

Level 2 Technical Certificate in Engineering (1145-21)

Version 2.3
August 2017

Qualification Handbook

Qualification at a glance

| | |
|---------------------------------------|---|
| Industry area | Engineering |
| City & Guilds number | 1145-21 |
| Entry requirements | Centres must ensure that any pre-requisites stated in the <i>What is this qualification about?</i> section are met. |
| Age group | 16-18 (Key Stage 5), 19+ |
| Assessment | <p>To gain this qualification, candidates must successfully achieve the following assessments:</p> <ul style="list-style-type: none">• One externally set, externally moderated assignment• One externally set, externally marked exam, sat under examination conditions |
| Grading | <p>This qualification is graded Pass/Merit/Distinction/Distinction*</p> <p>For more information on grading, please see Section 7: Grading.</p> |
| Approvals | This qualification requires full centre and qualification approval |
| Support materials | Sample assessments Guidance for delivery Guidance on use of marking grids |
| Registration and certification | Registration and certification of this qualification is through the Walled Garden, and is subject to end dates. |
| External quality assurance | This qualification is externally quality assured by City & Guilds. Internally marked assignments are subject to external moderation. There is no direct claim status available for this qualification. |

| Title and level | GLH | TQT | City & Guilds qualification number | Ofqual accreditation number |
|--|-----|-----|------------------------------------|-----------------------------|
| Level 2 Technical Certificate in Engineering | 360 | 600 | 1145-21 | 603/0294/X |

| Version and date | Change detail | Section |
|------------------|--|--|
| 2.2 July 2017 | Removal of AO 6-8 from Synoptic Assignments and the readjusted approximate weightings (only if applicable) | 5. Assessment – Assessment Objectives |
| 2.3 August 2017 | Removal of component number 521, 522, 523 and 524 | 1. Introduction – Assessment requirements and employer involvement |
| | Removal of Examination specifications for component numbers 521, 522, 523 and 524 | 5. Assessment – Summary of assessment methods and conditions |
| | Integration added to component 520 Examination specification | 5. Assessment – Examination specifications |
| | Removal of Assessment Method Exam 2, component numbers 521, 522, 523 and 524. Contribution weightings adjusted | 7. Grading – Awarding grades and reporting results |

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1 Introduction

What is this qualification about?

The following purpose is for the **City & Guilds Level 2 Technical Certificate in Engineering (603/0294/X)**.

| Area | Description |
|-------------------------------------|---|
| OVERVIEW | |
| Who is this qualification for? | <p>This qualification is for you if you are aged 16-19 and want to work in the Engineering and Manufacturing sectors.</p> <p>If you like to explore how simple components and complex machines are designed, made or maintained and are keen to develop practical, technical skills, then this qualification is for you.</p> |
| What does this qualification cover? | <p>This qualification allows you to focus on one of four specialist pathways. The following mandatory content is included in each pathway:</p> <p>Principles of engineering – this allows you to understand the basic principles of mathematics, science and materials that are important wherever you work in engineering.</p> <p>Engineering workshop practice – this allows you to recognise and use safe working practices, develop the knowledge and skills for producing components for assembly using appropriate tools, different materials and inspection techniques.</p> <p>Working in engineering businesses – this will provide you with an understanding of how an engineering business is built up, functions and achieves commercial success. You will learn how to communicate effectively and gain knowledge of business improvement approaches.</p> <p>The four specialist pathways are:</p> <ol style="list-style-type: none">1. Fabrication and Welding – you will gain an understanding of the welding processes and how to weld. You will also learn how to use fabrication equipment and perform cutting of metals.2. Maintenance – you will gain an understanding of mechanical, electrical and fluid power systems and how these are maintained. Also why planned maintenance is important and the different types of maintenance.3. Manufacturing Technologies – you will gain an understanding of what CAD/CAM is and the importance to manufacturing; produce components through manual machining and CNC machines.4. Electronics – you will gain an understanding of electronic components, be able to assemble and interconnect electronic circuits, test electronic components and understand why automation is used |

Centres and providers work with local employers who will contribute to the knowledge and delivery of training. The different ways in which centres could support your learning, by working with both local and national engineering and manufacturing employers, include:

- structured work-experience or work-placements within their business
- your attendance at classes or lectures given by industry experts
- employer input into projects and exercises, or their involvement with setting assessments and examinations
- employers who act as 'expert witnesses' to contribute to the assessment of your work.

This practical based training is ideal preparation for gaining employment in engineering and manufacturing sectors or further specialist study.

WHAT COULD THIS QUALIFICATION LEAD TO?

Will the qualification lead to employment, and if so, in which job role and at what level?

Depending upon the pathway chosen, this qualification provides opportunities to gain employment, including an apprenticeship, in job roles such as:

Fabrication and Welding

- Sheet metal fabricator
- General welder

Maintenance

- Production setter
- Mechanical maintenance fitter

Manufacturing Technologies

- Tool room operative
- CNC operator

Electronics

- Electronics equipment assembler
- Electronics systems installer

Why choose this qualification over similar qualifications?

There are no other qualifications within this suite at this Level.

Will the qualification lead to further learning?

Your understanding and skills can be developed further through progression to other qualifications and apprenticeships, these include:

- The Intermediate Apprenticeship in Improving Operational Performance
- The Advanced Apprenticeship in Engineering Manufacture
- Level 3 Advanced Technical Certificate in Engineering
- Level 3 Advanced Technical Diploma in Engineering (540)
- Level 3 Advanced Technical Extended Diploma in Engineering (720)
- Level 3 Diploma in Food and Drink Engineering Maintenance

WHO SUPPORTS THIS QUALIFICATION?

Employer

The qualification is supported by:

- Manufacturing Technologies Association
 - BID Group Ltd
-

Qualification structure

For the **Level 2 Technical Certificate in Engineering (Fabrication and Welding)** the teaching programme must cover the content detailed in the structure below:

| Unit number | Unit title | GLH |
|------------------|--|-----|
| Mandatory | | |
| 203 | Principles of engineering | 60 |
| 204 | Developing engineering workshop practice | 60 |
| 205 | Working in engineering businesses | 60 |
| 206 | Welding processes | 90 |
| 207 | Fabrication practice | 60 |
| 208 | Cutting processes | 30 |

For the **Level 2 Technical Certificate in Engineering (Maintenance)** the teaching programme must cover the content detailed in the structure below:

| Unit number | Unit title | GLH |
|------------------|--|-----|
| Mandatory | | |
| 203 | Principles of engineering | 60 |
| 204 | Developing engineering workshop practice | 60 |
| 205 | Working in engineering businesses | 60 |
| 209 | Engineered systems | 60 |
| 210 | Planned maintenance | 90 |
| 211 | Principles of maintenance | 30 |

For the **Level 2 Technical Certificate in Engineering (Manufacturing Technologies)** the teaching programme must cover the content detailed in the structure below:

| Unit number | Unit title | GLH |
|------------------|--|-----|
| Mandatory | | |
| 203 | Principles of engineering | 60 |
| 204 | Developing engineering workshop practice | 60 |
| 205 | Working in engineering businesses | 60 |
| 212 | Manufacturing principles | 90 |
| 213 | Manufacturing products | 90 |

For the **Level 2 Technical Certificate in Engineering (Electronics)** the teaching programme must cover the content detailed in the structure below:

| Unit number | Unit title | GLH |
|------------------|--|-----|
| Mandatory | | |
| 203 | Principles of engineering | 60 |
| 204 | Developing engineering workshop practice | 60 |
| 205 | Working in engineering businesses | 60 |
| 214 | Electronic components | 60 |
| 215 | Electronic assembly | 60 |
| 216 | Electronic test equipment | 30 |
| 217 | Automation | 30 |

Total Qualification Time

Total Qualification Time (TQT) is the total amount of time, in hours, expected to be spent by a Learner to achieve a qualification. It includes both guided learning hours (which are listed separately) and hours spent in preparation, study and assessment.

| Title and level | GLH | TQT |
|--|-----|-----|
| Level 2 Technical Certificate in Engineering | 360 | 600 |

Assessment requirements and employer involvement

To achieve the **Level 2 Technical Certificate in Engineering (Fabrication and Welding)** candidates must successfully complete **all** of the mandatory assessment components.

| Component number | Title |
|------------------|---|
| Mandatory | |
| 025 | Fabrication and Welding – Synoptic Assignment |
| 520 | Theory exam |

To achieve the **Level 2 Technical Certificate in Engineering (Maintenance)** candidates must successfully complete **all** of the mandatory assessment components.

| Component number | Title |
|------------------|-----------------------------------|
| Mandatory | |
| 026 | Maintenance - Synoptic assignment |
| 520 | Theory exam |

To achieve the **Level 2 Technical Certificate in Engineering (Manufacturing Technologies)** candidates must successfully complete **all** of the mandatory assessment components.

| Component number | Title |
|------------------|--|
| Mandatory | |
| 027 | Manufacturing Technologies – Synoptic Assignment |
| 520 | Theory exam |

To achieve the **Level 2 Technical Certificate in Engineering (Electronics)** candidates must successfully complete **all** of the mandatory assessment components.

| Component number | Title |
|------------------|-----------------------------------|
| Mandatory | |
| 028 | Electronics – Synoptic Assignment |
| 520 | Theory exam |

In addition, candidates **must** achieve the mandatory employer involvement requirement for this qualification **before** they can be awarded a qualification grade. For more information, please see guidance in *Section 4: Employer involvement*.

Employer involvement

| Component number | Title |
|------------------|----------------------|
| Mandatory | |
| 821 | Employer involvement |

2 Centre requirements

Approval

New centres will need to gain centre approval. Existing centres who wish to offer this qualification must go through City & Guilds' **full** Qualification Approval Process. There is no fast track approval for this qualification. Please refer to the City & Guilds website for further information on the approval process: www.cityandguilds.com

Resource requirements

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

Centre staffing

Staff delivering these qualifications must be able to demonstrate that they meet the following requirements:

- be technically competent in the areas in which they are delivering
- be able to deliver across the breadth and depth of the content of the qualification being taught
- have recent relevant teaching and assessment experience in the specific area they will be teaching, or be working towards this
- demonstrate continuing CPD.

Physical resources

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

Internal Quality Assurance

Internal quality assurance is key to ensuring accuracy and consistency of tutors and markers. Internal Quality Assurers (IQAs) monitor the work of all tutors involved with a qualification to ensure they are applying standards consistently throughout assessment activities. IQAs must have, and maintain, an appropriate level of technical competence and be qualified to make both marking and quality assurance decisions through a teaching qualification or recent, relevant experience.

Learner entry requirements

Centres must ensure that all learners have the opportunity to gain the qualification through appropriate study and training, and that any prerequisites stated in the "*What is this qualification about?*" section are met when registering on this qualification.

Age restrictions

This qualification is approved for learners aged 16-18, 19+

3 Delivering technical qualifications

Initial assessment and induction

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

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

We recommend that centres provide an induction programme so the 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.

Employer involvement

Employer involvement is essential to maximise the value of each learner's experience. Centres are required to involve employers in the delivery of technical qualifications at Key Stage 5 and/or their assessment, for every learner. This must be in place or planned before delivery programmes begin in order to gain qualification approval. See Employer involvement for more detail.

Support materials

The following resources are available for these qualifications:

| Description | How to access |
|----------------------------------|---|
| Sample assessments | Available on the qualification pages on the City & Guilds Website: www.cityandguilds.com |
| Guidance for delivery | |
| Guidance on use of marking grids | |

4 Employer involvement

Employer involvement is a formal component of Key Stage 5 Technical qualifications. It does not contribute to the overall qualification grading, but is a mandatory requirement that all learners must meet. As such it is subject to external quality assurance by City & Guilds.

Department for Education (DfE) requirements state:

Employer involvement in the delivery and/or assessment of technical qualifications provides a clear 'line of sight' to work, enriches learning, raises the credibility of the qualification in the eyes of employers, parents and students and furthers collaboration between the learning and skills sector and industry.

[Technical qualifications] must:

- *require all students to undertake meaningful activity involving employers during their study; and*
- *be governed by quality assurance procedures run by the awarding organisation to confirm that education providers have secured employer involvement for every student.*

Extract from: [Vocational qualifications for 16 to 19 year olds, 2017 and 2018 performance tables: technical guidance for awarding organisations, paragraphs 89-90](#)

City & Guilds will provide support, guidance and quality assurance of employer involvement.

Qualification approval

To be approved to offer City & Guilds technicals, centres must provide an Employer Involvement planner and tracker showing how every learner will be able to experience meaningful employer involvement, and from where sufficient and suitable employer representatives are expected to be sourced.

Centres must include in their planner a sufficient range of activities throughout the learning programme that provide a range of employer interactions for learners. Centres must also plan contingencies for learners who may be absent for employer involvement activities, so that they are not disadvantaged.

As part of the approval process, City & Guilds will review this planner and tracker. Centres which cannot show sufficient commitment from employers and/or a credible planner and tracker will be given an action for improvement with a realistic timescale for completion. **Approval will not be given** if employer involvement cannot be assured either at the start of the qualification, or through an appropriate plan of action to address this requirement before the learner is certificated.

