques, and quality control
- understand legal and regulatory requirements for safe working in the engineering industry
- apply knowledge and understanding of engineering principles to straightforward situations that reflect entry into the industry.

Assessment component: 2145-251

Units	Outcome
204, 205	Task 1: Plan a maintenance activity
204, 205, 206	Task 2: Carry out a maintenance activity
206	Task 3: Produce a maintenance report

Permitted materials: Permitted materials will be given to candidates by centres.

Graded: Pass/Fail

Candidates must gain a Pass in all tasks within the assignment to achieve a Pass overall for this component.

Assessment component: 2145-252

Units	Outcome
207	Task 1: Prototype planning
207, 208	Task 2: Manufacture prototype
207, 208	Task 3: CAD/CAM file for volume production

Permitted materials: Permitted materials will be given to candidates by centres.

Graded: Pass/Fail

Candidates must gain a Pass in all tasks within the assignment to achieve a Pass overall for this component.

Assessment component: 2145-253

Units	Task
209, 210	Task 1: Plan a fabrication and welding activity
209, 210	Task 2: Produce a fabricated component
209, 210	Task 3: Produce a quality inspection report

Permitted materials: Permitted materials will be given to candidates by centres.

Graded: Pass/Fail

Candidates must gain a Pass in all tasks within the assignment to achieve a Pass overall for this component.

Assessment objectives

The following assessment objectives are used within the **2145-201 theory exam.**
The weightings for how the assessment objectives are applied in the assessment are shown in the table below.

Assessment objective	Description	Weighting in assessment 2145-201
AO1a Demonstrate knowledge of the content	The ability to demonstrate basic recall of relevant knowledge in response to straightforward questioning.	22 marks 37%
AO1b Demonstrate understanding of the content	The ability to demonstrate understanding of principles and concepts beyond recall of definitions.	26 marks 43%
AO2 Apply knowledge and understanding of the content to different situations and contexts	Applying knowledge and understanding taking the understanding of generalities and applying them to specific situations.	12 marks 20%

Availability of assessments

Practical assignment material availability will be communicated through the publication of a key date schedule. This schedule will include when assignment materials will be released to centres.

All assessments that are on e-volve are on demand and can be booked by the provider when the candidate is ready to be entered for the assessment.

Retakes/resits

Theory exam

Candidates who have failed the theory exam should be entered for a resit in the next available assessment window. Candidates can re-sit the theory exam once only.

Practical assignment(s)

Candidates who have failed one or more tasks in the practical assignment will be advised to complete a further period of learning before then resitting fully, all tasks, within a different version of the assessment. Candidates can re-sit a different version of the practical assignment up to maximum of **three** times before reregistration is required to retake the qualification.

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. RPL can be used to exempt learners from areas of learning previously achieved, but does not exempt them from assessment.

RPL is allowed and is also sector specific.

8 Units

Structure of the units

These units each have the following:

- City & Guilds reference number
- title
- level
- guided learning hours (GLH)
- unit aim
- assessment type
- learning outcomes, which are comprised of a number of topics
- content elements
- supporting information
- relationship to transferrable employability skills.

Unit guidance for delivery

This qualification comprises a number of units. A unit describes what is expected of a competent person in particular aspects of their job.

Each unit is divided into learning outcomes which describe in further detail the knowledge and skills that a candidate should possess.

Each learning outcome has a set of topics (knowledge or skills) that are simple and concise statements that indicate to a learner something specific they will be learning in relation to the learning outcome. A topic should provide clarity to a learner at a high level on what they should be expecting to learn or be able to do about a specific area of the learning outcome.

Content elements define the 'depth and breadth' to which the teaching / learning must be delivered.

It is important that these sections define all the essential content that must be covered for learners to achieve the learning outcome. It is the information in this section that learners will be assessed on.

Transferable employability skills

The Institute for Apprenticeships have developed a transferable skills mapping framework which provides elaboration of generic, transferable employability skills that can be applied across all relevant occupational areas. This framework can be found here.

City & Guilds have considered which transferable employability skills within this framework are relevant to this qualification, and then mapped these skills to the relevant practical outcomes within the qualification content. A mapping grid that outlines how the skills are best reflected in the content is found in each relevant practical unit within this qualification. NB – units with no practical learning do not include this mapping.

Unit 201 Principles of engineering

Unit level:	2
Guided Learning Hours (GLH):	60
Unit aim:	The purpose and aim of this unit are to provide the learner with understanding of the fundamental principles of mathematics, science, and materials used within engineering.
Assessment method:	Theory exam
Links to Occupational Standards:	ST0537 Engineering Operative ST0349 Welder

Learning outcomes

1. Understand the application of maths in engineering
2. Understand the application and principles of science in engineering
3. Understand engineering materials

Learning outcome 1

Understand the application of maths in engineering

Topics	Content elements
1.1 Mathematical principles applied within engineering	1.1.1 Mathematical principles and the functions of a scientific calculator applied to calculations in engineering. a) Mathematical principles and calculations: i. addition, subtraction, multiplication, division ii. order of operation (BODMAS/BOMDAS/BIDMAS) iii. International System of Units (SI): • millimetres (mm) • centimetres (cm) • metres (m) • grams (g) • kilograms (kg) • second (s) • minutes (min) • Kelvin (K) • centigrade (°c) • degrees (°) • Newtons (N) • Pascal (Pa) • Watts (w)

	• Amperes (Amps) • Volts (V) • Ohms (resistance) (Ω) iv. unit conversions v. power and roots: • squaring a number • taking the square root vi. transposition of formulae to find a subject: • three variables vii. degrees of accuracy: • expressing a measurement with two significant figures viii. decimal places: • rounding a number to two decimal places ix. significant figures x. calculating percentages: • decreases • increases. b) Functions of a scientific calculator to complete calculations: i. addition, subtraction, multiplication, division ii. unit conversions iii. power and roots: • squaring a number • taking the square root iv. calculating percentages: • decreases • increases v. trigonometric functions.
1.2 Area, volume and surface area of shapes in engineering	1.2.1 Formulas to calculate circumference, area, surface area and volume of shapes in engineering. a) Circumference of circle: i. 2 x π x radius = 2πr ii. π x diameter = πd b) Areas of shapes and their associated equations: i. square: • area = length x length • $A = s^2$ ii. rectangle: • area = length x width • A = LW iii. circle:

	• area = π x radius^2 • A = πr^2 • Area= $\frac{(\pi \text{ x diameter}^{2})}{4}$ • $A = \frac{\pi D^2}{4}$ iv. triangle: • area = ½ × base × height • A = ½bh v. compound shape: add the areas of simpler shapes. c) Surface areas of shapes and their associated equations: i. rectangular prism: • surface area = 2((length x width) + (length x height) + (width x height)) • SA = 2(LW + LH + WH) ii. cylinder: • surface area = (2 x π x radius^2) + (2 x π x radius x height) • SA = 2πr^2 + 2πrh iii. cone: • surface area = (π x radius^2) + (π x radius x slant height) • SA = πr^2 + πrl iv. sphere: • surface area = 4 x π x radius^2 • SA = 4πr^2 d) Volumes of shapes and their associated equations: i. rectangular prism: • volume = length x width x height • V = LWH ii. cylinder: • volume = π x radius^2 x height • V = πr^{2}h iii. cone: • volume = ⅓ x π x radius^2 x height • V = ⅓πr^{2}h iv. sphere: • volume = $^4/_3$ x π x radius^3 • V = $^4/_3$ πr^3
1.3 Trigonometry to calculate unknown values	1.3.1 Equations that use the relationship between lengths and angles of shapes and how they are applied to calculate unknown values.

	a) Trigonometric functions: i. sin θ = opposite/hypotenuse ii. cos θ = adjacent/hypotenuse iii. tan θ = opposite/adjacent iv. tan θ = sin θ/cos θ b) Inverse trigonometric functions: i. Arcsine ($\sin^{-1}$) ii. Arccosine ($\cos^{-1}$) iii. Arctangent ($\tan^{-1}$) c) Types of equations: i. length of unknown side from two given lengths of a right-angled triangle: • Pythagoras formula for right-angled triangles • $a^2 + b^2 = c^2$
1.4 Equations for solving problems	1.4.1 Types of equation for solving problems. a) Types of mathematical equations: i. linear: • The relationship of two variables is proportional. • A graph is a straight line. ii. simultaneous: • Two variables are considered together to find a common solution. • Analysing systems.
1.5 Representation of data in graphs, charts and tables	1.5.1 Types of graphs, charts and tables used to represent data in engineering, and how they are used. a) Purposes of graphs and charts: i. line graphs: • Straight line graphs represent linear relationships and show rate of change. • Curved graphs represent non-linear relationships and show trends. ii. scatter plots or scatter graphs: • These display individual data points on a graph: ○ one variable on the x-axis ○ one variable on the y-axis.

	• They are used to identify how one variable may affect the other. iii. pie charts: • Each segment of the pie represents a portion or percentage of the whole. b) Purposes of tables: i. trigonometric tables: values of trigonometric quantities at specific angles for manual calculations ii. specification tables: data to ensure that components or materials meet design requirements and standards: • dimensions • tolerances. iii. statistical tables: reference values for analysis and to inform decision making.

Learning outcome 2

Understand the application and principles of science in engineering

Topics	Content elements
2.1 Scientific principles applied in engineering	2.1.1 Scientific principles and equations and their application in engineering. a) Types of scientific principles and their associated equations and units of measurement: i. force: • force = mass × acceleration • F = ma ii. pressure: • pressure = force ÷ area • P = F/A iii. power: • power = work ÷ time • P = W/t iv. moment of a force: • moment of a force = force x perpendicular distance • MF = Fpd v. mechanical energy: • mechanical energy = force × distance • E = Fd vi. kinetic energy: • energy = ½ x mass x velocity^2 • E = ½mv^2 vii. potential energy:

- potential energy = mass x gravity x height
- E = mgh

viii. electrical and mechanical energy:
- energy = power x time
- E = Pt

ix. work done:
- work = force × distance
- W = Fd

x. torque:
- torque = force × lever arm radius
- τ = Fr

xi. efficiency:
- efficiency (E) = energy output/energy input

xii. Ohm's Law:
- voltage = current x resistance
- V = IR

xiii. Watt's Law:
- power = voltage × current
- P = VI

xiv. ratio:
- ratio (R) = value 1 ÷ value 2

xv. frictional force:
- frictional force = coefficient of friction × normal force
- F = μN

2.1.2 Scientific principles applied in engineering.

a) Scientific principles and their associated equations:

i. moments of force, work, energy, and power:
- designing and optimising mechanical systems
- equilibrium of clockwise and anticlockwise moments
- achieving mechanical advantage (levers)
- assessing structural stability
- calculating work and energy in designing efficient engineering systems
- determining power requirements for engineering systems.

ii. efficiency:
- minimising energy waste
- improving performance

iii. mechanical advantage:
- designing mechanisms and machines to amplify or reduce forces in pulley systems, gears and levers.

iv. Ohm's Law:
- calculating voltage
- calculating current
- calculating resistance.

	v. Series circuits: • controlling and distributing electrical power sequentially • a maximum of two resistors. vi. Parallel circuits: • providing redundancy and distributing electrical loads efficiently • a maximum of two resistors.

