Certificate
Extended Certificate
Diploma

Specification

BTEC FIRST ENGINEERING

From September 2018

BTEC Level 1/Level 2 First Certificate in Engineering
BTEC Level 1/Level 2 First Extended Certificate in Engineering
BTEC Level 1/Level 2 First Diploma in Engineering

Issue 7

Pearson
BTEC Level 1 / Level 2
First Certificate
in Engineering

Pearson
BTEC Level 1 / Level 2
First Extended Certificate
in Engineering

Pearson
BTEC Level 1 / Level 2
First Diploma in
Engineering

Specification

First teaching September 2018

Issue 7

Edexcel, BTEC and LCCI qualifications

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This specification is Issue 7. We will inform centres of any changes to this issue. The latest issue can be found on our website.

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All information in this specification is correct at time of publication.

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Summary of Pearson BTEC Level 1/Level 2 Certificate, Extended Certificate and Diploma in Engineering Issue 7 changes

Summary of changes made between previous issue and this current issue	**Page/section number**
TQT for the Certificate has changed to 320. TQT for the Extended Certificate has changed to 480. TQT for the Diploma has changed to 640.	Page 6

Summary of changes made between Issue 4 and Issue 6	**Page/section number**
The wording in *Section 8 Internal assessment* subsection *Dealing with malpractice* has been updated to clarify suspension of certification in certain circumstances.	Page 45
Section 10 Awarding and reporting the qualifications The wording under *Calculation of qualification change* has been updated.	Pages 50
The wording under *Section 10 Awarding and reporting for the qualifications* subsection *Calculation of the qualification grade* has been updated to clarify current practice in ensuring maintenance and consistency of qualification standards.	Pages 53-54
Unit 2: Investigating an Engineering Product *Assessment guidance* ● 'a witness statement,' updated to 'an observation record,'	Page 74
Unit 3: Health and Safety in Engineering Learning aim A: Understand safe and effective working in an engineering workplace Topic A1: Accident and emergency procedures ● 'to uses.' removed from the content Topic A2: Working safely in an engineering organisation ● 'with' updated to 'with the most current' Learning aim B: Know how to follow procedures and undertake a work activity safely Assessment guidance ● 'explaining their importance, or making suggestions' updated to 'explaining their importance and making suggestions'	Pages 78, 83
Unit 4: Engineering Maintenance Learning aim B: Be able to resource and plan a maintenance activity on an engineering product or system Topic B2: Maintenance planning ● 'Detailed maintenance plan, e.g.:' updated to 'Detailed maintenance plan (in addition to the straightforward maintenance plan), e.g.:' Assessment guidance ● 'accurately' updated to 'appropriately'	Pages 87, 91

Summary of changes made between Issue 4 and Issue 6	**Page/section number**
Unit 5: Engineering Materials Learning aim A: Know about the properties of common engineering materials and selection for engineering applications Topic A1: Types of engineering materials ● ‘Piezoelectricity’ updated to ‘piezoelectric’ Topic A3: Suitability of materials in engineering applications ● ‘(bench shears or tinsnips used to devise test)’ updated to ‘ (using bench shears or tin snips)’	Page 97
Unit 6: Computer-aided Engineering Resources ● ‘CAD drawing’ updated to ‘CAD drawing, where they can, for example, set the offsets/tool changes and feeds/speeds.’ Assessment guidance ● ‘three assignments’ updated to ‘two assignments’ ● ‘carried out and evidenced,’ updated to ‘checked,’ ● ‘grabs’ updated to ‘shots’	Page 108
Unit 7: Machining Techniques Resources ● ‘tools’ updated to ‘equipment’	Page 117
Unit 8: Electronic Circuit Design and Construction Learning aim A: Know about electronic systems design Topic A4: Passive components ● ‘/BS’ removed from EN 60062 Assessment guidance ● ‘or justify’ updated to ‘and explain’ ● ‘state’ updated to describe’ ● ‘1B.2,’ updated to ‘1A.2’ ● ‘will’ updated to ‘could’ ● ‘could be’ updated to ‘could also be’ ● ‘authenticated discussion of hazards,’ updated to ‘a report’ ● ‘questioning’ updated to ‘learner observation records’ Suggested assignment outlines ● In criteria covered ‘2D.D4’ updated to ‘2D.D4, 1D.7, 2D.P7’	Pages 120, 126, 127, 129
Unit 28: Fabrication Techniques All dates removed from legislation.	Pages 326, 327 and 329

If you need further information on these changes or what they mean, please contact us via our website at: qualifications.pearson.com.

Welcome to your BTEC First specification

For more than 25 years, BTECs have earned their reputation as well-established, enduringly effective qualifications. They have a proven track record in improving motivation and achievement among young learners. Additionally, BTECs provide progression routes to the next stage of education or to employment.

What are the key principles of the BTEC Firsts?

To support young people to succeed and progress in their education, we have drawn on our consultation and embedded four key design principles into the BTEC Firsts.

1 Standards: a common core and external assessment

Each Level 2 BTEC First qualification has an essential core of knowledge and applied skills. We have introduced external assessment appropriate to the sector. This provides independent evidence of learning and progression alongside the predominantly portfolio-based assessment.