Monitoring and reporting learner engagement

Employer involvement is a formal component of this qualification and is subject to quality assurance monitoring. Centres must record evidence that demonstrates that each learner has been involved in meaningful employer based activities against the mandatory content before claiming the employer involvement component for learners.

Centres must record the range and type of employer involvement each learner has experienced and submit confirmation that all learners have met the requirements to City & Guilds. If a centre cannot provide evidence that learners have met the requirements to achieve the component, then the learner will not be able to achieve the overall Technical Qualification.

Types of involvement

Centres should note that to be eligible, employer involvement activities **must** relate to one or more elements of the mandatory content of this qualification.

As the aim of employer involvement is to enrich learning and to give learners a taste of the expectations of employers in the industry area they are studying, centres are encouraged to work creatively with local employers.

Employers can identify the areas of skills and knowledge in their particular industry that they would wish to see emphasised for learners who may apply to work with them in the future. Centres and employers can then establish the type of input, and which employer representative might be able to best support these aims.

To be of most benefit this must add to, rather than replace the centre's programme of learning. Some examples of meaningful employer involvement are listed below. Employer involvement not related to the mandatory element of the qualification, although valuable in other ways, does not count towards this element of the qualification.

The DfE has provided the following examples of what does and does not count as meaningful employer involvement, as follows¹:

The following activities meet the requirement for meaningful employer involvement:

- *students undertake structured work-experience or work-placements that develop skills and knowledge relevant to the qualification;*
- *students undertake project(s), exercises(s) and/or assessments/examination(s) set with input from industry practitioner(s);*
- *students take one or more units delivered or co-delivered by an industry practitioner(s). This could take the form of master classes or guest lectures;*
- *industry practitioners operate as 'expert witnesses' that contribute to the assessment of a student's work or practice, operating within a specified assessment framework. This may be a specific project(s), exercise(s) or examination(s), or all assessments for a qualification.*

In all cases participating industry practitioners and employers must be relevant to the industry sector or occupation/occupational group to which the qualification relates.

The following activities, whilst valuable, do not meet the requirement for meaningful employer involvement:

- *employers' or industry practitioners' input to the initial design and content of a qualification;*
- *employers hosting visits, providing premises, facilities or equipment;*
- *employers or industry practitioners providing talks or contributing to delivery on employability, general careers advice, CV writing, interview training etc;*
- *student attendance at career fairs, events or other networking opportunities;*
- *simulated or provider-based working environments eg hairdressing salons, florists, restaurants, travel agents, small manufacturing units, car servicing facilities;*
- *employers providing students with job references.*

Types of evidence

For each employer involvement activity, centres are required to provide evidence of which learners undertook it, e.g. a candidate attendance register. The types of additional evidence required to support a claim for this component will vary depending on the nature of the involvement. E.g. for a guest lecture it is expected that a synopsis of the lecture and register would be taken which each learner and the guest speaker will have signed; expert witnesses will be identified and will have

¹ Based on Technical and applied qualifications for 14 to 19 year olds Key stage 4 and 16 to 19 performance tables from 2019: technical guidance for awarding organisations, August 2016

signed the relevant assessment paperwork for each learner they have been involved in assessing; evidence of contribution from employers to the development of locally set or adapted assignments.

Quality assurance process

As the employer involvement component is a requirement for achieving the KS5 Technical qualifications, it is subject to external quality assurance by City & Guilds at the approval stage and when centres wish to claim certification for learners.

Evidence will be validated by City & Guilds before learners can achieve the employer involvement component. Where employer involvement is not judged to be sufficient, certificates cannot be claimed for learners.

Sufficiency of involvement for each learner

It is expected that the centre will plan a range of activities that provide sufficient opportunities for each learner to interact directly with a range of individuals employed in the related industry.

Centres must also provide contingencies for learners who may be absent for part of their teaching, so they are not disadvantaged. Any absence that results in a learner missing arranged activities must be documented. Where learners are unable to undertake all employer involvement activities due to temporary illness, temporary injury or other indisposition, centres should contact City & Guilds for further guidance.

Live involvement

Learners will gain most benefit from direct interaction with employers and/or their staff; however the use of technology (e.g. the use of live webinars) is encouraged to maximise the range of interactions. Where learners are able to interact in real time with employers, including through the use of technology, this will be classed as 'live involvement'.

It is considered good practice to record learning activities, where possible, to allow learners to revisit their experience and to provide a contingency for absent learners. This is not classed as live involvement however, and any involvement of this type for a learner must be identified as contingency.

Timing

A learner who has not met the minimum requirements cannot be awarded the component, and will therefore not achieve the qualification. It is therefore important that centres give consideration to scheduling employer involvement activities, and that enough time is allotted throughout delivery and assessment of the qualification to ensure that requirements are fully met.

5 Assessment

Summary of assessment methods and conditions

This qualification is assessed by:

- externally marked exam
- synoptic assignment

All assessments are set by City & Guilds. The assignment is marked in the centre and the marking is checked and verified by City & Guilds moderators. The exam is marked by City & Guilds.

| Component numbers | Assessment method | Description and conditions |
|--------------------|---------------------|--|
| 025, 026, 027, 028 | Synoptic assignment | <p>The synoptic assignment is externally set, internally marked and externally moderated. The assignment requires candidates to identify and use effectively, in an integrated way, an appropriate selection of skills, techniques, concepts, theories, and knowledge from across the content area. Candidates will be judged against the Assessment Objectives.</p> <p>Assignments will be released to centres as per dates indicated in the Assessment and Examination timetable published on our website.</p> <p>Centres will be required to maintain the security of all live assessment materials. Assignments will be password protected and released to centres through a secure method.</p> <p>There will be one opportunity within each academic year to sit the assignment. Candidates who fail the assignment will have one re-sit opportunity. The re-sit opportunity will be in the next academic year, and will be the assignment set for that academic year once released to centres. If the re-sit is failed, the candidate will fail the qualification.</p> <p>Please note that for externally set assignments City & Guilds provides guidance and support to centres on the marking and moderation process.</p> |

| Component numbers | Assessment method | Description and conditions |
|-------------------|------------------------|--|
| 520 | Externally marked exam | <p>This exam is externally set and externally marked.</p> <p>The exam is designed to assess candidate's depth and breadth of understanding across the mandatory content in the qualification at the end of the period of learning, and will be sat under invigilated examination conditions. See JCQ requirements for details: http://www.jcq.org.uk/exams-office/ice---instructions-for-conducting-examinations</p> <p>The exam specification shows the coverage of the exam across the qualification content. Candidates who fail the exam at the first sitting will have one opportunity to re-sit. If the re-sit is failed the candidate will fail the qualification. For exam dates, please refer to the Assessment and Examination timetable.</p> |

What is synoptic assessment?

Technical qualifications are based around the development of a toolkit of knowledge, understanding and skills that an individual needs in order to have the capability to work in a particular industry or occupational area. Individuals in all technical areas are expected to be able to apply their knowledge, understanding and skills in decision making to solve problems and achieve given outcomes independently and confidently.

City & Guilds technical qualifications require candidates to draw together their learning from across the qualification to solve problems or achieve specific outcomes by explicitly assessing this through the synoptic assignment component.

In this externally set, internally marked and externally moderated assessment the focus is on bringing together, selecting and applying learning from across the qualification rather than demonstrating achievement against units or subsets of the qualification content. The candidate will be given an appropriately levelled, substantial, occupationally relevant problem to solve or outcome to achieve. For example this might be in the form of a briefing from a client, leaving the candidate with the scope to select and carry out the processes required to achieve the client's wishes, as they would in the workplace.

Candidates will be marked against assessment objectives (AOs) such as their breadth and accuracy of knowledge, understanding of concepts, and the quality of their technical skills as well as their ability to use what they have learned in an integrated way to achieve a considered and high quality outcome.

How the assignment is synoptic for this qualification

The typical assignment brief could be for the candidate to respond to a design problem for a new engineered product or to adapt an existing product. This will typically require the candidate to carry out a range of activities related to resolving a design problem. This may include carrying out experiments on prototypes to evaluate the suitability of different materials; producing design specifications (with drawings) against a specified brief and producing reports to develop designs into commercial products.

External exam for stretch, challenge and integration

The external assessment will draw from across the mandatory content of the qualification, using a range of shorter questions to confirm breadth of knowledge and understanding. Extended response questions are included to go into more depth, giving candidates the opportunity to demonstrate higher level understanding and integration through discussion, analysis and evaluation, and ensuring the assessment can differentiate between 'just able' and higher achieving candidates.

Assessment objectives

The assessments for this qualification are set against a set of assessment objectives (AOs) which are used across all City & Guilds Technicals to promote consistency among qualifications of a similar purpose. They are designed to allow judgement of the candidate to be made across a number of different categories of performance.

Each assessment for the qualification has been allocated a set number of marks against these AOs based on weightings recommended by stakeholders of the qualification. This mark allocation remains the same for all versions of the assessments, ensuring consistency across assessment versions and over time.

The following table explains all AOs in detail, including weightings for the synoptic assignments. In some cases, due to the nature of a qualification's content, it is not appropriate to award marks for some AOs. Where this is the case these have been marked as N/A. Weightings for the exam (AOs 1, 2 and 4 only) can be found with the exam specification.

| Assessment objective | Typical expected evidence of knowledge, understanding and skills | Approximate weighting |
|--|--|-----------------------|
| AO1 Recalls knowledge from across the breadth of the qualification. | Risk assessment contents, isolation procedures, job cards, use of SOPs, tools and equipment used, production plans, technical reports, graphs. | 25% |
| AO2 Demonstrates understanding of concepts, theories and processes from across the breadth of the qualification. | Risk ratings with consideration for controls, rationale for process, measurement, inspection and testing; selection of correct tools and equipment; application of techniques; planning for production, visual management and business improvement techniques. | 15% |
| AO3 Demonstrates technical skills from across the breadth of the qualification. | Completion of all tasks; maintenance activities; following SOP; use of tools and equipment; manual dexterity; application of techniques; sequencing. | 30% |
| AO4 Applies knowledge, understanding and skills from across the breadth of the qualification in an integrated and holistic way to achieve specified purposes. | Applying knowledge and understanding to a particular scenario/ problem, attention to health and safety across all tasks, justifying decisions/approaches taken eg materials, techniques, adapting practice to meet contextual challenges. | 15% |
| AO5 Demonstrates perseverance in achieving high standards and attention to detail while showing an understanding of wider impact of their actions. | Maintenance reports and documentation, accuracy of measurements and testing, attention to detail when producing technical sketches, accuracy of calculations. | 15% |

Examination specification

| Assessment objective | 520 weighting (approx.%) |
|--|--------------------------|
| A01 Recalls knowledge from across the breadth of the qualification. | 40% |
| A02 Demonstrates understanding of concepts, theories and processes from across the breadth of the qualification. | 35% |
| A04 Applies knowledge, understanding and skills from across the breadth of the qualification in an integrated and holistic way to achieve specified purposes. | 25% |

The table below shows how marks for the exam are allocated in relation to the qualification content:

Assessment type: Examiner marked, written exam

Assessment conditions: Invigilated examination conditions

Grading: X/P/M/D

| 520 | | | |
|-------------------|--|-----------------|-----|
| Duration: 2 hours | | | |
| Unit | Title | Number of marks | % |
| 203 | 1. Apply mathematical applications to engineering | 23 | 38 |
| | 2. Apply science to engineering | | |
| | 3. Understand engineering materials | | |
| 204 | 1. Understand engineering health and safety requirements | 10 | 17 |
| | 2. Prepare for engineering workshop activities | | |
| | 3. Use hand skills for engineering activities | | |
| | 4. Review the quality of engineered products | | |
| 205 | 1. Understand how engineering businesses are organised | 12 | 20 |
| | 2. Use business communication | | |
| | 3. Understand approaches to business | | |
| | 4. Understand technical drawings | | |
| N/A | Integration | 15 | 25 |
| Total | | 60 | 100 |

6 Moderation and standardisation of assessment

City & Guilds' externally set assignments for technical qualifications are designed to draw from across the qualifications' content, and to contribute a significant proportion towards the learner's final qualification grade. They are subject to a rigorous external quality assurance process known as external moderation. This process is outlined below. For more detailed information, please refer to 'Marking and moderation - Technicals centre guidance' available to download on the City & Guilds website.

It is vital that centres familiarise themselves with this process, and how it impacts on their delivery plan within the academic year.

Supervision and authentication of internally assessed work

The Head of Centre is responsible for ensuring that internally assessed work is conducted in accordance with City & Guilds' requirements.

City & Guilds requires both tutors and candidates to sign declarations of authenticity. If the tutor is unable to sign the authentication statement for a particular candidate, then the candidate's work cannot be accepted for assessment.

Internal standardisation

For internally marked work² the centre is required to conduct internal standardisation to ensure that all work at the centre has been marked to the same standard. It is the Internal Quality Assurer's (IQA's) responsibility to ensure that standardisation has taken place, and that the training includes the use of reference and archive materials such as work from previous years as appropriate.