Learning outcome 3

Understand engineering materials

Topics	Content elements
3.1 Properties of engineering materials	3.1.1 Types of engineering materials, their properties, characteristics and forms of supply. a) Types of engineering materials: i. metallic: • barred steel • mild steel (low carbon) • stainless steel ii. ferrous metals: • mild steel iii. non-ferrous metals: • aluminium • brass iv. non-metallic: • plastic • wood • elastomers (rubber) v. composites: • carbon fibre • fibre glass vi. smart materials: • piezo electric • shape memory alloys. b) Forms of supply of different types of engineering materials: i. sheet ii. plate iii. tube iv. bar stock

	v. universal beams and columns vi. rolled steel angle (RSA) vii. granules. c) Physical characteristics of different types of engineering materials: i. change of state due to temperature: • freezing • melting • boiling ii. thermal conductivity iii. tensity iv. corrosion resistance v. electrical conductivity vi. resistivity. d) Mechanical properties of different types of engineering materials: i. hardness ii. strength iii. ductility iv. malleability v. elasticity vi. creep resistance.
3.2 Suitability of engineering materials for engineering applications	3.2.1 Considerations when selecting engineering materials. a) Considerations when selecting engineering materials: i. ease of manufacture ii. aesthetics iii. environment iv. sustainability v. availability vi. properties vii. end use.
3.3 Testing properties of engineering materials	3.3.1 Test methods used to evaluate the properties of engineering materials and why they are used. a) Types of testing methods: i. hardness: • Brinell • Vickers • Rockwell ii. toughness: resistance to impact (shock loading): • Charpy • Izod iii. fatigue life:

	• Wöhler iv. mechanical properties: • tensile. b) Reasons for tests: i. material selection ii. design considerations iii. quality control.
3.4 Degradation of engineering materials	3.4.1 Types of degradation in different types of engineering materials, their causes and symptoms. a) Types of engineering materials: i. metallic ii. ferrous metals iii. non-ferrous metals iv. non-metallic v. composites vi. smart materials. b) Symptoms of degradation: i. pitting ii. oxidation. c) Causes of degradation: i. age ii. corrosion iii. contamination iv. fatigue v. galvanic vi. sunlight vii. temperature. 3.4.2 Suitability of different types of degradation prevention, and their correct and safe usage. a) Types of prevention: i. coatings: • paint • powder • plastic • oil ii. keeping materials apart iii. changing the properties iv. cathodic v. anodic.

	b) Considerations of suitability: i. ease of manufacture ii. aesthetics iii. environment iv. sustainability v. availability vi. properties vii. end use.
3.5 Heat treatment of engineering materials	3.5.1 Processes and effects of different heat treatments to change the physical properties of engineering materials. a) Types of engineering materials: i. metallic ii. ferrous metals iii. non-ferrous metals iv. non-metallic v. composites vi. smart materials. b) Process and effects of heat treatment on engineering materials: i. annealing: • Increases ductility. • Reduces hardness. • Relieves internal stresses. • Refines grain structure (homogeneous). ii. quenching: • Increases hardness. • Increases strength. iii. tempering: • Reduces brittleness caused by quenching. • Increases ductility. • Increases impact resistance, maintaining a reasonable level of hardness. iv. normalising: • Refines grain structure to become more uniform. • Increases strength. • Increases ductility. v. hardening: • Increases hardness. • Increases strength. • Reduces ductility. vi. case hardening:

	• Increases surface hardness. • Maintains softer core. vii. ageing (precipitation hardening): • Used with some alloys. • Increases strength. • Increases hardness. • Maintains ductility. viii. stress relieving: • Increases dimensional stability. • Reduces risk of failure due to residual stresses. ix. spheroidising: • Increases ductility.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201 and 203.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to observe manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Staff CPD in line with current practice. Utilising employer/stakeholder engagement within the delivery of the course with steering groups where employers can have sight of delivery.
Equity, diversity and inclusion (EDI) or accessibility considerations:	Centres must deliver the unit in line with their EDI policy and organisational procedures. Consideration needs to be given to neurodiverse learners, as they may have difficulty with interactions. Ensure all personal protective equipment (PPE) can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	Bird, J.O. (ed.) (2005) *Basic engineering mathematics.* 4th edn. Amsterdam, Boston: Newnes Boston, MA: (2003) *Manual of Engineering Drawing.* Oxford: Butterworth-Heinemann *Engineering Technologies Level 2*. London, New York
Websites:	Lunch Box sessions (subscription) LunchBox Sessions

Unit 202 Engineering workshop practice

Unit level:	2
Guided Learning Hours (GLH):	60
Unit aim:	The purpose and aim of this unit are to provide the learner with knowledge and understanding of the fundamental principles of safe practice, use of hand tools, and quality control procedures in an engineering environment.
Assessment method:	Theory exam
Links to Occupational Standards:	ST0537 Engineering Operative ST0349 Welder

Learning outcomes

1. Understand engineering health and safety requirements
2. Understand how to prepare for engineering workshop activities
3. Understand hand tools and skills in engineering
4. Understand quality control procedures in engineering

Learning outcome 1

Understand engineering health and safety requirements

Topics	Content elements
1.1 Legislation affecting health and safety in engineering	1.1.1 Legislation and regulations that promote health and safety in the workplace. a) Types and purpose of legislation and regulations: i. Health and Safety at Work Act (HASWA): • General duties of employers and employees to ensure the health, safety and welfare of all people at work. ii. Provision and Use of Work Equipment Regulations (PUWER): • Requirements for the selection (use for intended purpose), safe use and maintenance of work tools, equipment and machinery to prevent accidents. iii. Personal Protective Equipment (PPE) at Work Regulations: • Mandates the provision, correct use and maintenance of personal protective equipment (PPE) to protect employees from workplace hazards. iv. Control of Substances Hazardous to Health (COSHH):

- Guidelines for employers to assess and control the safe handling, storage and disposal of hazardous substances to protect employees from exposure.

v. Manual Handling Operation Regulations:
- Employers are required to assess and minimise the risks associated with manual handling tasks.

vi. Lifting Operations and Lifting Equipment Regulations (LOLER):
- Ensures that lifting equipment is inspected, tested, maintained and operated safely to prevent accidents and injuries.

vii. Electricity at Work Regulations:
- Electrical systems and equipment in the workplace must be properly maintained and inspected to prevent electrical accidents and fires.

viii. Reporting of Injuries and Diseases and Dangerous Occurrences Regulations (RIDDOR):
- Mandates the reporting of certain workplace accidents, injuries, diseases and dangerous incidents.

ix. Management of Health and Safety at Work Regulations:
- Employers must assess risks, implement control measures and provide information and training to employees.

1.1.2 Standards and regulations that relate to environmental and sustainability projects and practices.

a) Types of standards and regulations:

i. Environmental Protection Regulations:
- are laws related to air quality, water quality, waste management and habitat protection to minimise the environmental impact of projects
- vary by country and regio.

ii. Energy Efficiency Standards and Codes:
- reduce energy consumption and greenhouse gas emissions
- apply to buildings, appliances and industrial processes.

iii. Renewable Energy Standards:
- mandate the use of renewable energy sources for a certain percentage of electricity generation.

iv. Green Building Codes and Certification Programmes:
- These are guidelines for sustainable building design and construction.
- Compliance can be mandatory in some locations.

	v. Waste Management Regulations: • Engineering projects must minimise waste generation and follow safe disposal practices. • Covers waste disposal, recycling and hazardous materials handling. vi. Water Resource Management Regulations: • water use • water conservation • protection of aquatic ecosystems. vii. Emissions Reduction Targets: • targets and regulations to combat climate change viii. Social and Environmental Impact Assessment (SEIA): • assess and mitigate potential social and environmental impacts. ix. Biodiversity Protection Regulations: • protect biodiversity, including endangered species and ecosystems, in natural habitats. x. Corporate Social Responsibility (CSR) reporting: • are regulations and stock exchange requirements that mandate companies to disclose their sustainability practices, including environmental and social impacts. xi. International standards of the International Organization for Standardization (ISO): • ISO 14001 for environmental management systems • ISO 50001 for energy management systems. xii. Sustainable Transportation Regulations: • public transportation • fuel-efficiency standards for vehicles • development of sustainable transportation infrastructure. xiii. Circular Economy: • regulations and initiatives to reduce waste and promote the reuse and recycling of materials.
1.2 Safe working practices in engineering	1.2.1 Procedures for safe working practices and the purpose of each procedure. a) Safe working procedures: i. Create and/or follow risk assessments. ii. Familiarity with safety policies and procedures. iii. Prepare self (select appropriate PPE). iv. Prepare area to safely carry out work. v. Prepare tools, equipment and machinery for safe use. vi. Work safely whilst carrying out activities. vii. Follow instructions; if in doubt, ask. viii. Return tools, equipment and machinery to store.

	ix. Dispose of waste materials appropriately. x. Leave work area in a safe condition. 1.2.2 The types and purpose of commonly used safety signs that people must respond to in order to maintain safety. a) Types of safety signs and their purposes: i. prohibition signs: • red circle with a diagonal line (diagonal slash) across the image or text, which is superimposed on a white background • actions or behaviours that are strictly forbidden or prohibited within a specific area • signs: No smoking, No entry/admittance, No access for industrial vehicles, Not drinking water/Not drinkable, Do not touch, No open flames ii. mandatory signs: • circle shape • blue background with white text, symbols or pictograms • actions or behaviours that are required or mandatory • signs: Ear protection, Eye protection, Gloves, Safety boots, Face mask, Face screen, Respiratory protection, Protective clothing/overalls, Hard hat, Safety harness, Use guards, Lift correctly iii. warning signs: • triangle shape • high-visibility yellow background to attract attention with black text, symbols or pictograms • hazardous chemicals (COSHH): red border on diamond shape, white background • to alert individuals to potential hazards or dangerous conditions that may exist in the area • signs: Chemicals, Electrical warning or High voltage, Corrosive (acids), Flammable liquid, Flammable, Oxidising, Toxic, Irritant/Harmful, Laser radiation, Explosion risk, Forklift trucks, Slippery floor iv. safe condition signs: • rectangular shape • green background with white text, symbols or pictograms • location of safety equipment, emergency facilities, or exits • signs: First aid point, Fire assembly point, Eye wash station, Emergency stop, Fire exits (green arrows), Telephone, Refuge point
1.3 Risk assessment process	1.3.1 Process to carry out a risk assessment following Health and Safety Executive (HSE) guidance to identify, evaluate and control risks in the workplace. a) Process to create a risk assessment: i. Identify hazards in the workplace and in a process. ii. Assess the risks.

	iii. Control the risks. iv. Record the findings in a risk assessment form: • hazards • who might be harmed and how (risk) • precautions and actions by whom and when (control measures) • risk rating (high, medium, low). v. Review the controls for continuous improvement.
1.4 Employer and employee responsibilities for safe working	1.4.1 Employer and employee responsibilities under the Health and Safety at Work Act (HASWA). a) Employer responsibilities: i. provision of safe working environment ii. provision of access to adequate staff training iii. provision of health and safety information iv. completion of risk assessments v. supervision vi. provision of PPE for employees vii. reporting hazards, accidents and near misses viii. providing provision for employee welfare ix. displaying public liability insurance and health and safety law posters/information. b) Employee responsibilities: i. exercising a duty of care to themselves and to others ii. working in a safe manner iii. complying with employer instructions iv. attending safety training v. working safely with other trades vi. reporting hazards, accidents and near misses vii. following organisational policies and procedures, including risk assessments.

Learning outcome 2

Understand how to prepare for engineering workshop activities

Topics	Content elements
2.1 Technical information used to prepare for engineering activities	2.1.1 Types and sources of information used to prepare for workshop activities. a) Types of technical information and their uses: i. engineering material properties used to select a material to meet performance and durability requirements:

- mechanical
- thermal
- electrical
- chemical

ii. component information that defines the component:
- specification
- dimension
- material
- tolerance
- functionality

iii. dimensions that define the size and shape of a component:
- length
- width
- height
- diameter
- angles

iv. tolerance:
- allowable variations from specified dimensions, characteristics or performance criteria while still meeting the required quality and functionality standards
- specified in engineering drawings and written specifications

v. finish (surface treatment or coating) applied to a component or material to achieve specific properties or appearances:
- painting
- plating
- anodising
- polishing
- heat treatment

vi. quantity information used in procurement, inventory management and project planning:
- the number of units, parts, or components

vii. function information about the intended purpose, operation and performance requirements of a component or system:
- the context of the larger system and the specific functions it must perform
- guides design, testing and quality assurance to ensure components and systems meet their functional requirements.

b) Information sources:

i. technical manuals

ii. specifications

	iii. manufacturer's instructions iv. engineering drawings v. online resources vi. online forums vii. professional bodies.
2.2 Considerations when planning engineering activities	2.2.1 Considerations when planning safe engineering activities and how they impact each other. a) Types of considerations: i. health and safety: • risk assessments to identify potential hazards and risks • use of control measures • suitable work area ii. materials to meet specifications and quality standards: • sourcing • inspecting • handling • storing iii. tools and equipment: • availability • functionality • maintenance • safety iv. time: • planning/scheduling to optimise efficiency • preparation • execution v. quality: • procedures/inspections/reports • quality standards and specifications vi. tolerances vii. activity: • steps • procedures • actions viii. sequence of operations: • chronological order • workflow • dependencies.

Learning outcome 3

Understand hand tools and skills in engineering

Topics	Content elements
3.1 Methods of measuring and marking out materials in engineering	3.1.1 Tools and methods used for measuring and marking out engineering materials to meet specifications and quality standards, including their accuracy. a) Types of tools for measuring and marking out engineering materials, and their use: i. rules/tapes: • linear measurement ii. dividers: • drawing precise circles and arcs • transferring measurements iii. scribers: • marking lines (scribing) • precise measurements iv. surface plate: • reference point to measure and inspect flatness and straightness v. centre and prick punches: • creating holes in materials • marking specific points vi. scribing blocks: • transferring measurements vii. squares: • combination squares • try squares • marking and checking right angles • component alignment viii. protractor: • measuring and drawing angles ix. chalk line: • creating straight lines over relatively long distances x. lasers: • alignment • measurement • levelling xi. vernier instruments: • callipers • micrometers • height gauges xii. marking blue/layout fluid. b) Methods for marking out, and their use: i. datum lines: • referencing axes or planes to establish the primary point of contact or reference on a part • aligning and inspecting parts ii. square and rectangular profiles: • specifying the desired shape and orientation of features

	on a component • defining the cross-section of a feature which can be square or rectangular in shape and must be perpendicular to a reference datum iii. circles: • specifying the diameter of a circular feature • ensuring that the cross-section of the feature is circular iv. radial profiles: • specifying the desired shape and orientation of features that are radial in nature • ensuring that the features maintain a specific radial relationship to a reference datum v. linear hole positions (positional tolerances): • specifying allowable deviation in the location of a feature along a linear axis • ensuring that holes are positioned accurately with respect to a reference point or datum vi. angles between two surfaces or angular profiles: • specifying desired angular relationship between features • orientation of a feature relative to a datum • angular alignment of multiple features
3.2 Hand tools used in engineering	3.2.1 Hand tools and their uses for shaping, modifying and joining engineering materials. a) Types of tools and their uses in engineering: i. saws ii. cutting wheels iii. files: • shaping • smoothing iv. chisels: • cutting • shaping v. angle, bench and die grinders: • grinding • polishing • shaping vi. drills: • creating holes vii. taps and dies: • taps create internal threads. • dies create external threads. viii. tin snips: • cutting sheet metal and thin materials. b) Types of tools and their uses in electrical systems: i. crimpers: • crimping or compressing connectors, sleeves or

	terminals onto wires or cables ii. wire strippers: • removing the insulation from wires to expose the conductive core iii. diagonal and cable wire cutters: • cutting wires, cables. c) Types of mechanical tools and their uses: i. screwdrivers ii. spanners: • adjustable • socket • open-end iii. hammer: • claw hammers • ball-pein hammers. iv. pliers: • slip-joint pliers • needle-nose pliers • locking pliers (vise-grips). v. torque wrench to apply a specific amount of torque (rotational force). d) Techniques for material removal: i. cutting ii. sawing iii. filing iv. chiselling v. drilling vi. threading vii. desoldering viii. etching: • chemical • abrasive.
3.3 Methods of assembly in engineering	3.3.1 Considerations of assembly methods that ensure materials and components are securely and accurately joined. a) Methods of assembly: i. mechanical (physical) methods: • screws • nuts and bolts • rivets • pins • clips • press fit • snap fit ii. electrical components: • electrical connectors

	• terminals • wires • soldering iii. thermal bonding: • welding • brazing • soldering • adhesive iv. non-thermal bonding: • adhesive. b) Considerations of assembly methods: i. ease of manufacture ii. aesthetics iii. environment iv. sustainability v. availability vi. properties of the assembly method vii. properties of the engineering material viii. end use ix. accuracy/alignment x. stability xi. strength/durability xii. disassembly.

Learning outcome 4

Understand quality control procedures in engineering

Topics	Content elements
4.1 Quality control in engineering	4.1.1 Purposes and timing of quality control in engineering, and the associated records. a) Purposes of quality control: i. checking that it meets the specification ii. checking work is within tolerances iii. prevention of defects. b) Records of information: i. sources of information to check against: • technical drawings • specifications • standards ii. record of the quality control process: • inspection reports • test results • functionality of completed product. c) Timing of quality assurance:

	i. during manufacture ii. after manufacture.
4.2 Measuring devices used in quality control	4.2.1 Types of measuring devices, their accuracy and their uses for measurement, inspection and testing as part of quality control. a) Types of measuring devices and their uses: i. micrometers: • external dimensions (outside micrometer) • depth measurements (depth micrometer) ii. tape measures: • linear measurements iii. multimeter (electrical and electronic systems): • voltage • current • resistance iv. vernier calliper: • external dimensions • internal dimensions v. comparison plates: • comparing dimensions and shapes of parts to standard reference plates vi. infrared thermometer: • non-contact temperature measurement vii. rules: • linear measurements viii. continuity tester: • checking electrical continuity • identifying open circuit ix. squares: • checking right angles and alignment of components x. protractors: • measuring angles xi. plug and ring gauges: • checking the dimensions and tolerances to meet specifications xii. dial test indicator (DTI): • small distances • surface flatness • runout xiii. coordinate measuring machine (CMM): • automated three-dimensional measurements xiv. insulation resistance tester: • insulation resistance of electrical equipment.
4.3 Quality inspections used in engineering	4.3.1 Methods of verification that a product, component or system meets the required specification and standard, and reliably performs as expected. a) Quality inspection checks in engineering: i. specification: • requirements

	• characteristics • features • design • performance ii. dimensions: • measurements/sizes • geometric characteristics iii. functionality: • effectiveness • reliability iv. tolerances v. visual: • free from false cuts, burrs and sharp edges • free from damage.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201 and 203.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to observe manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Staff CPD in line with current practice. Utilising employer/stakeholder engagement within the delivery of the course with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Centres must deliver the unit in line with their EDI policy and organisational procedures. Consideration needs to be given to neurodiverse learners, as they may have difficulty with interactions. Ensuring all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring where possible that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	Bird, J.O. (ed.) (2005) *Basic engineering mathematics.* 4th edn. Amsterdam; Boston: Newnes Boston, MA: *Manual of Engineering Drawing.* Oxford: Butterworth-Heinemann, 2003 Engineering Technologies Level 2 London, [England]; New York, New York
Websites:	Lunch Box sessions (subscription) LunchBox Sessions

Unit 203 Working in engineering

Unit level:	2
Guided Learning Hours (GLH):	60
Unit aim:	The purpose and aim of this unit are to provide the learner with knowledge of the organisation of engineering businesses, and understanding of communication in engineering businesses.
Assessment method:	Theory exam
Links to Occupational Standards:	ST0537 Engineering Operative ST0349 Welder

Learning outcomes

1. Know how engineering businesses are organised
2. Understand business communications
3. Understand approaches to business improvement
4. Understand technical drawings used by engineering businesses

Learning outcome 1

Know how engineering businesses are organised and managed

Topics	Content elements
1.1 Organisation of engineering businesses	1.1.1 Types of engineering business and the characteristics of how businesses are organised and managed. a) Types of engineering business i. business ownership: • sole trader • partnership • limited company • corporation ii. classification by business size: • small • medium • large iii. geographical operation: • local • regional • national • international/multinational

	iv. engineering sectors: • chemical • civil • electrical • mechanical • interdisciplinary. b) Characteristics of how engineering business are organised: i. organisational structure and organisational charts: • functional or role based – centralised/hierarchical • product or market based – centralised/hierarchical • geographical divisional structure • process based • matrix • circular ii. levels of responsibility: • craft • engineering technician • senior engineer • operations management • project management • director/CEO iii. lines of internal and external communication: • managers • colleagues • across departments • external stakeholders (customers, suppliers) iv. roles and responsibilities of employers and employees: • achieving company targets • continuous development of skills • developing working relationships.
1.2 Functional areas of engineering businesses	1.2.1 Functional areas and engineering job roles within engineering businesses. a) Purpose of functional areas: i. management functions ii. human resources/personnel iii. sales iv. marketing v. engineering: various disciplines vi. manufacturing

	vii. quality control viii. accounts ix. research and development x. customer support. b) Types of engineering job roles: i. servicing and maintenance operative ii. machine setter/operative iii. mechanical engineering operative iv. fabricator v. multidisciplined engineering operative vi. materials, processing and finishing operative vii. technical support operative viii. founding/casting operative ix. electrical engineer.
1.3 Stakeholders of engineering businesses	1.3.1 Internal and external stakeholders in engineering businesses. a) Types of internal stakeholders and their roles: i. Board of Directors/owners: • governance • strategic direction • long-term goals and objectives ii. colleagues/team members: • working collaboratively to achieve project goals and organisational objectives iii. investors: • providing financial resources iv. consultants and contractors: • specialised technical expertise • managing labour, equipment, materials and subcontractors. b) Types of external stakeholders: i. existing clients/users (customers) ii. potential clients/users (customers) iii. external shareholders iv. standard-setting bodies v. government regulatory bodies vi. suppliers vii. subcontractors.

1.4 Standards for engineering and manufacturing businesses	1.4.1 Industry-specific standards and their purpose in ensuring safety, quality and consistency, and minimising risk in processes, systems and products within a business. a) Standards and their purposes: i. industry body codes of practice: • guidelines, recommendations and standards developed and endorsed by associations or organisations • addressing industry-specific challenges, best practices and safety measures • ensuring safety, quality and consistency • promoting uniformity ii. national standards: • technical specifications, guidelines and requirements • ensuring safety, quality and compatibility of products, services and processes • regulatory requirements that must be met for compliance with local laws iii. international standards: • established by the International Organization for Standardization (ISO) • globally recognised technical guidelines, specifications and requirements • facilitation of international trade • ensuring product/service quality • promotion of innovation • promotion of safety. b) Types of standards and practices, and their purposes: i. managing quality: • implementing processes and practices to ensure that products, services or processes meet or exceed established quality standards and customer expectations • quality planning • quality assurance • quality control ii. continuous improvement: • efficiency • effectiveness • overall performance • performance metrics • performance improvement methodologies

	iii. managing health and safety: • creating a safe and healthy work environment • developing and implementing safety policies, procedures and practices to prevent accidents and injuries iv. risk reduction: • identifying hazards and risks • assessing hazards and risks • mitigating hazards and risks • minimising likelihood and impact v. managing security: • protecting physical assets, data and intellectual property from unauthorised access, theft, damage or disruption • cybersecurity measures • physical security protocols vi. sustainability: • minimising environmental impact • reducing resource consumption • lowering emissions • promoting eco-friendly design and manufacturing vii. demonstrating good service: • delivering high-quality services to clients, customers or stakeholders • responsiveness/meeting expectations • professionalism • value-added solutions viii. standardisation: • recognition of quality marks • adherence to established industry standards and specifications • consistency • compatibility • interoperability ix. organisational requirements: • needs, policies and procedures of an organisation • compliance with standards, regulations and operational guidelines.
1.5 Individual role in an organisation	1.5.1 Professional behaviour and development of an individual in the workplace. a) Professional behaviour:

	i. personal standards: • time management • being on time • doing what you say you will do • focusing on the task in hand • positive attitude • willingness to learn and listen ii. teamwork: • working as a team towards a common goal • communication with your team and line manger so that they know what you are doing • asking for and providing help • dealing with conflict. 1.5.2 The methods and benefits of maintaining Continuous Professional Development (CPD) and lifelong learning. a) Methods of development: i. online learning ii. workplace learning iii. staying up to date with industry trends, advancements and best practices. b) Benefits of maintaining CPD: i. keeping knowledge and skills up to date ii. maintaining professional standard of qualifications and registrations iii. building and enhancing credibility and confidence iv. increased employment opportunities

Learning outcome 2

Understand business communications

Topics	Content elements
2.1 Communication in the engineering workplace	2.1.1 Methods of business communication and considerations for their effective use with technical and non-technical people in the engineering workplace. a) Communication methods: i. verbal: • face to face • radio • mobile phone ii. visual: • hand signals

	• video calls/online meetings iii. written: • specifications • drawings • plans • signage and notices • agenda items and minutes of meetings • email • text • orders to suppliers • delivery notes. b) Considerations for effective use of communication methods: i. verbal: • offering ideas, opinions, emotions or instructions in a direct and personal way • should be confident, engaging, respectful and persuasive • using appropriate language, tone of voice ii. visual: • graphical or pictorial information • capturing attention and enhancing understanding • should be simple, attractive, relevant and consistent • using appropriate colours, shapes and symbols effectively iii. written: • formal, detailed or complex information • should be clear, concise, accurate and well structured • following the appropriate tone, style and format for intended audience.
2.2 Business documentation in the engineering workplace	2.2.1 Types of business documentation, their uses and considerations for document storage in the engineering workplace. a) Uses of engineering documents: i. tables and charts about engineering materials ii. bill of materials (BoM) iii. reports iv. technical/engineering drawings v. health and safety documents vi. work instructions vii. specifications viii. time sheets ix. work records

	x. training records. b) Considerations for storing business documents: i. security ii. accessibility (physical and digital) iii. distribution (internal and external) iv. retention periods v. compliance with standards, regulations and operational guidelines