Internal appeal

Centres must have an internal process in place for candidates to appeal the marking of internally marked components, ie the synoptic assignment and any optional unit assignments. This must take place before the submission of marks for moderation. The internal process must include candidates being informed of the marks (or grades) the centre has given for internally assessed components, as they will need these to make the decision about whether or not to appeal.

Centres cannot appeal the outcome of moderation for individual candidates, only the moderation process itself. A request for a review of the moderation process should be made to appeals@cityandguilds.com.

Moderation

Moderation is the process where external markers are standardised to a national standard in order to review centre marking of internally marked assessments. These markers are referred to as 'moderators'. Moderators will mark a representative sample of candidates' work from every centre. Their marks act as a benchmark to inform City & Guilds whether centre marking is in line with City & Guilds' standard.

² For any internally assessed optional unit assignments, the same process must be followed where assessors must standardise their interpretation of the assessment and grading criteria.

Where moderation shows that the centre is applying the marking criteria correctly, centre marks for the whole cohort will be accepted.

Where moderation shows that the centre is either consistently too lenient or consistently too harsh in comparison to the national standard, an appropriate adjustment will be made to the marks of the whole cohort, retaining the centre's rank ordering.

Where centre application of the marking criteria is inconsistent, an appropriate adjustment for the whole cohort may not be possible on the basis of the sample of candidate work. In these instances a complete remark of the candidate work may be necessary. This may be carried out by the centre based on feedback provided by the moderator, or carried out by the moderator directly.

Moderation applies to all internally marked assignments. Following standardisation and marking, the centre submits all marks and candidate work to City & Guilds via the moderation platform. The deadline for submission of evidence will be available on Walled Garden. See the *Marking and moderation - Technicals Centre Guidance* document for full details of the requirements and process.

In most cases candidate work will be submitted directly to the moderator for moderation. This includes written work, photographic and pictorial evidence, or video and audio evidence. For some qualifications there will be a requirement for moderators to visit centres to observe practical assessments being undertaken. This will be for qualifications where the assessment of essential learner skills can only be demonstrated through live observation. The purpose of these visits is to ensure that the centre is assessing the practical skills to the required standards, and to provide the moderators with additional evidence to be used during moderation. These visits will be planned in advance with the centre for all relevant qualifications.

Post moderation procedures

Once the moderation process has been completed, the confirmed marks for the cohort are provided to the centre along with feedback from the moderator on the standard of marking at the centre, highlighting areas of good practice, and potential areas for improvement. This will inform future marking and internal standardisation activities.

City & Guilds will then carry out awarding, the process by which grade boundaries are set with reference to the candidate evidence available on the platform.

Centres retaining evidence

Centres must retain assessment records for each candidate for a minimum of three years. To help prevent plagiarism or unfair advantage in future versions, candidate work may not be returned to candidates. Samples may however be retained by the centre as examples for future standardisation of marking.

7 Grading

Awarding individual assessments

Individual assessments will be graded, by City & Guilds, as pass/merit/distinction where relevant. The grade boundaries for pass and distinction for each assessment will be set through a process of professional judgement by technical experts. Merit will usually be set at the midpoint between pass and distinction. The grade descriptors for pass and distinction, and other relevant information (eg archived samples of candidate work and statistical evidence) will be used to determine the mark at which candidate performance in the assessment best aligns with the grade descriptor in the context of the qualification's purpose. Boundaries will be set for each version of each assessment to take into account relative difficulty.

Please note that as the Merit grade will usually be set at the arithmetical midpoint between pass and distinction, there are no descriptors for the Merit grade for the qualification overall.

Grade descriptors

To achieve a pass, a candidate will be able to

- Demonstrate the knowledge and understanding required to work in the occupational area, its principles, practices and legislation.
- Describe some of the main factors impacting on the occupation to show good understanding of how work tasks are shaped by the broader social, environmental and business environment it operates within.
- Use the technical industry specific terminology used in the industry accurately.
- Demonstrate the application of relevant theory and understanding to solve non-routine problems.
- Interpret a brief for complex work related tasks, identifying the key aspects, and showing a secure understanding of the application of concepts to specific work related tasks.
- Carry out planning which shows an ability to identify and analyse the relevant information in the brief and use knowledge and understanding from across the qualification (including complex technical information) to interpret what a fit for purpose outcome would be and develop a plausible plan to achieve it.
- Achieve an outcome which successfully meets the key requirements of the brief.
- Identify and reflect on the most obvious measures of success for the task and evaluate how successful they have been in meeting the intentions of the plan.
- Work safely throughout, independently carrying out tasks and procedures, and having some confidence in attempting the more complex tasks.

To achieve a distinction, a candidate will be able to

- Demonstrate the excellent knowledge and understanding required to work to a high level in the occupational area, its principles, practices and legislation.
- Analyse the impact of different factors on the occupation to show deep understanding of how work tasks are shaped by the broader social, environmental, and business environment it operates within.
- Demonstrate the application of relevant theory and understanding to provide efficient and effective solutions to complex and non-routine problems.

- Analyse the brief in detail, showing confident understanding of concepts and themes from across the qualification content, bringing these together to develop a clear and stretching plan, that would credibly achieve an outcome that is highly fit for purpose.
- Achieve an outcome which shows an attention to detail in its planning, development and completion, so that it completely meets or exceeds the expectations of the brief to a high standard.
- Carry out an evaluation in a systematic way, focussing on relevant quality points, identifying areas of development/improvement as well as assessing the fitness for purpose of the outcome.

Awarding grades and reporting results

The overall qualification grade will be calculated based on aggregation of the candidate's achievement in each of the assessments for the mandatory units, taking into account the assessments' weighting. The **Level 2 Technical Certificate in Engineering** will be reported on a four grade scale: Pass, Merit, Distinction, Distinction*.

All assessments **must** be achieved at a minimum of Pass for the qualification to be awarded. Candidates who fail to reach the minimum standard for grade Pass for an assessment(s) will not have a qualification grade awarded and will not receive a qualification certificate.

The approximate pass boundaries for the synoptic assignments in this qualification are

| Synoptic Assignments | Pass mark % |
|----------------------|-------------|
| 025, 026, 027, 028 | 40 |

Please note that each synoptic assignment is subject to an awarding process before final grade boundaries are confirmed.

The contribution of assessments towards the overall qualification grade is as follows:

| Assessment method | Grade scale | % Contribution |
|--|-------------|----------------|
| Theory exam (520) | X/P/M/D | 40% |
| Synoptic assignment (025, 026, 027, 028) | X/P/M/D | 60% |

Both synoptic assignments and the exam are awarded (see 'Awarding individual assessments', at the start of Section 7, above), and candidates' grades converted to points. The minimum points available for each assessment grade is listed in the table below. A range of points between the Pass, Merit and Distinction boundaries will be accessible to candidates. For example a candidate that achieves a middle to high Pass in an assessment will receive between 8 and 10 points, a candidate that achieves a low to middle Merit in an assessment will receive between 12 and 14 points. The points above the minimum for the grade for each assessment are calculated based on the candidate's score in that assessment.

| | Pass | Merit | Distinction |
|-----------------|-------------|--------------|--------------------|
| Assignment: 60% | 6 | 12 | 18 |
| Exam: 40% | 6 | 12 | 18 |

The candidate's points for each assessment are multiplied by the % contribution of the assessment and then aggregated. The minimum points required for each qualification grade are as follows:

| Qualification Grade | Minimum points |
|----------------------------|-----------------------|
| Distinction* | 20.5 |
| Distinction | 17 |
| Merit | 11 |
| Pass | 6 |

Candidates achieving Distinction* will be the highest achieving of the Distinction candidates.

8 Administration

Approved centres must have effective quality assurance systems to ensure valid and reliable delivery and assessment of qualifications. Quality assurance includes initial centre registration by City & Guilds and the centre's own internal procedures for monitoring quality assurance procedures.

Consistent quality assurance requires City & Guilds and its associated centres to work together closely; our Quality Assurance Model encompasses both internal quality assurance (activities and processes undertaken within centres) and external quality assurance (activities and processes undertaken by City & Guilds).

For this qualification, standards and rigorous quality assurance are maintained by the use of:

- internal quality assurance
- City & Guilds external moderation.

In order to carry out the quality assurance role, Internal Quality Assurers (IQAs) must have and maintain an appropriate level of technical competence and have recent relevant assessment experience. For more information on the requirements, refer to Centre requirements.

To meet the quality assurance criteria for this qualification, the centre must ensure that the following procedures are followed:

- suitable training of staff involved in the assessment of the qualification to ensure they understand the process of marking and standardisation;
- completion by the person responsible for internal standardisation of the Centre Declaration Sheet to confirm that internal standardisation has taken place;
- the completion by candidates and supervisors/tutors of the record form for each candidate's work.

External quality assurance

City & Guilds will undertake external moderation activities to ensure that the quality assurance criteria for this qualification are being met. Centres must ensure that they co-operate with City & Guilds staff and representatives when undertaking these activities.

City & Guilds requires the Head of Centre to:

- facilitate any inspection of the centre which is undertaken on behalf of City & Guilds
- make secure arrangements to receive, check and keep assessment material secure at all times
- maintain the security of City & Guilds confidential material from receipt to the time when it is no longer confidential and
- keep completed assignment work and examination scripts secure from the time they are collected from the candidates to their dispatch to City & Guilds.

Enquiries about results

The services available for enquiries about results include a review of marking for exam results and review of moderation for internally marked assessments.

For further details on enquiries and appeals process and for copies of the application forms, please visit the [appeals page](#) of the City & Guilds website at www.cityandguilds.com.

Re-sits and shelf-life of assessment results

Candidates who have failed an assessment or wish to re-take it in an attempt to improve their grade, can re-sit this assessment once only. The best result will count towards the final qualification. See guidance on individual assessment types in Section 5.

Factors affecting individual learners

If work is lost, City & Guilds should be notified immediately of the date of the loss, how it occurred, and who was responsible for the loss. Centres should use the JCQ form, JCQ/LCW, to inform City & Guilds Customer Services of the circumstances.

Learners who move from one centre to another during the course may require individual attention. Possible courses of action depend on the stage at which the move takes place. Centres should contact City & Guilds at the earliest possible stage for advice about appropriate arrangements in individual cases.

Malpractice

Please refer to the City & Guilds guidance notes *Managing cases of suspected malpractice in examinations and assessments*. This document sets out the procedures to be followed in identifying and reporting malpractice by candidates and/or centre staff and the actions which City & Guilds may subsequently take. The document includes examples of candidate and centre malpractice and explains the responsibilities of centre staff to report actual or suspected malpractice. Centres can access this document on the City & Guilds website.

Examples of candidate malpractice are (please note that this is not an exhaustive list):

- falsification of assessment evidence or results documentation
- plagiarism of any nature
- collusion with others
- copying from another candidate (including the use of ICT to aid copying), or allowing work to be copied
- deliberate destruction of another's work
- false declaration of authenticity in relation to assessments
- impersonation.

These actions constitute malpractice, for which a penalty (e.g. disqualification from the assessment) will be applied.

Where suspected malpractice is identified by a centre after the candidate has signed the declaration of authentication, the Head of Centre must submit full details of the case to City & Guilds at the earliest opportunity. Please refer to the form in the document *Managing cases of suspected malpractice in examinations and assessments*.

Access arrangements and special consideration

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.

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>

Special consideration

We can give special consideration to candidates who have had a temporary illness, injury or indisposition at the time of the examination. Where we do this, it is given after the examination.

Applications for either access arrangements or special consideration should be submitted to City & Guilds by the Examinations Officer at the centre. For more information please consult the current version of the JCQ document, *A guide to the special consideration process*. This document is 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>

Unit 203 Principles of engineering

GLH: 60

What is this unit about?

Bridges, microwave ovens, sports cars, life support systems and robots that can carry out operations on patients: every one of these products depends on the application of maths and scientific principles. Choosing the best materials and components, and carrying out design calculations, is essential if the product is to achieve all of the customer requirements.

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

Learners can be introduced to this unit by asking themselves questions, such as:

- Why are F1 components made of carbon fibre?
- Why is maths so important to engineers?
- How does an oil tanker stay afloat?
- Why are there different size gear wheels on my bicycle?