Learning outcome 3

Understand approaches to business improvement

Topics	Content elements
3.1 Processes used in engineering	3.1.1 Types of manufacturing, service and engineering processes in the engineering sector. a) Types of manufacturing process and their benefits: i. design to order: • custom manufacturing to specific customer requirements • uniquely designed and manufactured ii. one-off production: • custom manufacturing of a single, unique product iii. batch production: • efficient manufacturing of a limited quantity of identical products in a single production run • may be repeated for another set of identical items iv. mass production: • continuous production of large quantities of standardised products • maximising efficiency and reducing production costs v. just-in-time manufacturing (JIT): • lean manufacturing, producing only what is needed when it is needed • minimising stock • increasing efficiency vi. manufacture to stock and distribute: • stock manufacturing in anticipation of customer demand and maintaining stock • products distributed to customers in good time.

	b) Types of service-related processes: i. maintenance and repair of machinery, equipment and infrastructure: • inspection • repair • upkeep ii. service provision: • consultancy • repair • maintenance • technical support. c) Types of engineering design processes: i. design of products, systems and structures: • conceptualisation • drafting • modelling ii. analysis of designs, systems and components against standards and specifications: • mathematical • computational • analytical.
3.2 Approaches to business improvement	3.2.1 Approaches to business improvement and how they can improve performance for processes, systems and workflows. a) Approaches to business improvement and their characteristics: i. continuous improvement: • overarching philosophy • ongoing, systematic approach to identifying, addressing and improving • improving quality • reducing costs • increasing efficiency ii. data-driven methodology: • identifying defects/variations in process • reducing process variation • improving product quality • optimising manufacturing processes • minimising defects • cost reduction

	• increased customer satisfaction iii. small-scale changes: • emphasises incremental changes • streamlined production • reducing waste • increasing overall efficiency • involvement from all employees • implementing improvements regularly iv. lean manufacturing: • organising and optimising workspaces • just-in-time (JIT) • reducing waste • increasing efficiency v. visual management: • visual cues to communicate information and monitor processes • real-time data • track progress • problem identification • improving decision-making • process control • quality assurance vi. mind mapping: • visual representation technique • organising and structuring ideas/concepts/information • project planning • problem solving • concept development.
3.3 New and developing technologies	3.3.1 New and developing technologies to maintain, increase or enhance the effectiveness and sustainability of engineering projects, and the factors affecting their use. a) Technologies: i. electrically powered vehicles/machinery ii. solar/photovoltaic panels iii. wind power iv. hydro power v. augmented reality (AR)/virtual reality (VR)/simulated training environments vi. artificial intelligence.

	b) Factors affecting use of technologies: i. cost ii. availability iii. planning and design requirements iv. legislation v. local authority initiatives/restrictions.

Learning outcome 4

Understand technical drawings used in engineering

Topics	Content elements
4.1 Technical drawings used in engineering	4.1.1 Characteristics of technical drawings and their advantages. a) Types of technical drawing: i. part ii. sub-assembly iii. general assembly iv. general arrangement v. flow diagram vi. schematics vii. computer-aided design (CAD) viii. working/detailed drawing. b) Characteristics of technical drawings: i. orthographic (first- and third-angle projection) ii. isometric iii. exploded iv. section v. hidden detail vi. breakout vii. auxiliary. c) Advantages of characteristics of technical drawings: i. orthographic: • clarity: clear and accurate representation of an object from multiple viewpoints (front, top, side) • precise measurements and dimensioning of the object • first- and third-angle projections follow standardised conventions, making them universally understood in engineering and manufacturing ii. isometric: • 3D visualisation of an object on a 2D plane, making it easier to visualise and understand the object's form

	• simplified perspective, avoids the distortion of perspective drawings, simplifying the depiction of complex objects iii. exploded: • shows how individual components fit together (assembly instructions) • enhances clarity by separating components, making it easier to understand the assembly process iv. section: • shows the internal details of an object • clarifies the structure and assembly of complex objects v. hidden detail: • highlights specific features or components that are typically hidden • enables focus on critical areas vi. breakout: • enlarged and detailed representations of specific sections or components within a larger assembly • enhances clarity by zooming in on critical areas, making it easier to analyse and understand complex parts vii. auxiliary: • provides additional information about an object, such as true shapes or angles of features that are not parallel to the primary drawing planes • precision in representing features that are challenging to depict accurately in orthographic views.
4.2 Information found on technical drawings in engineering	4.2.1 Information found in technical drawings, their purpose and use. a) Types of information found in technical drawings, their purpose and use: i. International Organization for Standardization (ISO) standards: • ensure consistency and uniformity • provide guidelines for drawing layout, conventions, symbols and terminology, • facilitate worldwide communication and collaboration ii. Zones or drawing zones: • are designated areas where specific information or views are presented • organise the drawing, making it easier to locate and interpret details. iii. Scale:

- defines the relationship between the drawing's dimensions and the actual dimensions of the object being represented
- allows the reader to determine real-world sizes and proportions.

iv. Revision notations and version control:
- track changes and update to a technical drawing over time
- help ensure that everyone is working with the most current version and understand the history of modifications.

v. Status:
- refers to whether the drawing is preliminary, final, approved or pending further review.

vi. Dimensions:
- are precise measurements of the object's size, shape and placement
- are used for quality control
- ensure that components fit and function as intended.

vii. Associated drawings:
- are supplementary drawings or reference documents
- provide additional information, details or views
- relate to the primary drawing
- enhance understanding of the object or system.

viii. Bill of materials (BoM)/parts list:
- contains all the components, materials and quantities needed for the assembly or construction of the object
- aids procurement, inventory management and assembly planning.

ix. Symbols and abbreviations:
- convey information concisely and efficiently
- represent common features, materials or processes
- save space
- reduce clutter.

x. Tolerances:
- specify acceptable variations in dimensions or geometric properties
- ensure manufactured parts meet design requirements.

xi. Elevation views
- are detailed representations of an object's vertical or side-facing surfaces.

4.3 Features found in technical engineering drawings	4.3.1 Features found in engineering drawings. a) Types of features that provide information about the part or component, and their symbols where applicable: i. balloon ii. dimension iii. diameter iv. counterbore v. countersink vi. depth vii. centre mark viii. centre line ix. tolerance x. scale. b) Types of features that provide reference, and their symbols: i. datum: • line • surface • edge • corner • centre ii. parallelism iii. perpendicular iv. concentricity v. straightness.
4.4 Symbols found in engineering drawings	4.4.1 Types of electrical, hydraulic, mechanical and welding symbols found in engineering technical drawings. a) Types of electrical symbols: i. batteries ii. amplifiers iii. resistors iv. capacitors v. lamps vi. transformers vii. diodes viii. inductors ix. relays x. transistors xi. wiring xii. switches.

b) Types of hydraulic symbols:

i. pumps
ii. actuators
iii. control valves
iv. reservoirs
v. pressure regulator
vi. motors
vii. filters
viii. pressure release valves.

c) Types of mechanical symbols:

i. drive shafts
ii. pulleys
iii. sprockets
iv. clutches
v. gears
vi. type of fixing:
    - nut
    - bolt
    - rivet.

d) Types of welding symbols:

i. fillet
ii. butt
iii. open corner
iv. weld both sides
v. weld on site.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201 and 202.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to visit manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Staff CPD in line with current practice. Utilising employer/stakeholder engagement within the delivery of the course, with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Centres must deliver the unit in line with their EDI policy and organisational procedures. Consideration needs to be given to neurodiverse learners, as they may have difficulty with interactions. Centres must ensure all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	Bird, J.O. (ed.) (2005) *Basic engineering mathematics.* 4th edn. Amsterdam: Newnes Boston, MA: *Manual of Engineering Drawing.* Oxford: Butterworth-Heinemann, 2003

	Engineering Technologies Level 2 London, [England]; New York, New York Pritchard, D. (2001) *Soldering, brazing and welding: a manual of techniques.* Marlborough: Crowood. Galvery, W.L. and Marlow, F.M. (2001) *Welding essentials: questions and answers.* Norwalk, CT: Industrial Press.
Websites:	Lunch Box sessions (subscription) LunchBox Sessions

Unit 204 Maintenance principles

Unit level:	Level 2
Guided Learning Hours (GLH):	60
Unit aim:	The aim of this unit is for learners to have the knowledge and understanding of maintenance principles and procedures for different types of maintenance. The unit will provide learners with knowledge and understanding of the characteristics of different types of maintenance and an understanding of the considerations of machine maintenance.
Assessment method:	Synoptic practical assignment
Links to Occupational Standard:	ST0537 Engineering Operative

Learning outcomes

1. Know different types of machine maintenance
2. Understand the considerations of machine maintenance

Learning outcome 1

Know different types of machine maintenance

Topics	Content elements
1.1 Understanding the characteristics of different types of maintenance within engineering	1.1.1 Characteristics of maintenance engineering: a) definition b) conditions c) costs d) personnel e) resources f) service level agreements g) support from equipment manufacturers h) reporting requirements i) communication methods needed j) data collection k) preparation activities l) periods of servicing and maintenance m) maintenance activities carried out n) quality considerations o) component upgrading and monitoring p) training required q) planning tools/critical analysis r) variation order s) engineering technical drawings. 1.1.2 Types of maintenance:

Topics	Content elements
	a) reactive b) planned c) preventative d) condition-based monitoring e) total planned maintenance. 1.1.3 The advantages and disadvantages of different approaches to maintenance: a) costs b) downtime c) lifespan of the machine components d) planning and scheduling e) disruption.
1.2 Maintenance activity requirements	1.2.1 Different types of maintenance activities: a) cleaning b) inspection c) diagnostic d) fault finding e) monitoring f) adjustment g) repair h) refurbishment i) replacement.
1.3 Maintenance planning	1.3.1 Types of maintenance planning activities: a) scheduling of planned maintenance b) ordering and receiving parts and consumables c) duration of task d) planning tools. 1.3.2 Types of documentation and its purpose: a) maintenance history b) manufacturer's literature c) test certificates d) distribution of information e) specification and instructions. 1.3.3 Types, purpose and interpretation of technical drawings: a) schematic b) assembly c) wiring d) plan e) site. 1.3.4 Responsibilities of different types of stakeholders: a) internal b) external. 1.3.5 Communication methods: a) verbal b) written

Topics	Content elements
	c) technical language d) non-technical language. 1.3.6 Purpose and completion of planning documentation: a) risk assessment b) method statement.

Learning outcome 2

Understand the considerations of machine maintenance

Topics	Content elements
2.1 Considerations of different types of maintenance activity	2.1.1 Areas for consideration: a) financial: i. budget ii. affordability iii. key performance indicators (KPIs) b) productivity: i. morale ii. quality iii. timescales iv. deadlines v. scheduling vi. customer service vii. reputation viii. communication ix. resource implications x. equipment life cycle xi. sustainability xii. decision-making.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201 and 203.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to observe manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Utilising employer/stakeholder engagement within the delivery of the course, with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Ensuring all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	N/A
Websites:	N/A

Unit 205 Engineered systems

Unit level:	2
Guided Learning Hours (GLH):	60
Unit aim:	The aim of this unit is for learners to understand the working principles of engineering systems. The unit will provide learners with underpinning knowledge of mechanical and electrical systems.
Assessment method:	Synoptic practical assignment
Links to Occupational Standard:	ST0537 Engineering Operative

Learning outcomes

1. Understand mechanical systems
2. Understand electrical systems
3. Understand fluid power systems

Learning outcome 1

Understand mechanical systems

Topics	Content elements
1.1 Mechanical systems	1.1.1 Definition of mechanical systems. 1.1.2 Characteristics and purpose of different types of mechanical systems: a) machine tools: i. lathes ii. milling machines iii. grinding machines iv. drilling machines b) conveyors: i. belt ii. roller c) processing plant: i. hoppers/elevators ii. vessels d) process control measuring equipment: i. levels ii. pressures iii. gauges e) lifting and handling equipment and accessories: i. lifting eyes and hooks ii. chains and slings f) gearboxes:

Topics	Content elements
	i. gear drive ii. worm drive. 1.1.3 Characteristics and application of general mechanical system components: a) shafts b) couplings c) bearings d) seals e) gears f) chains and belts.
1.2 Maintenance of mechanical systems	1.2.1 Reasons for maintenance of mechanical systems: a) component failure b) replacement of end-of-life components c) repair or replacement of components d) adjustment due to wear e) alignment of parts.