Learning outcomes

In this unit, learners will

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

Scope of content

Learning outcome

- 1 Apply mathematical applications to engineering
-

Topics

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

Depth

Topic 1.1

Apply general mathematical principles in engineering:

- addition, subtraction, multiplication, division
- order of operation (BODMAS)
- SI units (metric) and prefixes, imperial units
- unit conversions
- power and roots
- angles of shapes
- transposition of formulae
- degrees of accuracy
- decimal places
- significant figures
- use of scientific calculator

Topic 1.2

Calculate areas of shapes:

- squares
- rectangles
- circles
- triangles
- compound shapes

Calculate surface areas and volumes of shapes:

- cubes
 - rectangular prisms
 - cylinders
 - cones
 - spheres
-

Topic 1.3

Use trigonometry to calculate:

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

Topic 1.4

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

- linear
- quadratic
- simultaneous

Topic 1.5

Create different types of graph:

- straight line graphs
- curved graphs

Learning outcome

2 Apply science to engineering

Topics

2.1 Definitions of scientific principles

2.2 Apply engineering principles in engineering situations

Depth

Topic 2.1

Definitions of scientific principles:

- force
 - power
 - energy
 - work
 - moments
 - efficiency
 - Ohm's law
 - watt's law
 - heat
 - latent
 - specific
 - transfer methods
 - coefficient of expansion
 - ratio
 - friction
-

Topic 2.2

Apply engineering principles in engineering situations:

- levers (class one, class two, class three)
- moments of force/work, energy and power
- efficiency of a device
 - electrical efficiency
 - mechanical advantage
- Ohm's law
 - series circuits
 - parallel circuits
- heat
 - latent heat
 - specific heat capacity
 - coefficient of expansion
- gear ratios

Learning outcome

3 Understand engineering materials

Topics

- 3.1 Types of engineering materials
- 3.2 Properties of engineering materials
- 3.3 Methods of testing material properties
- 3.4 Corrosion of engineering materials
- 3.5 Heat treatment of metals
- 3.6 Suitability of materials for engineering applications

Depth

Topic 3.1

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

- metallic
 - ferrous metals
 - non-ferrous metals
- non-metallic
- composites
- smart materials

Topic 3.2

Characteristics of material properties of different types of material:

- physical
 - melting, boiling, freezing points/change of state/temperature characteristics
 - thermal conductivity
 - density
 - corrosion resistance
 - electrical conductivity
 - resistivity
 - mechanical
-

- hardness
- strength
- ductility
- malleability
- elasticity
- creep resistance

Topic 3.3

Purpose of and processes used for different types of test:

- Brinell
- Vickers
- Rockwell
- Charpy
- Izod
- Fatigue (Wohler)
- Tensile

Topic 3.4

Causes of corrosion:

- pitting
- galvanic
- oxidation

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

- coating
- cathodic
- anodic

Topic 3.5

Effects of different types of heat treatments on materials:

- annealing
- normalising
- hardening
- tempering

Topic 3.6

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

- ease of manufacture
- application
- aesthetics
- environment
- sustainability
- availability
- properties

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Whilst some of the unit content will be delivered in a classroom environment, learners would benefit significantly from contextualised delivery in a workshop environment. For example, where skills are required in pathway units (or Unit 204) allow for the use of different materials, there are opportunities to learn about the properties of those materials, their suitability and testing methods.

Mathematics can be applied when planning practical activities. For example, learners interpret drawings (Unit 205) and apply principles of area and volume when calculating the materials required.

The unit lends itself to work closely with employers. Employer representatives can provide masterclasses on any of the learning outcomes, providing a real context where the learning is relevant to working in industry.

Unit 204 Developing engineering workshop practice

GLH: 60

What is this unit about?

The components of a smartphone or those of a joystick used for keyhole surgery are assembled using the types of skills that are developed through this unit.

The unit will cover the basic underpinning skills and knowledge needed to function in the engineering sectors. It will cover the need to recognise and use safe working practices. This unit covers a broad range of engineering hand skills that are required in the sector. It covers skills and knowledge needed to produce components for assembly. Learners will learn to use appropriate tools, different materials and inspection techniques in order to achieve required tolerances and conform to specifications.

Learners can be introduced to this unit by asking themselves questions, such as:

- Are you a logical thinker, could you convert a drawing into an engineering component?
- How is a control panel in a nuclear power station made?
- Can you produce engineering components to an accuracy of less than 1mm?

Learning outcomes

In this unit, learners will

- 1 Understand engineering health and safety requirements
- 2 Prepare for engineering workshop activities
- 3 Use hand skills for engineering activities
- 4 Review the quality of engineered products

Scope of content

Learning outcome

- 1 Understand engineering health and safety requirements
-

Topics

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

Depth

Topic 1.1

Employee responsibilities under health and safety legislation:

- Health and Safety at Work Act 1974
- Provision and Use of Work Equipment Regulations 1998 (PUWER)
- Personal Protective Equipment Regulations 1992
- Control of Substances Hazardous to Health 2002 (COSHH)
- Manual Handling Operation Regulations 1992
- Electricity at Work Regulations 1989

Topic 1.2

Procedures for safe working practice:

- safe isolation of energy sources
- prepare self and area to be in a safe condition to carry out work
- work safely whilst carrying out activities
- ensure self and area are left in a safe condition upon the completion of activities

Topic 1.3

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

- warning
- mandatory
- safe condition
- prohibition

Topic 1.4

Process undertaken when carrying out risk assessments:

- identification of hazards
 - evaluation of risk
 - severity
 - likelihood
 - number affected
 - risk rating
 - recommendation of control measures
-

Learning outcome

2 Prepare for engineering workshop activities

Topics

2.1 Use technical information to prepare for engineering activities

2.2 Plan engineering workshop activities

Depth

Topic 2.1

Extract and use technical information from a range of different information sources in order to prepare for workshop activities:

Technical information:

- materials
- components
- dimensions
- tolerances
- finishes
- quantity
- function

Information sources:

- technical manuals
- specifications
- manufacturer's instructions

Topic 2.2

Considerations to be taken when planning engineering workshop activities:

- health and safety
- materials
- equipment
- tools
- time
- quality checks
- tolerances
- activity/task/operations
- sequence

Learning outcome

3 Use hand skills for engineering activities

Topics

- 3.1 Mark out materials
- 3.2 Removal of material
- 3.3 Assemble components

Depth

Topic 3.1

Applications of marking out equipment

- rules/tapes
- dividers
- scribes
- surface plate
- punches
- scribing blocks
- squares
- protractor
- chalk line
- lasers
- Vernier instruments

Mark out:

- datum/centre lines
- square/rectangular profiles
- circles
- radial profiles
- linear hole positions
- angles/angular profiles

Topic 3.2

Applications of workshop equipment:

- hacksaws
 - files
 - chisels
 - grinders
 - drills
 - taps and dies
 - crimpers
 - wire strippers
 - wire cutters
 - tin snips
 - screwdrivers
 - spanners
 - hammer
-

- pliers
- torque wrench

Apply material removal operations:

- cutting
- sawing
- filing
- chiselling
- drilling
- threading
- desoldering
- etching

Topic 3.3

Assemble components following defined standard procedures:

- fitting
- securing using mechanical methods
- terminating using electrical methods

Learning outcome

4 Review the quality of engineered products

Topics

- 4.1 Characteristics of quality
- 4.2 Applications of measuring instruments
- 4.3 Carry out quality inspections

Depth

Topic 4.1

Characteristics of quality control:

- measurement of finished assembly
- documentation
 - inspection reports
 - test results

Characteristics of quality assurance:

- measurement of components during manufacture
- right first time – prevention of defects

Topic 4.2

Applications of measuring instruments:

- micrometres (external, depth)
 - tape measures
 - multimeter
 - Vernier calliper
 - comparison plates
-

- infrared thermometer
- rules
- continuity tester
- squares
- protractors
- gauges
- Dial Test Indicator (DTI)
- Coordinate Measuring Machine (CMM)
- insulation resistance tester

Topic 4.3

Carry out visual inspection to confirm components are:

- free from false cuts, burrs and sharp edges
- correctly used
- free from damage

Carry out quality checks in terms of:

- functionality
- tolerances
- specification
- dimensions
- output

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

The use of planning and inspection recording documentation can be supported through the use of real forms and templates provided by employers. The same documentation can be used when planning practical activities and carrying out inspections for Unit 210. The activities given to learners to develop hand skills could also be used to learn how to interpret and extract information from drawings, to link with Unit 205. The practical activities also allow learners to develop their understanding of scientific concepts and maths (Unit 203) in real contexts.

Visits to employers would allow a real world relevance of the activities undertaken within Centres and exposure to the wide range of methods used by employers. Sales representatives could be used to provide masterclasses on the use of tools. Employers could also provide feedback to learners on the quality of their work and skills demonstrated.

Unit 205 Working in engineering businesses

GLH: 60

What is this unit about?

The purpose of this unit is for learners to develop an understanding of how an engineering business is built up, functions and achieves commercial success. They will develop knowledge of how engineering businesses operate in an industry that is worth over £1 trillion annually to the UK.

The unit will develop skills that enable learners to communicate effectively in a role in this industry and further their career in Engineering. Learners will develop their knowledge of business improvement approaches which are used by the most successful businesses worldwide. They will explore how the application of these approaches are used to improve the profitability of engineering businesses. This unit introduces learners to technical drawings and how they are used by engineering businesses. They will develop the ability to read and interpret technical drawings, including understanding the key symbols used in mechanical and electrical technical drawings.

Learners can be introduced to this unit by asking themselves the following questions:

- How does a business operate and make money?
- What will 'lean' mean to my job role?
- How can I communicate effectively in a business?
- How are technical drawings used in an engineering business?

Learning outcomes

In this unit, learners will

- 1 Understand how engineering businesses are organised
- 2 Use business communication
- 3 Understand approaches to business improvement
- 4 Understand technical drawings

Scope of content

Learning outcome

- 1 Understand how engineering businesses are organised
-

Topics

- 1.1 Characteristics of types of engineering business
- 1.2 Functional areas of engineering businesses
- 1.3 Stakeholders of engineering businesses
- 1.4 Common standards for engineering businesses

Depth

Topic 1.1

Characteristics of engineering businesses of different:

- sizes
- geographical operation (local, national, international)
- sectors

Characteristics of how engineering business are organised:

- levels of responsibility
- lines of communication
- organisation charts

Topic 1.2

Characteristics of and job roles within different functional areas:

- support
- sales & marketing
- engineering
- manufacturing
- quality

Topic 1.3

Expectations of different types of stakeholders:

- existing clients/users
- potential clients/users
- board of directors
- external shareholders
- standards bodies
- regulator for that industry

Topic 1.4

Types of standards and reasons for their existence:

- industry
 - national
 - international
-

Learning outcome

2 Use business communication

Topics

- 2.1 Business communication skills
- 2.2 Use business documentation

Depth

Topic 2.1

Apply business communication skills:

- verbal
- non-verbal
- written
- technical language

Topic 2.2

Types of, purpose of and completion of business documentation:

- commercial documentation
 - Gantt charts
 - Bill of Materials (BoM)
 - reports
 - technical drawings
 - work instructions
-

Learning outcome

3 Understand approaches to business improvement

Topics

- 3.1 Types of engineering activity and their characteristics
- 3.2 Approaches to business improvement

Depth

Topic 3.1

Types of engineering activity and their characteristics:

- manufacturing
 - design to order
 - mass production
 - just in time manufacturing
 - manufacture to stock and distribute
 - maintenance
 - service provision
 - design
 - analysis
 - production
-

Topic 3.2

Characteristics of approaches to business improvement and how they can improve business performance for different types of engineering activity:

- six sigma
- kaizen
- lean manufacturing (5S)
- visual management
- continuous improvement

Learning outcome

4 Understand technical drawings used by engineering businesses

Topics

- 4.1 Types of technical drawing
- 4.2 Information on engineering drawings
- 4.3 Mechanical symbols used on engineering drawings
- 4.4 Electrical symbols used on engineering drawings
- 4.5 Create technical sketches

Depth

Topic 4.1

Types of technical drawing:

- part
- general assembly
- general arrangement
- flow diagram
- schematics

Difference between first and third angle projection.

Characteristics of and advantages of using different views:

- orthographic
- isometric
- exploded
- section
- detail
- breakout
- auxiliary

Topic 4.2

Information

- zones
-

- title block
- scale
- paper size
- revision
- status
- dimensions
- associated drawings
- Bill of Materials (BoM)/ parts list

Topic 4.3

Mechanical symbols:

- balloon
- diameter
- counterbore
- countersink
- depth
- centre mark
- centre line

Geometric Dimensioning and Tolerancing (GDT) symbols:

- datum
- parallelism
- perpendicularity
- concentricity
- straightness

Topic 4.4

Electrical symbols:

- batteries
- amplifiers
- resistors
- capacitors
- lamps
- transformers
- diodes
- inductors
- relays
- transistors
- wiring
- switches

Topic 4.5

Produce mechanical and electrical sketches

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Delivery of the unit could begin with a focus on how an engineering business is made up of different business functions. Delivery could be used so that all work carried out in Units 203 and 204 are only possible if there is a successful business where employees can use their skills. Learners could be presented with case studies that takes them through a process from client introduction to the business to delivery of an engineered product. This could be considered in relation to different sizes of business and how the different functional areas are organised and would be involved. This approach would also provide opportunities to consider the use of documentation and communication throughout the process. Practical application could then be developed with learners working with drawings that would be developed in relation to the case studies. These could be linked to their pathways units (Units 206 - 217), where learners can further develop their practical skills in relation to the case studies. Links to these pathway specific units also provide opportunities to develop communication skills in realistic industrial contexts.