Learning outcome 2

Understand electrical systems

Topics	Content elements
2.1 Electrical systems	2.1.1 Definition of electrical systems. 2.1.2 Characteristics and purpose of different types of electrical systems: a) power i. ring final ii. radial b) lighting circuits i. one way ii. two way iii. intermediate c) fire and security i. alarm devices ii. emergency/standby batteries d) fault protection i. safety devices ii. overload protection devices e) electronic control devices i. sensors and actuators ii. electronic modules/units f) containment systems i. tray work ii. conduit iii. trunking g) cable types i. fire protection: FP 200/400, mineral insulated copper clad (MICC)

Topics	Content elements
	ii. armoured iii. data/communication iv. fibre optics v. PVC vi. screened vii. cable connectors h) terminations and connections i. loom/harness ii. bus bars. 2.1.3 Characteristics and application of general electrical system components: a) switches b) luminaires c) push buttons d) emergency stop e) contactors f) overloads g) power sockets h) motors and starters i) cables j) fuses k) circuit breakers l) panels or sub-assemblies m) switchgear n) relays o) solenoids.
2.2 Maintenance of electrical systems	2.2.1 Reasons for maintenance of electrical systems: a) degradation of/damage to insulation b) repair or replacement of faulty component(s) c) adjustment due to use (tolerances and limits) d) loose connections and terminations.

Learning outcome 3

Understand fluid power systems

Topics	Content elements
3.1 Fluid power systems	3.1.1 Definition of fluid power systems. 3.1.2 Characteristics and purpose of different types of fluid systems: a) hydraulic: i. pumps ii. centrifugal iii. reciprocating iv. gear v. vane b) pneumatic: i. compressors

Topics	Content elements
	ii. screw iii. reciprocating. 3.1.3 Characteristics and application of general fluid system components: a) filters b) reservoir c) receiver d) dryer e) oil mist lubricator f) drain g) actuator h) valves i) accumulator j) pressure gauges k) cylinders.
3.2 Maintenance of fluid power systems	3.2.1 Reasons for maintenance of fluid power systems: a) wear b) adjustment due to wear c) to prolong the life of filters, pumps, cylinders and valves d) replacement of components.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201 and 203.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to observe manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Utilising employer/stakeholder engagement within the delivery of the course, with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Ensuring all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	N/A
Websites:	N/A

Unit 206 Carrying out planned maintenance

Unit level:	2
Guided Learning Hours (GLH):	60
Unit aim:	The aim of this unit is for learners to have the knowledge, understanding and skills to carry out planned maintenance. The unit will provide learners with underpinning knowledge of preparation and application of planned maintenance and post-maintenance activities. Topics relate to the systems and subsystems listed in unit 205: mechanical, electrical and fluid power.
Assessment method:	Synoptic practical assignment
Links to Occupational Standard:	ST0537 Engineering Operative

Learning outcomes

1. Understand how to prepare for maintenance activities
2. Prepare to undertake maintenance activities on mechanical, electrical and fluid power systems
3. Perform maintenance activities on mechanical, electrical and fluid power systems
4. Maintain maintenance documentation

Learning outcome 1

Understand how to prepare for maintenance activities

Topics	Content elements
1.1 On-site planning requirements	1.1.1 Reasons for and process of meeting organisational planning: a) site induction b) site visit c) site meetings d) planning schedule distribution e) communication with key stakeholders f) safety briefings g) tool box talks.

Learning outcome 2

Prepare to undertake maintenance activities on mechanical, electrical and fluid power systems

Topics	Content elements
2.1 Prepare and carry out maintenance activities	Refer to systems and subsystems listed in unit 205. 2.1.1 Carry out preparation activities safely and following standard procedures: a) Check and use appropriate PPE. b) Prepare self and work area to be in a safe condition to carry out work. c) Work safely whilst carrying out activities. 2.1.2 Communicating with different types of stakeholders: a) internal b) external. 2.1.3 Carry out the safe application of isolation techniques: a) isolation of electrical supplies b) isolation of fluid power supplies c) isolation of networked systems d) temporary shutdowns. 2.1.4 Carry out lock-off procedures: a) personal b) multi-lock c) erecting barriers and signage d) completing appropriate certification/documentation. 2.1.5 Preparation of general maintenance tools and equipment for use: a) selection of appropriate tools and equipment b) checking the condition of tools and equipment c) calibration of tools and equipment. 2.1.6 Selection, checking and calibration of specialist maintenance tools and equipment: a) pullers b) electrical test equipment: i. multifunction tester ii. voltage indicator iii. proving unit c) press d) torque wrench e) pressure gauges f) flow meter.

Learning outcome 3

Perform maintenance activities on mechanical, electrical and fluid power systems

Topics	Content elements
3.1 Maintenance aids	3.1.1 Use of maintenance information and documentation: a) manuals b) flow charts c) troubleshooting guides d) maintenance records e) manufacturer's maintenance logs f) operator experience g) previous repairs log h) model predictions.
3.2 Disassemble systems and subsystems	3.2.1 Process of and carrying out disassembling techniques on systems and subsystems of: a) safety guarding b) equipment to sub-assembly c) sub-assembly to component d) draining of liquids and gases sustainably e) labelling and marking of components. Refer to systems and subsystems listed in unit 205.
3.3 Inspection and maintenance testing	3.3.1 Suitability, selection and safe use of inspection and maintenance testing on systems and subsystems listed in unit 205: a) visual inspection b) vibration tests c) heat tests d) electrical tests e) damage checks f) checking of measurements against specifications g) measurement of alignments. 3.3.2 Carrying out diagnostic techniques on systems and subsystems listed in unit 205: a) sensory information: i. sight ii. sound iii. smell iv. touch b) fault report c) measurement d) movement e) alignment checks f) instrumentation readings.
3.4 Maintain systems and subsystems	3.4.1 Repair, replace, adjust and align components within systems and subsystems. Refer to systems and subsystems listed in unit 205.

Topics	Content elements
3.5 Reassemble systems and subsystems	3.5.1 Process of and carrying out safe assembling techniques on systems and subsystems: a) use of labelling and marking of components b) functional testing and final commissioning of components c) reassembly of safety guards d) cleaning and restoring work area. Refer to systems and subsystems listed in unit 205.

Learning outcome 4

Maintain maintenance documentation

Topics	Content elements
4.1 Complete maintenance records	4.1.1 Complete planned maintenance records: a) signing off permits to work b) updating job cards/maintenance records c) commissioning documentation for replacement components d) stock requisitions e) waste disposal.
4.2 Review maintenance records	4.2.1 Review planned maintenance records: a) risk assessments b) method statements.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	Team building should be encouraged, as it would be beneficial to complete the practical activities working in small groups. It is recommended that this unit be taught alongside the engineering units so that practical activities are more contextualised.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Naturally occurring training activities used in engineering maintenance will facilitate the completion of this unit. This will support the holistic approach of delivering and assessing the qualification as well as stimulate a realistic experience for the learners.
Opportunities for visits/engagement with local industry and employers:	Research opportunities, visits to exhibitions and practical training to stimulate, motivate and educate the learner.
Considerations for innovative methods of delivery:	Health, safety and welfare issues are an important factor to consider during the delivery of this unit; therefore, strict safe-working methods, as outlined by legislation, should be demonstrated and reinforced through close supervision of all activities. Risk assessments and method statement assessments must be completed prior to any practical activities taking place. This unit should be delivered as knowledge/understanding supported by practical application. Tutors delivering this unit should ensure learners have a good understanding of the setting-out process and terminology prior to reinforcing learning with practical setting-out exercises.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Employer guest lectures or real site visits should be encouraged to allow students to gain insight and/or practical application of knowledge and skills in a real environment.
EDI or accessibility considerations:	None
Digital initiative considerations:	Accessing learning materials though QR codes directly on site through use of mobile electrical devices.
Sustainability considerations:	Learners should consider approaches to sustainability throughout the maintenance process in order to minimise environmental impact. These would include recycling of materials where possible, minimising waste and reusing components for practical tasks where possible.
Books:	N/A
Websites:	N/A

Transferable employability skills

Transferable employability skills	LO (and topic)
Communication in the workplace	
Selects appropriate formats for written communication for different purposes and audiences, in line with workplace conventions or procedures, where appropriate **(CSW1)**	**LO2 (2.1)** **LO3 (3.1)** **LO4 (4.1)**
Produces documents of different types that are appropriate (e.g., in terms of length, style and language use) for the purpose and intended audience **(CSW2)**	**LO4 (4.1)**
Uses available software appropriately to present written communication, including numerical information **(CSW4)**	
Accurately and appropriately uses terminology associated with a particular workplace or sector in written communication **(CSW5)**	**LO4 (4.1)**
Responds appropriately to queries, requests and/or complaints seeking resolutions where possible **(CSW9)**	
Problem solving	
Gathers appropriate information or advice from different sources to help solve a specific work-related problem **(PSW1)**	**LO3 (3.3)**
Assesses a range of potential solutions, applying appropriate problem-solving strategies **(PSW2)**	**LO3 (3.3)**
Selects a specific solution, justifying why this one is the most likely to prove effective **(PSW3)**	
Presents a clear action plan, including tasks and timelines, for implementing a chosen solution to a specific work-related problem **(PSW4)**	
Time management skills	
Plans work: • according to priority • taking into account length of time needed to complete tasks • in order to meet deadlines **(TMS1)**	**LO2 (2.1)** **LO3 (3.2, 3.3, 3.4, 3.5)**
Works at an appropriate pace to carry out tasks in accordance with plan **(TMS2)**	**LO3 (3.2, 3.3, 3.4, 3.5)**
Adjusts approach in response to any change of circumstance (e.g., one task over running), as appropriate, to ensure remaining time is spent effectively **(TMS3)**	
Evaluates how well they are managing their time **(TMS4)**	
Identifies areas for improvement **(TMS5)**	
Self- management skills	

Transferable employability skills	LO (and topic)
Plans and manages own time effectively to achieve a balance between personal and work/training-related demands **(SMS1)**	**LO2 (2.1) LO3 (3.2, 3.3, 3.4, 3.5)**
Plans and manages resources effectively **(SMS2)**	**LO3 (3.2, 3.3, 3.4, 3.5)**
Manages emotions appropriately, including when under pressure **(SMS3)**	
Assesses own effectiveness in self-management, citing specific evidence for judgements **(SMS4)**	
Describes the impact of own self-management on workplace effectiveness of self and others **(SMS5)**	
Explains how own self-management could be improved **(SMS6)**	

Unit 207 Manufacturing principles

Unit level:	2
Guided Learning Hours (GLH):	90
Unit aim:	The aim of this unit is for learners to have knowledge and understanding of machining operations and equipment and understand the use of computer-aided design (CAD) and computer-aided manufacturing (CAM) in manufacturing. The unit will provide learners with a broad scope of underpinning knowledge of manufacturing principles, operations and applications.
Assessment method:	Synoptic practical assignment
Links to Occupational Standard:	ST0537 Engineering Operative

Learning outcomes

1. Understand machining operations used in manufacturing
2. Understand the operation of machining equipment used in manufacturing
3. Understand the use of CAD and CAM in manufacturing

Learning outcome 1

Understand machining operations used in manufacturing

Topics	Content elements
1.1 Machining operations	1.1.1 Principles of machining processes: a) subtractive: i. milling ii. turning iii. grinding iv. drilling. 1.1.2 Advantages and disadvantages of machining processes: a) machinery and tooling: i. milling ii. turning iii. grinding iv. drilling b) size of material c) types of material: i. metallic (barred steel, stainless steel) ii. ferrous metals (mild steel) iii. non-ferrous metals (aluminium, brass) iv. non-metallic (plastic, elastomers, rubber)

Topics	Content elements
	v. composites (carbon fibre, fibre glass) vi. smart materials (piezo, electric, shape memory alloys) d) cost e) time f) accuracy g) expertise required h) sustainability.
1.2 Techniques and tooling to produce machined shapes, features and finishes	1.2.1 Different types of machined features and the machine processes used to produce them: a) types of machined features: i. face: • flat • perpendicular • parallel • angular ii. shoulders iii. recesses/slots: • enclosed • open ended • tee iv. diameters: • internal • external • bored • tapered • concentric v. holes: • drilled • reamed • blind • through • counterbored • countersunk • flat-bottomed • threaded vi. surface textures: • roughing • finishing • polishing b) use of datum in machine processes. c) sequence of operations: i. chronological order

Topics	Content elements
	ii. workflow iii. dependencies. d) milling machinery and tooling for different types of features: i. face ii. shoulder iii. recess/slot iv. hole e) turning machinery and tooling for different types of features: i. face ii. shoulder iii. recess/slot iv. diameter v. hole f) grinding machinery and tooling for different types of features: i. face ii. shoulder g) drilling machinery and tooling for different types of features: iii. face iv. shoulder v. recess/slot vi. hole 1.2.2 Types of tool combinations for specified shapes, features and finishes in 1.2.1. 1.2.3 Types of manual assembly of components produced by machine.