Visits to local SMEs and large businesses are encouraged. It is expected that learners have the opportunity to learn about different functions of an engineering business, to give learners the best idea of which area they would most like to gain employment. Tutors are encouraged to organise guest speakers from local businesses in the engineering sector. This may help contextualise the business concepts into a meaningful product being designed and/or made locally.

Links with employers could ensure that real technical drawings and related products can be seen by learners. This would provide links with the mathematical concepts in Unit 203 that can be applied through sketching and interpreting drawings.

Unit 206 Welding processes

GLH: 90

What is this unit about?

Welding is the most widely used process to create permanent joints between metal parts. It is used across the full range of engineering industries, ranging from the manufacture of aeroplanes and cars, to joining together offshore oil pipes, making frames for wheelchairs or the repair of damaged metal components.

The purpose of this unit is for learners to be able to join metals together using welding processes. Learners will prepare materials for welding and safely produce different types of joint. They will understand common flaws in welded joints and how to assess if a welded joint is satisfactory. They will develop understanding of a wide variety of welding processes, ranging from gas shielded arc welding to manual metal arc, laser and submerged arc welding. This would provide an excellent opportunity to develop the skills needed to pursue a career as a welder in the engineering industry.

Learners can be introduced to this unit by asking themselves questions, such as:

- What welding processes could be used to join two pieces of metal together?
- How are welding processes carried out?
- How are typical welding defects avoided?
- How can a weld be tested to make sure that it is sound?

Learning outcomes

In this unit, learners will

- 1 Understand the health and safety requirements for welding processes
- 2 Understand welding processes
- 3 Prepare materials for welding
- 4 Perform welding processes
- 5 Understand defects in welded joints

Scope of content

Learning outcome

- 1 Understand the health and safety requirements for welding processes
-

Topics

- 1.1 Common hazards when welding
- 1.2 Control measures for welding processes

Depth

Topic 1.1

General hazards:

- compressed gases
- handling heavy, sharp or hot materials

Hazards during the welding process:

- hot metal, slag and sparks
- fume (particulate, gaseous)
- electricity (shock, fire)
- arc radiation
- noise

Topic 1.2

Purpose and safe use of Personal Protective Equipment (PPE) as a control measure:

- headshields
- filter lens
- gauntlets
- protective footwear
- leather apron / flame retardant overalls
- ear protection

Purpose and safe use of control measures to create a safe welding environment:

- use of screens
 - fume extraction
 - electrical insulation
 - welding earth
 - using tongs and lifting devices
-

Learning outcome

2 Understand welding processes

Topics

- 2.1 Features of a weld
- 2.2 Gas shielded welding processes
- 2.3 Flux shielded welding processes
- 2.4 Advanced welding processes

Depth

Please note: this learning outcome relates to understanding the different welding processes and their capabilities. The practical use of welding processes is covered in Learning Outcome 4.

Topic 2.1

Characteristics of weld features:

- face
- root gap
- root face
- bevel angle
- included angle
- throat thickness
- leg length
- toe
- fusion zone
- penetration
- heat affected zone

Topic 2.2

Types and capabilities of gas shielded welding processes:

- Tungsten Inert Gas (TIG) welding
- Metal Inert Gas (MIG) welding
- Metal Active Gas (MAG) welding
- Flux Cored Arc Welding (FCAW)

Requirements for different types of gas shielded welding processes:

- hardware
- consumables
 - filler rod or wire
 - shielding gas

Operating considerations of different types of gas shielded welding processes:

- welding return and welding earth
 - influence of the shielding gas type
 - shielding gas flow rate
-

Topic 2.3

Types and capabilities of flux shielded welding processes:

- Manual Metal Arc (MMA) welding
- Submerged Arc Welding (SAW)

Requirements for different types of flux shielded welding processes:

- Hardware
- Consumables
 - Welding electrodes
 - Filler wire
 - Flux
 - Storage

Operating considerations of different types of flux shielded welding processes:

- welding return
- welding earth

Topic 2.4

Types and capabilities of advanced welding processes:

- laser welding
- friction welding

Learning outcome

3 Prepare materials for welding

Topics

- 3.1 Interpret sources of information for welding activities
- 3.2 Prepare material surfaces for welding
- 3.3 Characteristics of joint configurations
- 3.4 Methods of distortion control

Depth

Topic 3.1

Interpret sources of information:

- welding symbols on working drawings
- welding procedure sheets
- risk assessments
- manufacturers' data sheets

Topic 3.2

Prepare material surfaces for welding:

- removal of oxides, rust and surface debris
 - degreasing
-

Topic 3.3

Characteristics of joint configurations:

- butt joints (open, closed, v-groove)
- fillet joints (lap, tee, corner)

Topic 3.4

Methods of distortion control:

- alignment jigs
- clamping
- offsetting
- run on/off plates
- tack welding
- planned sequence of welding

Learning outcome

4 Perform welding processes

Topics

4.1 Use welding techniques

Depth

Please note: it is not necessary for learners to be able to use all of the welding processes covered in Learning Outcome 2. Learners should be able, at minimum, to use one arc welding process (TIG, MIG, MAG, FCAW, MMA or sub-arc), to create welded joints in steel and aluminium alloy.

Topic 4.1

Welding parameters:

- current
- voltage
- feed rate

Welding techniques:

- slope and tilt angles
- arc length
- arc striking
- crater filling at the end of a weld
- weld sequence (
 - single and multiple run/root
 - filler and cap passes)
- weave
- travel speed

Influences on welding technique:

- material thickness
 - material type
 - low carbon steel
-

- stainless steel
- aluminium alloy

Post welding activities:

- dressing and cleaning welded joints using:
 - angle grinders
 - files
 - chipping hammers
 - wire brushes
- visual inspection
- use of weld gauges

Welding positions:

- downhand (flat)
- horizontal
- vertical upwards
- horizontal/vertical
- inclined
- overhead

Learning outcome

- 5 Understand defects in welded joints
-

Topics

- 5.1 Welding defects
- 5.2 Testing welding joints
- 5.3 Testing data

Depth

Topic 5.1

Causes of and characteristics of welding defects:

- distortion (transverse, angular, longitudinal)
 - out of alignment/squareness
 - inclusions
 - porosity
 - cracks (internal, surface)
 - lack of fusion
 - lack of penetration
 - undercut
 - lack of continuity
 - spatter
-

Topic 5.2

Processes involved in testing welding joints and their suitability:

Non-destructive testing methods:

- visual inspection
- weld gauges
- dye penetrant
- magnetic particles
- radiography

Destructive testing methods:

- macroscopic examination
- bend test
- nick break tests

Topic 5.3

Interpret data derived from destructive and non-destructive testing.

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

The most important of the many learning tools for this unit will be supervised practical activities, where the learners develop skill using one of the welding processes through practical application. An understanding of health and safety must be integrated at all times into these lessons.

Delivery of this unit could be related to Unit 208 where materials would be prepared for welding and Unit 207 where they are working with materials for fabrication. Linking delivery of this unit allows for the development of hand skills in the context of welding, and the use of other generic skills such as measurement, marking out and use of generic tools. An understanding of the properties of materials required in Unit 203 could be demonstrated through welding activities and testing of welded joints. Learners could also develop an understanding of technical drawings and business improvement in the context of practical welding activities.

Centres would benefit strongly from links with local engineering companies who carry out welding activities that can be related and applied to lessons. Where possible, learners should be provided with the opportunity to visit engineering companies involved in welding activities, to see the different process options in use. They could also use these visits to carry out practical learning and welding activities, in conjunction with or supervised by staff from the engineering companies. Similarly, welders from local engineering companies could assist with training in the use of welding processes in the delivering centre.

Unit 207 Fabrication practice

GLH: 60

What is this unit about?

From building football stadia, rockets and skyscrapers to bikes, prosthetic limbs and jewellery, fabrication skills are needed throughout the world.

The purpose of this unit is for learners to develop the skills and understanding of equipment and processes used widely in the fabrication sector. The learning can provide a good basis for progression to apprenticeships where training will further develop the skills required to be successful in this sector. It provides training to allow the safe and accurate use of tools and equipment and the skills needed to be able to shape, cut and join metals to produce a range of product forms.

Learners can be introduced to this unit by asking themselves questions, such as:

- What is fabrication used for?
- Where can my skills take me?
- How would I make... ..?
- What part of a spaceship is a fabricator responsible for?

Learning outcomes

In this unit, learners will

- 1 Use fabrication equipment
- 2 Produce fabricated components

Scope of content

Learning outcome

- 1 Use fabrication equipment
-

Topics

- 1.1 Use fabrication hand tools
- 1.2 Use fabrication machinery

Depth

Topic 1.1

Characteristics, selection of and safe use of fabrication hand tools:

- hammers
 - planishing hammers
 - mallets
- bench stakes
- protractors
 - manual
 - vernier
 - digital
- trammels
- hand lever punch
- line of chords rule
- chalk line
- plate squares

Topic 1.2

Capabilities, selection of and safe use of fabrication machinery:

- hole making
 - drills
 - punch
 - press
 - folding
 - universal
 - box and pan
 - press brakes
 - horizontal benders
 - fly press
 - bending
 - pinch type bending rolls
 - pyramid bending rolls
 - section ring rollers
 - vertical bending rolls
 - 4 roll bending rolls
-

Learning outcome

2 Produce fabricated components

Topics

2.1 Joining techniques

2.2 Join materials

2.3 Finish materials

Depth

Learners should develop skills to work to the following fabrication tolerances:

- 1 – 3mm material +/- 2mm
- 4 – 8mm material +/- 3mm

Join materials to create product forms:

- boxes
- flanges
- segmental bends
- cylindrical
- frames
- support stands

Topic 2.1

Techniques of joining methods:

- mechanical
 - bolting
 - using screws
 - riveting
 - clinching
 - using adhesives
- thermal
 - soldering
 - brazing
 - spot welding

Suitability of jigs and fixtures in terms of:

- design considerations
- loading
- process access
- component removal
- accuracy
- distortion control

Topic 2.2

Use mechanical and thermal joining methods to fabricate components using different fabrication materials and forms of supply:

Fabrication materials:

- carbon steel
- stainless steel
- aluminium alloy

Forms of supply

- plate (1mm – 8mm thick)
- angle iron
- hollow section
- flat bar

Topic 2.3

Principles of finishing methods:

- grinding
- sanding
- shot blasting
- graining
- polishing

Use finishing methods:

- grinding
- sanding
- polishing

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

This is a practical unit designed to develop the skills required for the fabrication sector. Although the unit specifies fabrication specific tools, there are generic tools that are used in Unit 204. The types of materials, sections, tolerances and product forms used to develop technical skills allow for consideration of mathematical and scientific content developed from Unit 203. Setting tasks through the use of engineering information, such as technical drawings, allows for consideration of the content of Unit 205. The completion of a range of fabricated products could be delivered in relation to the welding and cutting Units (206 and 208).

Tutors are encouraged to organise masterclasses from specialists in the sector. These specialists could also provide learners with feedback on the skills they demonstrate when fabricating products.

Unit 208 Cutting processes

GLH: 30

What is this unit about?

The vast majority of materials are manufactured in standard forms and sizes. To use them to make products, these materials normally have to be cut to shape. Many manufacturing activities therefore involve the use of a cutting process, typically in the early stages of production.

The purpose of this unit is for learners to be able to cut metals so that they can be used for welding or fabrication. They will develop practical skills in a variety of cutting processes, ranging from shear cutting and chip forming to thermal cutting.

Learners can be introduced to this unit by asking themselves questions, such as:

- What processes could be used to cut a piece of metal?
- How are cutting processes carried out?

Learning outcomes

In this unit, learners

- 1 Perform shear cutting processes
- 2 Perform cutting using chip forming processes
- 3 Perform thermal cutting processes
- 4 Understand advanced cutting processes

Scope of content

Learning outcome

1 Perform shear cutting processes

Topics

- 1.1 Principles of shear cutting
- 1.2 Types of equipment used in shear cutting
- 1.3 Health and safety considerations
- 1.4 Perform shear cutting

Depth

Topic 1.1

Principles of shear cutting:

- method of cutting
- process capability

Topic 1.2

Capabilities, selection of and safe use of types of equipment:

- guillotines
- tin snips
- punches

Topic 1.3

Health and safety considerations:

- sharp edges
- risk of crushing
- noise

Topic 1.4

Performing shear cutting of thin sheet

Learning outcome

2 Perform cutting using chip forming processes

Topics

- 2.1 Principles of chip forming processes
- 2.2 Types of equipment used for chip forming
- 2.3 Health and safety considerations
- 2.4 Perform cutting using chip form processes

Depth

Topic 2.1

Principles of cutting using chip forming processes:

- method of cutting
- factors that affect the operating parameters (cutter speed, material feed rate)

Topic 2.2

Capabilities, selection of and safe use of sawing equipment:

- bandsaw
- powered hacksaw

Capabilities, selection of and safe use of milling equipment:

- horizontal miller
- vertical miller
- different types of cutting tool

Topic 2.3

Health and safety considerations and control measures:

- entanglement in rotating parts
- guarding of moving parts and blades
- interlocks
- automatic end stops
- noise

Topic 2.4

Perform cutting by sawing and milling to produce:

- faces
- slots
- angled surfaces (bevels for v-groove butt welds)

Learning outcome

3 Perform thermal cutting processes

Topics

- 3.1 Principles of thermal cutting
- 3.2 Types of equipment used in thermal cutting
- 3.3 Health and safety considerations
- 3.4 Perform thermal cutting

Depth

Topic 3.1

Principles of thermal cutting:

- method of cutting
- process capability

Topic 3.2

Characteristics, selection of and safe use of oxyfuel gas cutting equipment:

- cutting nozzles
- types of gases
- cylinder types
- hose types
- connector types

Characteristics, selection of and safe use of plasma cutting equipment:

- hardware for manual cutting
- computer controlled cutting systems
- return clamp

Topic 3.3

Health and safety considerations:

- hazards from compressed gas cylinders
- flashback arrestors (for oxyfuel gas cutting)
- electrical shocks and insulation (for plasma cutting)
- hot metal/sparks
- fume (particulate, gaseous)
- Personal Protective Equipment (PPE)
- noise

Topic 3.4

Perform thermal cutting of plate materials.