Learning outcome 2

Understand the operation of machining equipment used in manufacturing

Topics	Content elements
2.1 Characteristics of machine features	2.1.1 Characteristics and uses of machines: a) milling b) turning c) grinding. d) drilling 2.1.2 Types of machine features: a) cutting tools b) isolators c) speed control

Topics	Content elements
	d) feed control e) emergency stops f) work-holding devices g) tables and beds h) coolant system.
2.2 Machine set-up activities	2.2.1 Application of machine set-up for machines in 2.1.1 and materials in 1.1.2 c): a) mounting work-holding devices b) calibrating machine c) loading cutting tools d) loading stock e) setting speeds, feeds.
2.3 Machining process parameters	2.3.1 Purpose of the process control parameters used for operating machines: a) safety considerations: i. personal ii. machine iii. risk assessment b) standard operating procedures (SOPs): i. start-up and shut-down procedures ii. controls iii. speeds, feeds iv. quality.

Learning outcome 3

Understand the use of CAD and CAM in manufacturing

Topics	Content elements
3.1 Applications of CAD software	3.1.1 Principles of CAD software: a) hardware requirements b) software requirements c) user interfaces d) navigation of workspace e) data management f) links to CAM. 3.1.2 Applications of CAD software in machining processes listed in 1.1.1: a) 2D CAD b) 3D CAD.
3.2 Considerations in the application of CAD	3.2.1 Advantages and disadvantages of using CAD, with consideration of: a) speed b) ease of use c) modifying d) accuracy e) views

Topics	Content elements
	f) detail g) links to cam h) cost i) training required j) equipment required k) storage l) retrieval m) traceability.
3.3 Considerations in the application of CAM	3.3.1 Advantages and disadvantages of using CAM, with consideration of: a) speed b) accuracy c) repeatability d) form complexity e) safety f) links to cad g) cost h) training required i) skill level required j) equipment required k) likelihood of malfunction l) productivity.
3.4 Applications of CAM equipment	3.4.1 Reasons for different types of CAM equipment and how they work, with reference to 2.1.1 and 3.3.1: a) computer numerical control (CNC) machines b) CNC cutting tools.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201 and 203.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to observe manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Utilising employer/stakeholder engagement within the delivery of the course, with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Ensuring all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	N/A
Websites:	N/A

Unit 208 Manufacturing products

Unit level:	2
Guided Learning Hours (GLH):	90
Unit aim:	The aim of this unit is for learners to have the knowledge, understanding and skills to prepare equipment for machining operations and to produce products. The unit will provide learners with the underpinning knowledge of and skills to manufacture products both manually and with CAD and CNC software.
Assessment method:	Synoptic practical assignment
Links to Occupational Standard:	ST0537 Engineering Operative

Learning outcomes

1. Use CAD software
2. Use CNC software
3. Prepare equipment for machining operations
4. Produce engineered products

Learning outcome 1

Use CAD software

Topics	Content elements
1.1 Principles and operation of CAD software	1.1.1 Apply CAD software to: a) create templates: i. border, title block, margin and parts list b) produce line types, styles and colour c) create geometry: i. 2D ii. 3D d) insert and edit text e) modify geometry f) dimensioning g) annotate h) render i) assemble.
1.2 Produce CAD outputs	1.2.1 Produce CAD outputs to standard BS 8888: a) creating and modifying part drawings to meet a given specification b) command instructions for CAM c) output files: i. cloud application

Topics	Content elements
	ii. Wi-Fi server system.

Learning outcome 2

Use CNC software

Topics	Content elements
2.1 Generate CNC code	2.1.1 Simulate key G & M command codes for milling and turning machining operations specified in LO4: a) absolute programming b) incremental programming c) program start d) linear motions e) circular motions f) tool change g) coolant h) program stop.
2.2 Creating CNC programs	2.2.1 Create, evaluate and edit simulated programs for CNC equipment for milling and turning machining operations specified in LO4.

Learning outcome 3

Prepare equipment for machining operations

Topics	Content elements
3.1 Carry out safety checks on manual machines	3.1.1 Carry out safety checks prior to performing machining operations: a) Examine the work area and equipment to identify hazards. b) Use a risk assessment: i. power supply ii. protective personal equipment (PPE) iii. guards iv. emergency stops v. material handling. c) Machining operations: i. milling ii. turning iii. grinding iv. drilling.
3.2 Carry out operational checks	3.2.1 Carry out operational checks prior to performing machining operations specified in LO4: a) overall condition, pre-use inspection, calibration b) work-holding devices

Topics	Content elements
	c) tool mounting d) coolant e) work instruction.

Learning outcome 4

Produce engineered products

Topics	Content elements
4.1 Safety considerations during machining	4.1.1 Safety considerations during machining operations: a) safety considerations: i. guards ii. cutting tools: • condition • fitting iii. speeds and feeds iv. coolant v. machine working area. b) machining: i. milling ii. turning iii. grinding iv. drilling.
4.2 Standard machining procedures	4.2.1 Use standard procedures to achieve required outputs: a) setting machines: i. milling ii. turning iii. grinding iv. drilling b) sequencing of operations c) efficient sequencing of processes d) monitoring: i. adjust settings to prevent flaws and faults e) marking out.
4.3 Produce machined features	4.3.1 Produce machined features to specifications given: a) faces by milling, turning, grinding and drilling: i. flat ii. perpendicular iii. parallel iv. angular b) shoulders by milling, turning and grinding c) recesses/slots by milling, turning and drilling: i. enclosed ii. open ended

Topics	Content elements
	iii. tee d) diameters by turning: i. internal ii. external iii. bored iv. tapered v. concentric e) holes by milling, turning and drilling: i. drilled ii. blind iii. through iv. counterbores v. countersinks vi. threaded f) shapes and profiles by milling, turning, grinding and drilling.
4.4 Quality control of machined features	4.4.1 Evaluate machined features against specification, using inspection and testing methods and techniques: a) visual examination b) measurement c) assembly/disassembly d) functional testing. 4.4.2 Completion and review of documentation: a) quality control plan: i. acceptance criteria ii. quality standard to be met b) quality control inspection record: i. preventative measures ii. corrective actions.
4.5 Shutting-down procedures and restoration of the work area	4.5.1 Apply shutting-down procedures: a) electrical isolation. 4.5.2 Restoration of equipment and work area: a) removal of work holding devices and tooling b) cleaning up coolant leaks c) removal of swarf and waste disposable.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	Team building should be encouraged, as it would be beneficial to complete the practical activities working in small groups. It is recommended that this unit be taught alongside the engineering units so that practical activities are more contextualised.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Naturally occurring training activities used in engineering maintenance will facilitate the completion of this unit. This will support the holistic approach of delivering and assessing the qualification as well as stimulate a realistic experience for the learners.
Opportunities for visits/engagement with local industry and employers:	Research opportunities, visits to exhibitions and practical training to stimulate, motivate and educate the learner.
Considerations for innovative methods of delivery:	Health, safety and welfare issues are an important factor to consider during the delivery of this unit; therefore, strict safe-working methods, as outlined by legislation, should be demonstrated and reinforced through close supervision of all activities. Risk assessments, method statements and COSHH assessments must be completed prior to any practical activities taking place. This unit should be delivered as knowledge/understanding supported by practical application. Tutors delivering this unit should ensure learners have a good understanding of the setting-out process and terminology prior to reinforcing learning with practical setting-out exercises.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Employer guest lectures or real site visits should be encouraged to allow students to gain insight and/or practical application of knowledge and skills in a real environment.
EDI or accessibility considerations:	
Digital initiative considerations:	Accessing learning materials though QR codes directly on site through use of mobile electrical devices.
Sustainability considerations:	Learners should consider approaches to sustainability throughout the maintenance process in order to minimise environmental impact. These would include recycling of materials where possible, minimising waste and reusing components for practical tasks where possible.
Books:	N/A
Websites:	N/A

Transferable employability skills

Transferable employability skills	LO (and topic)
Communication in the workplace	
Selects appropriate formats for written communication for different purposes and audiences, in line with workplace conventions or procedures, where appropriate **(CSW1)**	**LO1 (1.1, 1.2)** **LO2 (2.1, 2.2)**
Produces documents of different types that are appropriate (e.g., in terms of length, style and language use) for the purpose and intended audience **(CSW2)**	
Uses available software appropriately to present written communication, including numerical information **(CSW4)**	**LO1 (1.1, 1.2)** **LO2 (2.1, 2.2)**
Accurately and appropriately uses terminology associated with a particular workplace or sector in written communication **(CSW5)**	
Responds appropriately to queries, requests and/or complaints seeking resolutions where possible **(CSW9)**	
Problem solving	
Gathers appropriate information or advice from different sources to help solve a specific work-related problem **(PSW1)**	**LO3 (3.1)**
Assesses a range of potential solutions, applying appropriate problem-solving strategies **(PSW2)**	**LO2 (2.2)**
Selects a specific solution, justifying why this one is the most likely to prove effective **(PSW3)**	**LO2 (2.2)**
Presents a clear action plan, including tasks and timelines, for implementing a chosen solution to a specific work-related problem **(PSW4)**	
Time management skills	
Plans work: • according to priority • taking into account length of time needed to complete tasks • in order to meet deadlines **(TMS1)**	**LO3 (3.1, 3.2)** **LO4 (4.2, 4.3)**
Works at an appropriate pace to carry out tasks in accordance with plan **(TMS2)**	**LO3 (3.1, 3.2)** **LO4 (4.2, 4.3)**
Adjusts approach in response to any change of circumstance (e.g., one task over running), as appropriate, to ensure remaining time is spent effectively **(TMS3)**	
Evaluates how well they are managing their time **(TMS4)**	
Identifies areas for improvement **(TMS5)**	
Self- management skills	

Transferable employability skills	LO (and topic)
Plans and manages own time effectively to achieve a balance between personal and work/training-related demands **(SMS1)**	
Plans and manages resources effectively **(SMS2)**	**LO3 (3.1, 3.2)** **LO4 (4.2, 4.3)**
Manages emotions appropriately, including when under pressure **(SMS3)**	
Assesses own effectiveness in self-management, citing specific evidence for judgements **(SMS4)**	
Describes the impact of own self-management on workplace effectiveness of self and others **(SMS5)**	
Explains how own self-management could be improved **(SMS6)**	

Unit 209 Fabrication principles and processes

Unit level:	2
Guided Learning Hours (GLH):	90
Unit aim:	The purpose and aim of this unit are to provide the learner with the fundamental skills and understanding of how to fabricate components.
Assessment method:	Synoptic practical assignment
Links to Occupational Standards:	ST0537 Engineering Operative ST0349 Welder

Learning outcomes

1. Understand the health and safety requirements for fabrication
2. Understand the uses of fabrication hand tools, machinery and equipment
3. Understand how to fabricate components
4. Produce fabricated components from sheet metal, thick plate, pipework and sectional steel

Learning outcome 1

Understand the health and safety requirements for fabrication

Topics	Content elements
1.1 Common hazards during fabrication processes	1.1.1 Types of hazards and their related risks when welding. a) Types of workshop and onsite hazards: i. handling heavy, sharp or hot materials ii. slipping/tripping hazards iii. flying debris, sparks, slag iv. falling objects v. fire vi. working in confined spaces vii. high voltage electricity viii. moving and rotating parts/equipment/machinery.
1.2 Control measures used in the fabrication environment	1.2.1 Safety and protective equipment and their function to control risks in the fabrication environment. a) Types of personal protective equipment (PPE): i. face protection ii. gloves/gauntlets

	iii. protective footwear iv. apron v. flame retardant overalls vi. ear protection. b) Types of control measures to create a safe fabrication environment: i. electrical insulation ii. devices for lifting and moving hot materials iii. clean and clear walkways iv. isolating and supporting machinery/equipment working on v. guarding of moving parts vi. emergency/automatic stop.