Learning outcome

4 Understand advanced cutting processes

Topics

4.1 Laser cutting

4.2 Abrasive water jet cutting

Depth

Topic 4.1

Laser cutting:

- process principles
- process capabilities (materials, thickness)
- equipment requirements
- health and safety considerations
- advantages and disadvantages compared to alternative cutting processes

Topic 4.2

Abrasive water jet cutting:

- process principles
- process capabilities (materials, thickness)
- equipment requirements
- health and safety considerations
- advantages and disadvantages compared to alternative cutting processes

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Delivery of this unit could be related to Unit 206 where the cut materials would be welded and Unit 207 where they are then fabricated. Linking delivery of this unit allows for the development of hand skills in the context of cutting, and the use of other generic skills such as measurement and marking out that are included in Unit 204. An understanding of the properties of materials and mathematical principles required of Unit 203 could be demonstrated through cutting activities.

The most important of the many learning tools for this unit will be supervised practical activities, where the learners develop skill using cutting processes through practical application. An understanding of health and safety must be integrated at all times into these lessons.

Centres would benefit strongly from links with local engineering companies who perform cutting activities that can be related and applied to lessons. Where possible, learners should be provided with the opportunity to visit engineering companies who use cutting processes, to see the different process options in use. They could also use these visits to perform practical learning and cutting activities, in conjunction with or supervised by staff from the engineering companies. Similarly, staff from local engineering companies could assist with training in the use of cutting processes in the delivering centre.

Unit 209 Engineered systems

GLH: 60

What is this unit about?

Maintenance engineers are expected to have knowledge of a range of engineered systems and components; including mechanical, electrical and fluid power. Planned maintenance activities can range from lubrication to replacing complex components; these techniques are to be applied in a controlled way following procedures and best practice which can come from a maintenance system.

This unit will provide learners with the underpinning knowledge needed to function in maintenance engineering.

Learners can be introduced to this unit by asking themselves questions, such as:

- Ever wondered how engineers keep robots working?
- Are you keen to take things apart; repair them and make them as good as new?
- Do you want to learn about a wide range of equipment such as motors, gearboxes and robots?

Learning outcomes

In this unit, learners will

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

Scope of content

Learning outcome

- 1 Understand mechanical systems
-

Topics

- 1.1 Mechanical systems
- 1.2 Components of mechanical systems
- 1.3 Maintenance of mechanical systems

Depth

Topic 1.1

Functions, applications and operation of different types of mechanical systems:

- pumps
 - centrifugal
 - reciprocating
- conveyors
 - belt
 - roller
- compressors
 - screw
 - reciprocating
- gearboxes
 - gear drive
 - worm drive

Topic 1.2

Applications and functions of mechanical system components:

- shafts
- couplings
- bearings
- seals
- gears
- chains and belts

Topic 1.3

Reasons for maintenance of mechanical systems:

- wear
 - component failure
 - replacement of end of life components
 - repair or replacement of components
 - adjustment due to wear
-

Learning outcome

2 Understand electrical systems

Topics

- 2.1 Electrical systems
- 2.2 Components of electrical systems
- 2.3 Maintenance of electrical systems

Depth

Topic 2.1

Functions, applications and operation of different types of electrical systems:

- lighting
 - one way
 - two way
 - intermediate
- power
 - ring final
 - radial
- motor/starter
 - Direct on Line (DoL) single phase motor
 - Direct on Line (DoL) three phase motor
 - Star Delta Starter three phase motor

Topic 2.2

Applications and functions of electrical system components:

- switches
- luminaires
- push buttons
- contactors
- overloads
- power sockets
- motors
- cables

Topic 2.3

Reasons for maintenance of electrical systems:

- wear
- component failure
- replacement of end of life component
- repair or replacement of components
- adjustment due to wear

Learning outcome

3 Understand fluid power systems

Topics

- 3.1 Fluid power systems
- 3.2 Components of fluid power systems
- 3.3 Maintenance of fluid power systems

Depth

Topic 3.1

Functions, applications and operation of different types of fluid power systems:

- hydraulic
- pneumatic

Topic 3.2

Applications and functions of fluid power system components:

- compressors
- valves
- filters
- reservoir
- receiver
- dryer
- lubricator
- drain
- actuator

Topic 3.3

Reasons for maintenance of fluid power systems:

- wear
- component failure
- replacement of lified component
- adjustment due to wear

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Scientific concepts in Unit 203 underpin the operation and functions of the systems referred to in this unit. This unit provides the foundation knowledge to support the practical activity covered in Units 204 and 209. The interpretation of technical drawings required for Unit 205 could be applied to systems and sub-assemblies referred to in this unit.

Delivery would ideally be through a range of interactive sessions including practical projects allowing learners to gain knowledge and experience the range of systems and components found in the mechanical, electrical and fluid power areas of engineering.

Visits to employers would provide a real world relevance of the activities undertaken within centres. Masterclass sessions where industry experts demonstrate industry tools, techniques and processes covered by the unit content would provide further opportunities for learners to engage with employers.

Unit 210 Planned maintenance

GLH: 90

What is this unit about?

Planned maintenance is really important to prevent equipment breaking down, causing loss of production and risks for a business in money terms. Poorly maintained equipment and delays in producing a customer's product will severely ruin a company's reputation leading to loss of business. A large number of people, contractors and visitors to a site may be involved in the maintenance of plant and equipment. These have to be coordinated and administered before work can start. The down time on equipment has to be planned for whilst the repair or maintenance work is undertaken by the skilled maintenance technician. Records of all work need to be kept for future analysis.

The purpose of this unit is for learners to understand the processes involved in preparing for and carrying out a planned maintenance activity.

Learners can be introduced to this unit by asking themselves questions, such as:

- Where do I start?
- How will processes be coordinated?
- What happens if I over run planned times?
- How will we work safely during the maintenance?

Learning outcomes

In this unit, learners will

- 1 Understand how engineers prepare for maintenance activities
- 2 Prepare to undertake maintenance activities
- 3 Perform maintenance activities
- 4 Maintain maintenance documentation

Learning outcome

- 1 Understand how engineers prepare for maintenance activities
-

Topics

- 1.1 Maintenance planning
- 1.2 Isolation techniques
- 1.3 Planning requirements

Depth

Topic 1.1

Maintenance planning activities within an organisation:

- scheduling of planned maintenance
- team meetings
- coordination meetings
- ordering of parts and consumables
- completion of a risk assessment
- completion of a method statement
- gathering relevant documentation
- reviewing relevant documentation

Topic 1.2

Processes involved in and safe application of different isolation techniques:

- isolation of electrical supplies
- isolation of fluid power supplies
- isolation of networked systems
- temporary shut downs

Content of and completion of process documentation required when applying safe isolation techniques:

- sign off
- work permits
- lock off

Topic 1.3

Processes involved in meeting organisational planning requirements:

- site induction
 - site visit
 - site meetings
 - distribution of information
 - drawings, specification and instructions
 - planning schedule distribution
 - communication with those affected
 - safety briefings
 - tool box talks
-

Learning outcome

2 Prepare to undertake maintenance activities

Topics

- 2.1 Prepare for maintenance activities
- 2.2 Applications of maintenance tools and equipment
- 2.3 Disassemble systems and subsystems

Depth

Topic 2.1

Standard procedures involved in and safe application of preparation activities:

- check and use PPE
- check documentation
- complete documentation
- erect barriers and signage
- communicate with key stakeholders
- carry out isolation procedures
- carry out locking off procedures
- select tools and equipment
- check condition of tools and equipment
- review working environment

Topic 2.2

Applications and safe use of maintenance tools and equipment:

- pullers
- electrical test equipment
- press
- torque wrench
- pressure gauges
- flow meter

Topic 2.3

Processes involved in and safe application when using disassembly techniques to disassemble systems and subsystems:

- disassembly of safety guarding
- labelling and marking of components
- disassembly of equipment to sub-assembly
- disassembly of sub-assembly to component
- draining of liquids and gases sustainably

Learning outcome

3 Perform maintenance activities

Topics

3.1 Maintain systems and subsystems

3.2 Inspection and testing

3.3 Assemble systems and subsystems

Depth

Topic 3.1

Replace and align components within systems and sub-systems:

- electric motors
- couplings
- valves
- actuators

Topic 3.2

Suitability, selection and safe use of inspection and testing techniques:

- visual inspection
- vibration tests
- heat tests
- electrical tests
- damage checks
- checking of measurements against specifications
- measurement of alignments

Topic 3.3

Processes involved in and safe use of assembly techniques when assembling systems and subsystems:

- use of labelling and marking
- testing and commissioning of components
- reassembly of safety guards

Learning outcome

4 Maintain maintenance documentation

Topics

4.1 Complete maintenance records

4.2 Review maintenance records

Depth

Topic 4.1

Complete planned maintenance records:

- permits to work
- job cards
- commissioning documentation
- stock requisitions
- waste disposal

Topic 4.2

Review planned maintenance records:

- risk assessments
- method statements

Considerations for the organisation of records and application:

- security
- accessibility
- location

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Aspects of health and safety are best demonstrated by learners working on practical maintenance activities. This will link the fundamental workshop practice from Unit 204 with the practical aspects of this unit. The theoretical technological concepts of different types of system addressed in Unit 209 can be addressed through practical maintenance activities. Planning and preparing for maintenance activities can be linked with Unit 205 where learners gain an understanding of how businesses are structured and their key stakeholders.

Inviting a maintenance engineer into the classroom would greatly benefit learner understanding of the administration and documentation associated with maintenance. The engineer would be able to demonstrate the complete system that is operated within their company, demonstrating all of the processes and procedures. The tutor could obtain copies of typical maintenance documentation that would be used along with a template for the risk assessment process that all learners will need to complete before starting work within the workshop simulation for maintenance. Equipment needed for practical activities can be sourced by developing a relationship with a manufacturer or supplier and/or an engineering company who could provide work related items that are no longer required as part of their processes.

Unit 211 Principles of maintenance

GLH: 30

What is this unit about?

A breakdown in equipment causes a delay and an economic cost as the processes are stopped whilst the repairs are undertaken. This is often costly for an engineering company that can be avoided by regular maintenance of the machinery and equipment.

This unit covers the maintenance procedures for reactive maintenance where machines have to be fixed straight away and planned where the machine is serviced to replace parts that are worn out and fittings such as oil filters. The purpose of this unit is for learners to understand that essential maintenance has to be undertaken on equipment, systems and plant. In this unit they will explore each system and how these are informed by monitoring of the equipment or plant.

Learners can be introduced to this unit by asking themselves questions, such as:

- What needs to be maintained?
- When is the best time to maintain?
- How often will equipment need maintaining?
- How will production be involved?

Learning outcomes

In this unit, learners will

- 1 Know different types of maintenance
- 2 Understand the importance of maintenance

Learning outcome

1 Know different types of maintenance

Topics

- 1.1 Maintenance activity requirements
- 1.2 Characteristics of different types of maintenance

Depth

Topic 1.1

Requirements of different types of maintenance activities:

- cleaning
- inspection
- monitoring
- adjustment
- repair
- refurbish
- replace

Topic 1.2

Types of maintenance:

- reactive
- planned
- condition based monitoring
- total planned maintenance

Characteristics of types of maintenance:

- definition
 - conditions when used
 - costs involved
 - personnel involved
 - resources required
 - service level agreements
 - support from equipment manufacturers
 - reporting requirements
 - communication methods needed
 - data collection
 - preparation activities
 - periods of servicing and maintenance
 - impact on production
 - maintenance activities carried out
 - quality considerations
 - component upgrading and monitoring
 - training required
-

Learning outcome

2 Understand the importance of maintenance

Topics

2.1 Advantages of different types of maintenance

2.2 Disadvantages of different types of maintenance

Depth

Topic 2.1

Advantages of different types of maintenance:

- financial
- productivity
- quality
- time
- morale
- customer service
- reputation
- legal
- safety
- decision-making
- continuous improvement

Topic 2.2

Disadvantages of different types of maintenance:

- productivity
- financial
- quality
- resource implications
- morale
- customer service
- reputation
- legal
- safety
- decision-making
- continuous improvement
- equipment life cycle
- Key Performance Indicators (KPIs)
- education and training

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

The use of case studies would equally provide an opportunity to see how the different types of maintenance can be applied to an engineering process or procedure. The case studies can be selected so the four types of maintenance can be investigated and the benefits from the application can be taken from the study. Reference to a large manufacturer's website may also help with this evidence gathering. The case studies would also allow the opportunity to relate the content to business improvement approaches in Unit 205. The use of the case studies could be applied to workshop activities, for Units 204 and 210, where maintenance skills are applied on the basis of different types of maintenance. The advantages and disadvantages could then be discussed as a result of their own experiences. The case studies could also be used to relate to the types of systems covered in Unit 209 so that learners see the relationship between the engineering systems and types of maintenance.