Learning outcome 2

Understand the uses of fabrication hand tools, machinery and equipment

Topics	Content elements
2.1 Fabrication hand tools	2.1.1 Types and uses of fabrication hand tools used for sheet metal, thick plate, pipework and sectional steel. a) Types and uses of hand tools: i. hammers ii. mallets iii. punches: • dot punch • centre punch iv. chisel v. files vi. bench stakes vii. protractors viii. vernier callipers ix. plate gauge x. dividers xi. scriber xii. trammels xiii. engineer's square xiv. combination square xv. plate square xvi. back mark gauge xvii. straight edge xviii. steel rule

	xix. measuring tape xx. chalk line xxi. saws xxii. cutting wheels xxiii. hacksaw xxiv. hand shears xxv. hand lever punch xxvi. hand grooving tool xxvii. spirit level xxviii. welding magnets xxix. sliding bevel xxx. taps and dies.
2.2 Fabrication machinery and equipment	2.2.1 Types and uses of fabrication machinery and equipment used for sheet metal, thick plate, pipework and sectional steel. a) Types and uses of fabrication machinery and equipment: i. cutting: • drills • saws • punch and dies • rotary shears • mechanical guillotines • hydraulic guillotines • laser cutting • plasma cutting • oxy-fuel cutting • universal iron worker • grinder • bandsaw ii. forming: • box and pan folder • press brake • horizontal bender • fly press • tinman's jenny iii. rolling – manual and powered: • pinch-type bending rolls • pyramid bending rolls • section ring rollers • vertical bending rolls • four roll bending rolls.

Learning outcome 3

Understand how to fabricate components

Topics	Content elements
3.1 Forms of supply of fabrication materials	3.1.1 Fabrication materials and their common forms of supply. a) Fabrication materials: i. carbon steel ii. stainless steel iii. aluminium alloy. b) Forms of supply – hot and cold rolled: i. sheet metal ii. plate iii. rolled steel angle iv. universal beam v. universal column vi. parallel and tapered flange channels vii. rectangular hollow section viii. square hollow section ix. round and flat bar x. tube/pipe. c) Finishes when supplied: i. galvanised ii. Zintec – electric zinc coated sheet iii. Aludip – hot-dip aluminium-silicon alloy coated steel.
3.2 Joining techniques	3.2.1 Methods for joining sheet metal, thick plate, pipework and sectional steel, including controlling the quality of work with jigs and fixtures. a) Types of mechanical methods: i. bolts and nuts ii. screw fasteners iii. rivets iv. self-secured and non-secured joints v. adhesives. b) Types of thermal methods: i. manual metal arc welding (MMA) ii. metal inert/active gas welding (MIG/MAG) iii. tungsten inert/active gas welding (TIG/TAG) iv. oxy-fuel gas welding

	v. resistance welding vi. soldering vii. brazing. c) Jigs and fixtures to control joining and assembling: i. design considerations ii. accuracy iii. distortion control.
3.3 Material finishes	3.3.1 Methods to protect and finish joined materials. a) Methods to finish joined materials: i. grinding ii. sanding iii. shot blasting iv. graining. b) Methods to protect joined materials: i. polishing ii. powder coating iii. paint finish iv. oil finish v. galvanising.

Learning outcome 4

Produce fabricated components from sheet metal, thick plate, pipework and sectional steel

Topics	Content elements
4.1 Follow safe working practices	4.1.1 Work safely at all times, complying with health and safety legislation, regulations and other relevant guidelines (see unit 202 LO1). a) Create and adhere to a risk assessment. b) Adhere to procedures or policies. c) Adhere to health and safety legislation and regulations. d) Maintain a safe and tidy work area. e) Ensure that all tools, equipment and machinery are in a safe and serviceable condition.
4.2 Plan the fabrication of a component	4.2.1 Plan and prepare for the safe fabrication of a component to specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1 and LO2.)

	a) Obtain component details to be fabricated from engineering drawing, job instructions and other related specification. b) Plan the fabrication: i. written plan with steps, timings and resources ii. parts and material quantities iii. cutting list. c) Communicate with stakeholders as required. d) Select the appropriate tools, equipment and machinery for the required fabrication processes (cutting, drilling, joining, finishing and inspection). e) Check that the tools, equipment and machinery are in a safe and serviceable condition. f) Select and obtain suitable material to fabricate the component.
4.3 Mark out materials for a component	4.3.1 Safely and accurately mark out materials for fabrication of a component to specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1 and LO2.) a) Mark out materials for a component: i. Use marking-out tools. ii. Use marking-out methods and techniques. iii. Work within tolerances given on engineering drawing. iv. Calculate bend allowances and use of datums, as required.
4.4 Cut materials for a component	4.4.1 Safely and accurately cut marked-out materials to specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1 and LO2.) a) Cut and shape the material to the required specification, using appropriate tools and techniques: i. faces ii. slots iii. angled surfaces. b) Check cut material dimensions, shape and angles using appropriate methods and equipment.
4.5 Forming for a component	4.5.1 Safely and accurately use forming for a component to the specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1 and LO2.) a) Types of forming: i. boxes ii. segmental bends iii. cylindrical

	iv. right-angle brackets v. radiused corners.
4.6 Assemble and join materials for a component	4.6.1 Safely, accurately and securely assemble and join materials to create forms for a component to the specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1 and LO2.) a) Types of forms: i. boxes ii. flanges iii. segmental bends iv. cylindrical v. frames vi. support stands. b) Methods of assembly and joining: i. mechanical ii. thermal: • tungsten inert/active gas welding (TIG/TAG) • metal inert/active gas welding (MIG/MAG) • flux cored arc (FCAW) • manual metal arc welding (MMA) • soldering • brazing.
4.7 Finish a component	4.7.1 Safely and accurately use finishing methods and protective coatings on a component to the specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1 and LO2.) a) Finishing methods: i. grinding ii. sanding iii. polishing. b) Protective coatings: i. polishing ii. paint finish iii. oil finish.
4.8 Shut-down procedures	4.8.1 Follow shutting-down procedures and restoration of the work area following fabrication activities. a) Follow shutting-down procedures: i. safe isolation of tools, equipment and machinery.

	b) Restore equipment and work area: i. complete record keeping as required (job card) ii. safe, clean and tidy work area iii. return tools, machinery and equipment to safe storage iv. review and update risk assessment v. dispose of waste appropriately.
4.9 Quality control of fabricated components	4.9.1 Evaluate fabricated components against specification on an engineering drawing using inspection and testing methods and techniques. Use appropriate tools, equipment and methods. (See unit 201 LO3, unit 202 LO3 and LO4, unit 203 LO4, and this unit LO1 and LO2.) a) Complete a quality inspection: i. Refer to technical drawings, specifications and standards. ii. Measure component against specified dimensions and tolerances. iii. Test functionality of component against specification. iv. Assess quality of component: • visual • finish • protective coating application. v. Record findings in a quality inspection report.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201, 202 and 203, and unit 210 on welding.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to visit manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Staff CPD in line with current practice. Utilising employer/stakeholder engagement within the delivery of the course, with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Centres must deliver the unit in line with their EDI policy and organisational procedures. Consideration needs to be given to neurodiverse learners, as they may have difficulty with interactions. Centres must ensure all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	Engineering Technologies Level 2 London, [England]; New York, New York Pritchard, D. (2001) *Soldering, brazing and welding: a manual of techniques*. Marlborough: Crowood.

	Galvery, W.L. and Marlow, F.M. (2001) *Welding essentials: questions and answers.* Norwalk, CT: Industrial Press.
Websites:	Manufacturers' websites

Transferable employability skills

Transferable employability skills	LO (and topic)
Communication in the workplace	
Selects appropriate formats for written communication for different purposes and audiences, in line with workplace conventions or procedures, where appropriate **(CSW1)**	**LO4 (4.1, 4.2, 4.9)**
Produces documents of different types that are appropriate (e.g., in terms of length, style and language use) for the purpose and intended audience **(CSW2)**	**LO4 (4.1, 4.2, 4.9)**
Uses available software appropriately to present written communication, including numerical information **(CSW4)**	
Accurately and appropriately uses terminology associated with a particular workplace or sector in written communication **(CSW5)**	**LO4 (4.1, 4.2, 4.9)**
Responds appropriately to queries, requests and/or complaints seeking resolutions where possible **(CSW9)**	
Problem solving	
Gathers appropriate information or advice from different sources to help solve a specific work-related problem **(PSW1)**	**LO4 (4.9)**
Assesses a range of potential solutions, applying appropriate problem-solving strategies **(PSW2)**	
Selects a specific solution, justifying why this one is the most likely to prove effective **(PSW3)**	
Presents a clear action plan, including tasks and timelines, for implementing a chosen solution to a specific work-related problem **(PSW4)**	
Time management skills	
Plans work: • according to priority • taking into account length of time needed to complete tasks • in order to meet deadlines **(TMS1)**	**LO4 (4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9)**
Works at an appropriate pace to carry out tasks in accordance with plan **(TMS2)**	**LO4 (4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9)**
Adjusts approach in response to any change of circumstance (e.g., one task over running), as appropriate, to ensure remaining time is spent effectively **(TMS3)**	
Evaluates how well they are managing their time **(TMS4)**	
Identifies areas for improvement **(TMS5)**	
Self- management skills	

Transferable employability skills	LO (and topic)
Plans and manages own time effectively to achieve a balance between personal and work/training-related demands **(SMS1)**	**LO4 (4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9)**
Plans and manages resources effectively **(SMS2)**	**LO4 (4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9)**
Manages emotions appropriately, including when under pressure **(SMS3)**	
Assesses own effectiveness in self-management, citing specific evidence for judgements **(SMS4)**	
Describes the impact of own self-management on workplace effectiveness of self and others **(SMS5)**	
Explains how own self-management could be improved **(SMS6)**	

Unit 210 Welding principles and processes

Unit level:	2
Guided Learning Hours (GLH):	90
Unit aim:	The purpose and aim of this unit are to provide the learner with the fundamental skills and understanding of how to use welding processes to produce components, and carry out quality control on the finished component.
Assessment method:	Synoptic practical assignment
Links to Occupational Standards:	ST0537 Engineering Operative ST0349 Welder

Learning outcomes

1. Understand the health and safety requirements for welding processes
2. Understand welding processes
3. Understand how to prepare materials for welding
4. Understand welding techniques and post-weld activities
5. Produce welded components from sheet metal, thick plate, pipework and sectional steel
6. Understand defects in welded joints

Learning outcome 1

Understand the health and safety requirements for welding processes

Topics	Content elements
1.1 Common hazards during the welding processes	1.1.1 Types of hazards and their related risks when welding. a) Types of workshop and onsite hazards: i. compressed gasses ii. handling heavy, sharp or hot materials iii. slipping/tripping hazards iv. flying debris, sparks, slag v. falling objects vi. fire vii. working in confined spaces viii. cable/hose management ix. moving and rotating parts/equipment/machinery.

	b) Hazards during the welding process: i. hot metal, slag and sparks ii. fume (particulate, gaseous) iii. electricity (AC and DC) iv. arc radiation (ultraviolet light) v. noise vi. gas levels.
1.2 Control measures used in the welding environment	1.2.1 Safety and protective equipment and their function to control risks in the welding environment. a) Types of personal protective equipment (PPE): i. headshield/welding mask (including air-fed) ii. full face visor iii. filter lens iv. gauntlets v. protective footwear vi. leather apron vii. flame-retardant overalls viii. ear protection. b) Types of control measures to create a safe welding environment i. welding screens/curtains ii. fume extraction iii. electrical insulation iv. devices for lifting and moving hot materials v. welding return lead vi. clean and clear walkways vii. isolating and supporting machinery/equipment working on.

Learning outcome 2

Understand welding processes

Topics	Content elements
2.1 Weld joints	2.1.1 Types of welding joints, and associated terminology. a) Types of joint: i. butt joint ii. T-fillet joint iii. lap joint iv. corner joint.

	b) Weld joint geometry terminology: i. root gap ii. root face iii. bevel angle iv. included angle. c) Weld joint dimensions terminology: i. throat thickness ii. leg length iii. toe iv. fusion zone v. penetration: • root • side wall vi. heat-affected zone vii. face: • concave • convex.
2.2 Welding processes	2.2.1 Types of welding processes, their power sources and required consumables. a) Types of welding process: i. tungsten inert/active gas (TIG/TAG) ii. metal inert/active gas (MIG/MAG) iii. flux cored arc (FCAW) iv. manual metal arc (MMA). b) Types of power source: i. transformer ii. invertor iii. generator. c) Types of consumables, their safe storage and handling: i. shielding gas ii. flux iii. welding electrode iv. filler/welding wire v. welding tips vi. welding shrouds vii. anti-spatter spray.

2.3 Types of advanced welding processes	2.3.1 Types and capabilities of advanced welding processes. a) Types of advanced welding processes: i. laser welding ii. plasma welding iii. friction welding iv. orbital welding v. resistance welding. b) Capabilities of advanced welding processes: i. laser welding – precision engineering ii. plasma welding – precision engineering iii. friction welding – joining shafts/gears to shafts iv. orbital welding – pipe/tube work v. resistance welding – general sheet metal.