A visit to an engineering company would support learning for this unit. This would provide learners with the opportunity to discuss and explore engineering maintenance with an experienced maintenance manager at the company. A guest speaker invited in from the engineering sector will also provide an ideal opportunity for learners to interact with the expert in the maintenance field and valuable resources may be provided by this representative. This approach will also enhance learners understanding of how business improvement is taken into account when planning maintenance activities.

Unit 212 Manufacturing principles

GLH: 90

What is this unit about?

Ever wondered how high quality products can be manufactured so accurately and in such high numbers? Or how bespoke products can be created to meet the needs of individual users and remain so cheap and accessible? It is through the use of technology that high quality products are manufactured. Equipment used in manufacturing can be operated manually or through computer programs. From 3D printers to lathes, the technologies at the disposal of today's engineers are allowing them to do their jobs ever faster, smarter and more efficiently.

In this unit learners will learn about machining processes and the types of equipment that are used. They will learn what is meant by CAD/CAM and how it is used in engineering and the many advantages (and some of the disadvantages!) of using computer aided equipment over manual processes.

Learners can be introduced to this unit by asking themselves questions, such as:

- What is CAM?
- What is 3D printing and how does it work?
- What produces the best products – people or machines?
- Why is it so cheap to customise sports equipment?

Learning outcomes

In this unit, learners will

- 1 Understand machining operations used in manufacturing
- 2 Understand the operation of machining equipment used in manufacturing
- 3 Understand the use of CAD/CAM in manufacturing
- 4 Understand engineering applications of CAM

Learning outcome

- 1 Understand machining operations used in manufacturing
-

Topics

- 1.1 Machining operations
- 1.2 How machined features are produced

Depth

Topic 1.1

Principles of machining operations:

- milling
- turning
- grinding
- drilling

Benefits and limitations of machining operations:

- size of material
- types of material
- machinery and equipment
- cost
- time
- accuracy
- expertise required

Topic 1.2

Characteristics of different types of machined features and how the principles of machining operations are used to produce them:

- faces (datum, flat, perpendicular, parallel, angular)
- shoulders
- recesses
- slots (enclosed, open ended, tee)
- diameters (internal, external, bored, tapered, concentric)
- holes (drilled, reamed, blind, through, counterbored, countersunk, flat-bottomed, threaded)

Learning outcome

2 Understand the operation of machining equipment used in manufacturing

Topics

- 2.1 Characteristics of machine features
- 2.2 Machine setup activities
- 2.3 Principles of machine operation

Depth

Topic 2.1

Characteristics and applications of machines:

- drills
- mills
- lathes
- grinders

Characteristics and applications of machine features:

- cutting tools
- isolators
- speed control
- feed control
- chuck
- emergency stops
- workholding devices
- tables and beds
- coolant system

Topic 2.2

Machine setup activities; how they are applied for different types of machine and when using different types of material:

- mount chuck
- mount workholding devices
- calibrate machine
- load cutting tools
- load stock
- set speeds, feeds

Topic 2.3

Principles of machine operation:

- safety considerations
 - personal
 - machine
 - start-up and shutdown procedures
 - controls
 - speeds, feeds
 - limitations
-

Learning outcome

3 Understand the use of CAD/CAM in manufacturing

Topics

3.1 Applications of CAD software

3.2 Suitability of using CAD

3.3 Suitability of using CAM

Depth

Topic 3.1

Applications of CAD software in manufacturing:

- 2D CAD
- 3D CAD

Topic 3.2

Suitability of using CAD with consideration of:

- speed
- ease of use
- modifying
- accuracy
- views
- detail
- links to CAM
- cost
- training required
- equipment required

Topic 3.3

Suitability of using CAM with consideration of:

- speed
- accuracy
- repeatability
- form complexity
- safety
- links to CAD
- cost
- training required
- skill level required
- equipment required

Learning outcome

4 Understand engineering applications of CAM

Topics

- 4.1 Applications of CAM equipment
- 4.2 Characteristics of CAM processes
- 4.3 Suitability of equipment for CAM processes

Depth

Topic 4.1

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

- CNC machines
- laser cutters
- drag knife cutters
- engravers
- 3D printers

Topic 4.2

Characteristics of CAM processes:

- cutting
- routing
- milling
- drilling
- turning
- shaping

Topic 4.3

Factors to consider to determine the suitability of CAM equipment for manufacturing:

- equipment capabilities
- ability of equipment to automate all tasks
- materials that can/cannot be used
- likelihood of malfunction
- level of human input needed
- importance of human input

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Although it is possible to deliver this unit solely in a computer suite (or workshop with an internal network of PCs or laptops), it is recommended that wherever possible learners are able to experience and develop their knowledge of each of the topics in a practical manner. This will enable them to contextualise and improve their understanding through application. Learners will need access to appropriate ICT equipment and CAD software in order for this to take place.

The use of scenario-led tasks will help with contextualisation in the delivery and assessment of this unit. Much of the work can be set in the context of case studies of local employers. Industrial visits will also help learners to further understand how their knowledge could be applied in the workplace by seeing CAD and CAM in use. Employers could provide feedback to learners on the quality of their drawings and outputs from CAD software.

This can be delivered with links to other units. The most significant link is with Units 204 and 213 where learners have the opportunity to apply their learning in practical situations. Other opportunities for links include cross referencing with the scientific principles of Unit 203 and consideration of business improvement in Unit 205.

Unit 213 Manufacturing products

GLH: 90

What is this unit about?

Whether it is an aircraft undercarriage main axle or a popcorn machine, all have engineered products which have been machined in some way. Highly developed skills are needed to develop the components that keep aircraft in the sky or prevent the popcorn machine from breaking up.

Learners will develop the skills needed to produce engineered components using different types of machining operations, including milling, turning and drilling. They will learn to set up and operate machines and use different techniques to check that what is produced is fit for purpose. Learners will either develop manual machining skills or CNC programming skills.

Learners can be introduced to this unit by asking themselves questions, such as:

- Is it dangerous to use a lathe?
- Why are F1 cars so light?
- What does CNC code look like?

Learning outcomes

In this unit, learners will

- 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

- 1.1 Use CAD software
- 1.2 Produce CAD outputs

Depth

Topic 1.1

Principles of CAD software:

- hardware requirements
- software requirements
- user interfaces
- navigation of workspace

- data management
- links to CAM

Operate CAD software to:

- create templates
- produce line types, styles and colour
- create geometry (2D, 3D)
- insert and edit text
- modify geometry
- dimension
- annotate
- render
- assemble

Topic 1.2

Produce CAD outputs to recognised standards:

- part drawings
- output files for CAM

Learning outcome

2 Use CNC software

Topics

2.1 Apply CNC code

2.2 Creating CNC programs

Depth

Topic 2.1

Apply key command codes:

- program start
- linear motions
- circular motions
- absolute programming
- incremental programming
- tool change
- coolant
- program stop

Topic 2.2

Create, evaluate and edit simulated programs for CNC equipment.

Learning outcome

3 Prepare equipment for machining operations

Topics

- 3.1 Carry out safety checks
- 3.2 Carry out operational checks

Depth

Topic 3.1

Carry out safety checks prior to performing machining operations:

- power supply
- PPE
- guards
- emergency stops

Topic 3.2

Carry out operational checks prior to performing machining operations:

- overall condition
 - work-holding devices
 - tool mounting
 - coolant
-

Learning outcome

4 Produce engineered products

Topics

- 4.1 Safety considerations when machining
- 4.2 Standard machining procedures
- 4.3 Produce machined features
- 4.4 Quality control of machined features

Depth

Topic 4.1

Safety considerations:

- guards
 - cutting tools (condition and fitting)
 - speeds and feeds
 - coolant
-

Topic 4.2

Standard procedures used to achieve required outputs:

- setting machines
- sequencing of operations
- efficient sequencing of processes
- monitoring

Topic 4.3

Produce machined features:

- faces (datum, flat, perpendicular, parallel, angular)
- shoulders
- recesses
- slots (enclosed, open ended, tee)
- diameters (internal, external, bored, tapered, concentric)
- holes (drilled, blind, through, counterbores, countersinks, threaded)
- shapes and profiles

Topic 4.4

Evaluate machined features against specification using inspection and testing techniques:

- visual inspection
- measurement
- functional testing

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners developing this understanding. This approach will also support their preparation for the qualification assessments.

Safety is paramount in this unit and must be taught and demonstrated from the outset and applied throughout. This provides the opportunity to link with Unit 204. Learners must have access to and use; engineering drawings, machines, ancillary equipment, materials and a range of engineering measuring equipment. They will have learned to use these through the content of Units 204 and 205. Learners will be applying prior learning of resistant materials, numeracy and scientific concepts covered in Unit 203.

Learners must be taught to set up machines correctly and to use them safely. They should be familiar with this concept through unit 204. Unit 204 will also provide the fundamental requirements of measurement. Links to unit 212 could be used to consider the advantages and disadvantages of manual machining over the use of computerised approaches.

Visits to manufacturing companies to carry out quality control activities on components produced would be helpful. This is an ideal unit for employer representatives to provide feedback on learners' outputs. Guest speakers, such as sales representatives, can give examples of machined products or provide masterclasses on specific techniques.

Unit 214 Electronic components

GLH: 60

What is this unit about?

Smartphones, game consoles, satellite navigation systems and life support systems all have electronic components that make them function.

The purpose of this unit is for learners to gain an understanding of the theory of how electronic components work. They will also learn how circuits are built from these components in order to enable more complex functions.

Learners can be introduced to this unit by asking themselves questions such as:

- What makes the picture on my TV?
- What makes the door on a washing machine stay locked when it is working?
- How does an electronic circuit work?

Learning outcomes

In this unit, learners will be able to

- 1 Understand electronic circuit principles
- 2 Understand electronic component functions in circuits
- 3 Understand preparation requirements for working with electronic circuits

Scope of content

Learning outcome

1 Understand electronic circuit principles:

Topics

- 1.1 International System of Units (SI Units)
- 1.2 Fundamental circuit theory
- 1.3 Calculate values in DC circuits

Depth

Topic 1.1

Multiples and sub-multiples of different quantities:

- resistance
- capacitance
- inductance
- voltage
- current
- frequency
- time
- power
- energy
- magnetic flux
- magnetic flux density
- temperature

Topic 1.2

Laws and theorems:

- electron theory
- Ohm's Law
- electrical power
- magnetism
- Fleming's rules

Principles of generation

- sources of energy
 - DC
 - AC
 - thermal
 - magnetic
 - chemical
-

Topic 1.3

Calculate values in series, parallel and combination circuits:

- voltage
- current
- power
- energy
- resistivity

Learning outcome

2 Understand electronic component functions in circuits

Topics

2.1 Discrete components

2.2 Integrated devices

Depth

Topic 2.1

Functions, applications, construction types and value identification of passive components:

- resistors
- capacitors

Applications of active components:

- diodes (Signal, LED)
- transistors (bipolar, field effect)

Characteristics of component packages:

- resistor
- capacitor
- diodes
- transistor

Functions of general components:

- fuses
- switches
- transformers
- inductors
- sensors
- relays
- lamps

Topic 2.2

Digital logic principles:

- logic gates
 - truth tables
-

Functions and applications of integrated devices:

- analogue devices
 - regulators
 - amplifiers
 - timers
- microprocessors
 - system architecture
 - buses
- component package types
 - DIL
 - PLCC
 - SMT

Learning outcome

3 Understand preparation requirements for working with electronic circuits

Topics

- 3.1 Function of circuit assembly equipment
- 3.2 Safety measures when working with electronic circuits

Depth

Topic 3.1

Function of circuit assembly equipment:

- soldering irons
- hand tools
- antistatic equipment
- clamps
- cable termination tools
- cleaning solutions

Topic 3.2

Potential hazards when working with electronic circuits:

- damaged tools
- incorrect tool usage
- solder splash
- solder fumes
- chemical effects
- electric shock
- soldering iron burns

Control measures to minimise risk from potential hazards:

- safe isolation
 - fume extraction
 - anti-static equipment
-

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

This unit will allow learners to gain electrical understanding which can be developed through the delivery of Unit 215, when assembling circuits. The understanding of components and circuits required of this unit can be developed through contexts provided in Unit 217 when learning about automation. An understanding of the theory related to this unit also supports the learning required in Unit 216 when developing skills of measurement and testing of circuits. There are opportunities to link with Unit 203 by applying maths to calculate resistance and other electrical properties. Using skills learned in Unit 205 would enable learners to interpret schematics.