Learning outcome 3

Understand how to prepare materials for welding

Topics	Content elements
3.1 Sources of information for welding	3.1.1 Sources of information. a) Sources of information: i. engineering drawings ii. weld procedure sheets iii. risk assessments iv. manufacturers' data sheets.
3.2 Material surface preparation for welding	3.2.1 Material surface stages of preparation for welding. a) Material surface preparation: i. Remove oxides and surface debris. ii. Degrease. iii. Pre-heat. iv. Shape material for joint geometry.
3.3 Methods of distortion control in welding	3.3.1 Methods of distortion control when welding. a) Methods of control: i. alignment jigs ii. clamping

	iii. offsetting iv. run on/off plates v. tack welding vi. planned sequence of welding vii. back-to-back welding.

Learning outcome 4

Understand welding techniques and post-weld activities

Topics	Content elements
4.1 Understand the influences on welding	4.1.1 Influences on selection and set-up of welding process and techniques. a) Influences on welding process and technique: i. material thickness ii. material type iii. environmental conditions iv. joint type v. specified strength of finished weld vi. specified size of weld vii. access to the weld location viii. welding position ix. access to power x. direction of travel xi. application of product. b) Welding variable parameters: i. current ii. voltage iii. wire speed iv. gas flow. c) Welding techniques: i. slope and tilt angles ii. arc length iii. arc striking iv. crater filling at the end of a weld v. weld sequence: • single run • multiple run • root filler • cap passes

	vi. weave vii. travel speed.
4.2 Welding positions	4.2.1 Welding positions and their ISO weld symbols. a) Welding positions and their ISO weld symbols: i. down hand (PA) ii. horizontal vertical (PB) iii. horizontal (PC) iv. horizontal vertical overhead (PD) v. overhead (PE) vi. vertical upwards (PF) vii. vertical downwards (PG).
4.3 Post-weld activities	4.3.1 Post-weld activities used to finish and inspect the weld. a) Types of post-welding activities: i. dressing and cleaning welds: • angle grinders • files • chipping hammers • wire brushes ii. quality inspection of the weld: • non-destructive test • destructive test • measuring – weld gauges iii. distortion rectification: • post-heat • rolling • pressing iv. normalising/post-heat.

Learning outcome 5

Produce welded components from sheet metal, thick plate, pipework and sectional steel

Topics	Content elements
5.1 Follow safe working practices	5.1.1 Work safely at all times, complying with health and safety legislation, regulations and other relevant guidelines. (See unit 202 LO1 and this unit LO1.) a) Create and adhere to a risk assessment. b) Adhere to procedures or policies.

	c) Adhere to health and safety legislation and regulations. d) Maintain a safe and tidy work area. e) Ensure that all tools, equipment and machinery are in a safe and serviceable condition.
5.2 Plan the welding of a joint or component	5.2.1 Plan and prepare for the safe welding of a joint or component to specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment, machinery and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1, LO2, LO3 and LO4.) a) Obtain component details to be welded from engineering drawing, job instructions and welding specification. b) Plan the welding: i. written plan with steps, timings and resources ii. parts and material quantities. c) Communicate with stakeholders as required. d) Select the appropriate tools, equipment, machinery and welding plant for the required welding processes. e) Check that the tools, equipment, machinery and plant are in a safe and serviceable condition. f) Select and obtain suitable materials and consumables to carry out the welding process.
5.3 Mark out materials for welding a joint or component	5.3.1 Safely and accurately mark out materials for welding a joint or component to specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment and methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1, LO2 and LO3.) a) Mark out materials for welding a joint or component: i. Use marking-out tools. ii. Use marking-out methods and techniques. iii. Work within tolerances given on engineering drawing.
5.4 Weld a joint or component	5.4.1 Safely, accurately and securely weld a joint or component to the specification on an engineering drawing. Use appropriate materials and forms of supply, tools, equipment, machinery and thermal welding methods. (See unit 201 LO3, unit 202 LO2 and LO3, unit 203 LO4, and this unit LO1, LO2, LO3 and LO4.) a) Assemble and secure the component. b) Use thermal welding: i. tungsten inert/active gas welding (TIG/TAG) ii. metal inert/active gas welding (MIG/MAG) iii. flux cored arc (FCAW) iv. manual metal arc welding (MMA) v. soldering

	vi. brazing. c) Complete post-weld activities: i. dressing ii. cleaning.
5.5 Shut-down procedures	5.5.1 Follow shutting-down procedures and restoration of the work area following welding activities. a) Follow shutting-down procedures: i. safe isolation of tools, equipment and machinery. b) Restore equipment and work area: i. Complete record keeping as required (job card). ii. Ensure the work area is safe, clean and tidy. iii. Return tools, machinery and equipment to safe storage. iv. Review and update risk assessment. v. Dispose of waste appropriately.
5.6 Quality control welded components	5.6.1 Evaluate welded components against specification on an engineering drawing using inspection and testing methods and techniques. Use appropriate tools, equipment and methods. (See unit 201 LO3, unit 202 LO2, LO3 and LO4, unit 203 LO4, and this unit LO1, LO2, LO3, LO4 and LO6.) a) Complete a quality inspection: i. Refer to technical drawings, specifications and standards. ii. Measure component against specified dimensions and tolerances. iii. Use appropriate destructive and non-destructive testing: • visual inspection • weld gauge • dye penetrant • nick break test. iv. Test functionality of a component against specification. v. Record findings in a quality inspection report: • profile of the weld • defects • heat-affected zone • penetration of weld • strength of weld.

Learning outcome 6

Understand defects in welded joints

Topics	Content elements
6.1 Causes of defects in welded joints	6.1.1 Causes of weld defects. a) Types of defects: i. distortion of the material or component: • transverse • angular • longitudinal • twisting • out of alignment/squareness ii. weld defects: • inclusions • porosity • crack • lack of fusion • lack of penetration • undercut • lack of continuity • spatter. b) Causes of weld defects: i. poor set-up of joint ii. incorrect settings/parameters iii. incorrect manipulation.
6.2 Test welded joints	Test the quality of welded joints, and use the test data. 6.2.1 Methods for testing the quality of welded joints and their suitability. a) Non-destructive testing methods: i. visual inspection ii. weld gauge iii. dye penetrant iv. magnetic particles v. radiography vi. ultrasonic. b) Destructive testing methods: i. macroscopic examination

	ii. bend test iii. nick break test. 6.2.2 Data collected during testing. a) Types of data: i. profile of the weld ii. defects iii. heat-affected zone iv. penetration of weld v. strength of weld. b) Use of data from testing: i. rectification of defects ii. review welding specification and engineering drawing.

Unit guidance for delivery

Opportunities for efficiencies in delivery across/between units:	It would be beneficial if this unit is delivered alongside core units 201, 202 and 203, and unit 209 on fabrication.
Suggestions for formative assessment opportunities, both for knowledge and practical outcomes:	Short formative assessments at the end of sessions or aligned to learning outcomes. Sample test exam to prepare for assessment.
Opportunities for visits/engagement with local industry and employers:	Opportunities for visits to national shows and reduced-cost student membership of institutions. Opportunities to visit manufacturing processes that implement engineering principles within research and development and manufacturing.
Considerations for innovative methods of delivery:	Providers should make the best use of available resources to provide learners with the opportunity to use a wide range of activities. These could include lectures, discussions and self-study. A blended learning approach, with online learning opportunities, could be adopted for content delivery.
Ways of ensuring content is delivered in line with current, up-to-date industry practice:	Staff CPD in line with current practice. Utilising employer/stakeholder engagement within the delivery of the course, with steering groups where employers can have sight of delivery.
EDI or accessibility considerations:	Centres must deliver the unit in line with their EDI policy and organisational procedures. Consideration needs to be given to neurodiverse learners, as they may have difficulty with interactions. Centres must ensure all PPE can be adapted to any considerations required by the individual, for example accessibility or personal requirements.
Digital initiative considerations:	Using QR codes for quick accessibility to tasks. Utilising online or electronic simulation before the task is undertaken in a real-world environment.
Sustainability considerations:	Encouraging paperless working practices – printing materials only where necessary. Ensuring, where possible, that practical activity outcomes are recorded electronically. Using online platforms where possible to underpin further understanding.
Books:	Engineering Technologies Level 2 London, [England]; New York Pritchard, D. (2001) *Soldering, brazing and welding: a manual of techniques.* Marlborough: Crowood. Galvery, W.L. and Marlow, F.M. (2001) *Welding essentials: questions and answers*. Norwalk, CT: Industrial Press.
Websites:	Manufacturers' websites

Transferable employability skills

Transferable employability skills	LO (and topic)
Communication in the workplace	
Selects appropriate formats for written communication for different purposes and audiences, in line with workplace conventions or procedures, where appropriate **(CSW1)**	**LO5 (5.1, 5.2, 5.6)**
Produces documents of different types that are appropriate (e.g., in terms of length, style and language use) for the purpose and intended audience **(CSW2)**	**LO5 (5.1, 5.2, 5.6)**
Uses available software appropriately to present written communication, including numerical information **(CSW4)**	
Accurately and appropriately uses terminology associated with a particular workplace or sector in written communication **(CSW5)**	**LO5 (5.1, 5.2, 5.6)**
Responds appropriately to queries, requests and/or complaints seeking resolutions where possible **(CSW9)**	
Problem solving	
Gathers appropriate information or advice from different sources to help solve a specific work-related problem **(PSW1)**	**LO5 (5.6)** **LO6 (6.2)**
Assesses a range of potential solutions, applying appropriate problem-solving strategies **(PSW2)**	
Selects a specific solution, justifying why this one is the most likely to prove effective **(PSW3)**	
Presents a clear action plan, including tasks and timelines, for implementing a chosen solution to a specific work-related problem **(PSW4)**	
Time management skills	
Plans work: • according to priority • taking into account length of time needed to complete tasks • in order to meet deadlines **(TMS1)**	**LO5 (5.1, 5.2, 5.3, 5.4, 5.5, 5.6)** **LO6 (6.2)**
Works at an appropriate pace to carry out tasks in accordance with plan **(TMS2)**	**LO5 (5.1, 5.2, 5.3, 5.4, 5.5, 5.6)** **LO6 (6.2)**
Adjusts approach in response to any change of circumstance (e.g., one task over running), as appropriate, to ensure remaining time is spent effectively **(TMS3)**	
Evaluates how well they are managing their time **(TMS4)**	
Identifies areas for improvement **(TMS5)**	
Self-management skills	

Transferable employability skills	LO (and topic)
Plans and manages own time effectively to achieve a balance between personal and work/training-related demands **(SMS1)**	**LO5 (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) LO6 (6.2)**
Plans and manages resources effectively **(SMS2)**	**LO5 (5.1, 5.2, 5.3, 5.4, 5.5, 5.6) LO6 (6.2)**
Manages emotions appropriately, including when under pressure **(SMS3)**	
Assesses own effectiveness in self-management, citing specific evidence for judgements **(SMS4)**	
Describes the impact of own self-management on workplace effectiveness of self and others **(SMS5)**	
Explains how own self-management could be improved **(SMS6)**	

Appendix 1 Qualification content mapping to Occupational Standards

The table below contain the mapping of the Knowledge, Skills and Behaviours (KSBs) for the Occupational Standard ST0537 Engineering Operative and ST0349 Welder to the City & Guilds Level 2 Extended Technical Occupational Entry in Engineering (Diploma) (2145-12).

The KSB reference to each unit in this document is not exhaustive.

Unit	KSBs (ST0537 Engineering Operative)
201 Principles of engineering	K1
202 Engineering workshop practice	K1, K2, K4, K5, K15, K16 S1, S2, S6, S7, S22, S24 B4
203 Working in engineering	K1, K3–K5 S3–S5, S7 B2–B5
204 Maintenance principles	K6–K8 S4, S5
205 Engineered systems	K5, K6
206 Carrying out planned maintenance	S1–S3, S6, S9–S12 B1, B3, B4
207 Manufacturing principles	K9–K11 S7
208 Manufacturing products	S1–S6, S8, S13–S16 B1, B3, B4
209 Fabrication principles and processes	K5, K15–K17 S1–S8, S21–S24 B1, B3, B4
210 Welding principles and processes	K5, K15, K16, K17 S1–S8, S22–S24 B1, B3, B4

Unit	KSBs (ST0349 Welder)
201 Principles of engineering	K1
202 Engineering workshop practice	K8–K10 S7, S8
203 Working in engineering	K9 B1–B5
209 Fabrication principles and processes	N/A
210 Welding principles and processes	K1–K10 S1, S3–S8 B2, B3, B5

Appendix 2 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.

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