Masterclass sessions undertaken within industry can show how the theory has been used to develop circuits and applications.

Unit 215 Electronic assembly

GLH: 60

What is this unit about?

Robots, medical instruments, satellites and sustainable building management systems all have electronic circuit boards that need to be assembled to make them function.

The purpose of this unit is for learners to develop the skills needed to assemble and interconnect electronic circuits. They will learn to select the correct components and cabling to interconnect the assemblies.

Learners can be introduced to this unit by asking themselves questions such as:

- How do I terminate different types of cable?
- How do I prevent damage to the electronic components in a circuit?
- How do I build a circuit?

Learning outcomes

In this unit, learners will

- 1 Assemble circuit boards
- 2 Wire circuit assemblies

Scope of content

Learning outcome

1 Assemble circuit boards

Topics

- 1.1 Assemble electronic circuits
- 1.2 Repair electronic circuits
- 1.3 Solder and de-solder circuit boards

Depth

Topic 1.1

Component installation taking account of:

- compliance
- damage
- value
- rating
- package
- orientation
- polarisation
- pin configuration
- mounting
- fixed heatsink
- socketed
- prevention of damage

Types of circuit board:

- prototype
- stripboard
- breadboard
- production
- PCB

Antistatic precautions involved in assembly operations:

- transportation
- component insertion

Topic 1.2

Repair electronic circuits:

- component removal
 - discrete
 - SMT
 - component replacement
 - de-soldering
-

Topic 1.3

Soldering and de-soldering within electronic circuits boards:

- components
- wires
- busbars

Learning outcome

2 Wire circuit assemblies

Topics

- 2.1 Types of cables used for wiring applications
- 2.2 Wiring considerations
- 2.3 Procedures for cable termination
- 2.4 Cable management methods
- 2.5 Complete circuit assemblies

Depth

Topic 2.1

Characteristics of cable types:

- single core
- multicore
- screened
- coaxial
- ribbon

Topic 2.2

Considerations for wiring assemblies:

- routing
 - heat avoidance
 - electrical interference
 - vibration
 - impact
- grouping
- sizing

Topic 2.3

Procedure for cable termination:

- preparation
 - stripping
- connections
 - solder
 - clamp
 - crimp
 - IDC

- conductor identification
 - colour coding
 - labelling
 - sleeving

Topic 2.4

Characteristics of cable management methods:

- cable ties
- lacing
- sleeving
- heatshrink
- channeling

Topic 2.5

Complete circuit assemblies:

- component installation
- cabling
- wiring
- termination

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners developing this understanding. This approach will also support their preparation for the qualification assessments.

This unit will allow learners to gain the skills needed to build and wire electronic circuits. The unit can be delivered with Unit 214, where learners gain understanding of electrical theory and components through practical activities. The delivery can be linked to Unit 217 if circuits were developed requiring programmable devices. The unit works closely with Unit 216 where testing and measurement skills and understanding can be applied to the circuits that have been built and wired. Using skills developed in Unit 205 would enable learners to interpret schematics and circuit assembly diagrams. The delivery of this unit could also be linked with Unit 204 where general workshop practice skills have been developed.

The unit provides opportunities to work with employers by visiting sites where assemblies take place. Employers could also provide feedback to learners on the quality of their assemblies and wiring.

Unit 216 Electronic test equipment

GLH: 30

What is this unit about?

The purpose of this unit is for learners to develop an understanding of the different types of measurement instruments; what they can measure and how to use them to get accurate measurements. Commonly used by test engineers, they will be taking measurements with different types of instrumentation equipment to be confident that the product that they are testing is safe and will perform accurately. All instrumentation equipment must be calibrated in order to get valid measurements. Learners will develop an understanding of the importance of calibration and how to follow a calibration procedure for given equipment. At the end of this unit they will be able to select the correct instrumentation for the measurements required, check if it is calibrated, set it up properly and validate the readings taken.

Learners can be introduced to this unit by asking themselves questions, such as:

- Would you buy a product that has never been tested?
- Why are products tested before they go to market?
- Who carries out the testing of products?

Learning outcomes

In this unit, learners will

- 1 Use electronic test equipment
- 2 Apply test equipment calibration techniques

Scope of content

Learning outcome

- 1 Use electronic test equipment
-

Topics

- 1.1 Characteristics of types of waveform signals
- 1.2 Use test equipment
- 1.3 Measure electrical parameters

Depth

Topic 1.1

Waveform signals:

- types of waveform
 - square wave
 - sawtooth
 - ramp
 - pulse
 - sinewave
 - triangle
- waveform characteristics
 - frequency
 - periodic time
 - peak to peak
 - peak
 - RMS
 - phase shift
 - offset

Topic 1.2

Functions, limitations and safe use of test equipment:

- digital multimeter
- function generator
- oscilloscope
- frequency counter
- logic probe
- computer simulation/virtual instruments

Topic 1.3

Use test equipment to measure electrical parameters:

- circuit/component resistance
 - current
 - voltage
 - AC
 - DC
 - signal amplitude
 - signal frequency
 - logic state
-

Learning outcome

2 Apply test equipment calibration techniques

Topics

2.1 Principles of electronic equipment calibration

2.2 Validate equipment functionality

Depth

Topic 2.1

Calibration principles:

- need for calibration
- accuracy
- precision
- resolution
- linear, non-linear
- recording
- certification

Topic 2.2

Apply procedures to validate electronic test equipment functionality:

- calibration checks
 - reference against known values
 - reference against calibrated equipment
 - validate certification
 - complete documentation
 - zero checks
 - nulling leads
 - zeroing meter displays
 - parallax checks
-

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

The unit can be used with all pathway units: whether learning the theory of how measurement instruments are used in automation (Unit 217) or to apply their use when testing circuits they have built (Unit 215). They will develop their ability to interpret circuit drawings (Unit 205) to identify circuit requirements for testing and apply the measurement skills developed in Unit 204.

Understanding of scientific principles developed in Unit 203 and 214 will also be applied when planning, carrying out and recording measurements. It is expected that learners will be provided with appropriate electronic circuits for measurements to be taken using instrumentation. This could include a variable power supply and a resistive circuit for the Digital Multimeter tests, a low voltage AC to DC power supply for the Oscilloscope tests, an oscillating circuit for the Frequency Counter tests and a digital circuit for the Logic Probe tests. This provides an opportunity to link the unit to Units 203, 214 and 217.

Staff delivering this unit should have access to a wide range of real instrumentation, as well as simulation/virtual instrumentation equipment found in an electronics laboratory. This provides an ideal opportunity for learners to engage with employers who can provide masterclasses on their use.

Unit 217 Automation

GLH: 30

What is this unit about?

The purpose of this unit is for learners to develop an understanding of how and why automation is used in a variety of industrial situations. Learners will develop their understanding of the advantages of automation. Learners will also be introduced to a range of input and output devices used in control system and their purpose. Learners will be able to download control programs to control systems and perform simple testing of them.

Learners can be introduced to this unit by asking themselves questions, such as:

- What is mass production and why is automation suited to certain manufacturing processes?
- Why are robots used to assemble and weld together motor vehicles?

Learning outcomes

In this unit, learners will

- 1 Understand the impact of automation in engineering
- 2 Understand control system elements in automation
- 3 Test control programs

Scope of content

Learning outcome

- 1 Understand the impact of automation in engineering
-

Topics

- 1.1 Impact of automation on employees
- 1.2 Advantages of automation for business

Depth

Topic 1.1

Impacts on employees:

- reduction of repetitive tasks
- environmental effects
- physiological effects
- skills development
- employment opportunities

Topic 1.2

Advantages for business:

- consistency in production quality
- efficiency of production
- consistency in accuracy / tolerances
- new business opportunities
- finance
- increased diversity of applications
 - aerospace
 - automotive
 - chemical
 - electronic
 - food and drink
 - marine

Learning outcome

2 Understand control system elements in automation

Topics

- 2.1 Operating principles of process control systems
- 2.2 Control input devices
- 2.3 Control output devices

Depth

Topic 2.1

Operating principles of process control systems:

- open loop
- closed loop
- microcontroller based

Topic 2.2

Functions and applications of input devices:

- switch
- light sensitive device
- optical sensor
- camera
- thermocouple
- pressure sensor
- proximity sensor
- strain sensor
- safety cut-out

Topic 2.3

Functions and applications of output devices:

- LED
- lamps
- relay
- motor
- visual display unit
- loudspeaker
- buzzer / alarm bell
- heating element
- safety interlock

Learning outcome

3 Test control programs

Topics

- 3.1 Principles of programming methods
- 3.2 Download control programs to devices
- 3.3 Test control programs

Depth

Topic 3.1

Principles of programming methods:

- ladder
- statement lists
- high level languages
 - BASIC
 - C++

Topic 3.2

Download control programs to devices:

- Microcontroller
- EEPROM

Topic 3.3

Test control programs using different methods:

- single block run
- full dry run
- force contacts

Guidance for delivery

Whilst some of the concepts and skills might need to be developed independently of other units, it is the intention that learners will understand connections between units. A holistic or project based approach to delivery would support learners to develop this understanding. This approach will also support their preparation for the qualification assessments.

Teaching should highlight how automation is important in manufacturing and industrial processes, linking closely with Units 214 and 215. Unit 216 covers electronic components so it may prove worthwhile to combine practical activities to avoid duplication of topic material.

Tutors are encouraged to organise guest speakers and/or visit relevant industrial and/or manufacturing establishments to experience examples of automated processes in industry. The focus should be on identifying the constituent parts of an automated process.

Appendix 1 Sources of general information

The following documents contain essential information for centres delivering City & Guilds qualifications. They should be referred to in conjunction with this handbook. To download the documents and to find other useful documents, go to the **Centres and Training Providers homepage** on www.cityandguilds.com.

City & Guilds Centre Manual

This document provides guidance for organisations wishing to become City & Guilds approved centres, as well as information for approved centres delivering City & Guilds qualifications. It covers the centre and qualification approval process as well as providing guidance on delivery, assessment and quality assurance for approved centres.

It also details the City & Guilds requirements for ongoing centre and qualification approval, and provides examples of best practice for centres. Specifically, the document includes sections on:

- the centre and qualification approval process
- assessment, internal quality assurance and examination roles at the centre
- registration and certification of candidates
- non-compliance and malpractice
- complaints and appeals
- equal opportunities
- data protection
- management systems
- maintaining records
- internal quality assurance
- external quality assurance.

Our Quality Assurance Requirements

This document explains the requirements for the delivery, assessment and awarding of our qualifications. All centres working with City & Guilds must adopt and implement these requirements across all of their qualification provision. Specifically, this document:

- specifies the quality assurance and control requirements that apply to all centres
- sets out the basis for securing high standards, for all our qualifications and/or assessments
- details the impact on centres of non-compliance

The **centre homepage** section of the City & Guilds website also contains useful information on

- **Walled Garden**: how to register and certificate candidates on line
- **Events**: dates and information on the latest Centre events
- **Online assessment**: how to register for e-assessments.

Useful contacts

UK learners

General qualification information

E: learnersupport@cityandguilds.com

International learners

General qualification information

E: intcg@cityandguilds.com

Centres

Exam entries, Certificates, Registrations/enrolment, Invoices, Missing or late exam materials, Nominal roll reports, Results

E: centresupport@cityandguilds.com

Single subject qualifications

Exam entries, Results, Certification, Missing or late exam materials, Incorrect exam papers, Forms request (BB, results entry), Exam date and time change

E: singlesubjects@cityandguilds.com

International awards

Results, Entries, Enrolments, Invoices, Missing or late exam materials, Nominal roll reports

E: intops@cityandguilds.com

Walled Garden

Re-issue of password or username, Technical problems, Entries, Results, e-assessment, Navigation, User/menu option, Problems

E: walledgarden@cityandguilds.com

Employer

Employer solutions, Mapping, Accreditation, Development Skills, Consultancy

E: business@cityandguilds.com

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As the UK's leading vocational education organisation, City & Guilds is leading the talent revolution by inspiring people to unlock their potential and develop their skills. We offer over 500 qualifications across 28 industries through 8500 centres worldwide and award around two million certificates every year. City & Guilds is recognised and respected by employers across the world as a sign of quality and exceptional training.

City & Guilds Group

The City & Guilds Group operates from three major hubs: London (servicing Europe, the Caribbean and Americas), Johannesburg (servicing Africa), and Singapore (servicing Asia, Australia and New Zealand). The Group also includes the Institute of Leadership & Management (management and leadership qualifications), City & Guilds Licence to Practice (land-based qualifications), the Centre for Skills Development (CSD works to improve the policy and practice of vocational education and training worldwide) and Learning Assistant (an online e-portfolio).

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