2 Quality: a robust quality-assurance model

Building on strong foundations, we have further developed our quality-assurance model to ensure robust support for learners, centres and assessors.

We will make sure that:

- every BTEC learner's work is independently scrutinised through the external assessment process
- every BTEC assessor will take part in a sampling and quality review during the teaching cycle
- we visit each BTEC centre every year to review and support your quality processes.

We believe this combination of rigour, dialogue and support will underpin the validity of the teacher-led assessment and the learner-centric approach that lie at the heart of BTEC learning.

3 Breadth and progression: a range of options building on the mandatory units, contextualised English and mathematics

The **mandatory units** assess knowledge, understanding and skills that are essential to the curriculum area or vocational industry. These mandatory units ensure that all learners receive a thorough grounding in the sector to support progression to their next stage in education or employment.

The **optional specialist units** provide a closer focus on a vocational area, supporting progression to a more specialised Level 3 vocational or academic course or to an Apprenticeship.

Opportunities to develop skills in English and mathematics are indicated in the units where appropriate. These give learners the opportunity to practise these essential skills in naturally occurring and meaningful contexts, where appropriate to the sector.

4 Recognising achievement: opportunity to achieve at Level 1

The BTEC Firsts will continue to provide for the needs of learners who are aiming to achieve a Level 2 qualification. However, we have recognised that for some learners achieving this standard in all units in one to two years may not be possible. Therefore, the qualifications have been designed as Level 1/Level 2 qualifications with grades available at Level 2 and at Level 1 Pass.

Improved specification and support

In our consultation, we also asked about what kind of guidance you, as teachers and tutors, need. As a result, we have streamlined the specification to make the units easier to navigate, and we provide enhanced support in the accompanying *Delivery Guide*.

Thank you

Finally, we would like to extend our thanks to everyone who provided support and feedback during the development of the new BTEC Firsts, particularly all of you who helped to shape these new qualifications. We hope you enjoy teaching the course.

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Purpose of this specification

The purpose of this specification, as defined by Ofqual, is to set out:

- the objectives of each qualification in the suite
- any other qualification that a learner must complete before taking a qualification
- any prior knowledge, skills or understanding that the learner is required to have before taking the qualifications
- units that a learner must complete before a qualification can be awarded, and any optional routes
- any other requirements that a learner must have satisfied before they can be assessed, or before a qualification can be awarded
- the knowledge, skills and understanding that will be assessed as part of the qualifications (giving a clear indication of their coverage and depth)
- the method of any assessment and any associated requirements relating to it
- the criteria against which learners' level of attainment will be measured (such as assessment criteria)
- any specimen materials (supplied separately)
- any specified levels of attainment.

Qualification titles and Qualification Numbers

Qualification title	**Pearson BTEC Level 1/Level 2 First Certificate in Engineering**
Qualification Number (QN)	**600/6628/3**

Qualification title	**Pearson BTEC Level 1/Level 2 First Extended Certificate in Engineering**
Qualification Number (QN)	**600/6630/1**

Qualification title	**Pearson BTEC Level 1/Level 2 First Diploma in Engineering**
Qualification Number (QN)	**601/0545/8**

These qualifications are on the Regulated Qualifications Framework (RQF).

Your centre should use the Qualification Number (QN) when seeking funding for your learners.

The qualification title, units and QN will appear on each learner's final certificate. You should tell your learners this when your centre recruits them and registers them with us. Further information on certification is in our *UK Information Manual*, available on our website: qualifications.pearson.com

1 What are BTEC Firsts?

BTEC First qualifications were originally designed for use in colleges, schools and the workplace as an introductory Level 2 course for learners wanting to study in the context of a vocational sector. This is still relevant today. The knowledge, understanding and skills learned in studying a BTEC First will aid progression to further study and prepare learners to enter the workplace in due course. In the Engineering sector, typical employment opportunities may include working as a mechanical engineer or technician.

These qualifications are intended primarily for learners in the 14–19 age group, but they may also be used by other learners who wish to gain an introductory understanding of a vocational area. When taken as part of a balanced curriculum, there is a clear progression route to a Level 3 course or an Apprenticeship.

BTECs are vocationally-related qualifications, where learners develop knowledge and understanding by applying their learning and skills in a work-related context. Additionally, they are popular and effective because they engage learners to take responsibility for their own learning and to develop skills that are essential for the modern-day workplace. These skills include: teamworking; working from a prescribed brief; working to deadlines; presenting information effectively; and accurately completing administrative tasks and processes. BTEC Firsts motivate learners and open doors to progression to further study and responsibility in the workplace.

The BTEC First suite of qualifications

The following qualifications are part of the BTEC First suite:

- Application of Science
- Applied Science
- Art and Design
- Business
- Children's Play, Learning and Development
- Construction and the Built Environment
- Creative Digital Media Production
- Engineering
- Health and Social Care
- Hospitality
- Information and Creative Technology
- Music
- Performing Arts
- Principles of Applied Science
- Public Services
- Sport
- Travel and Tourism.

Visit qualifications.pearson.com for information about these qualifications.

Objectives of the BTEC First suite

The BTEC First suite will:

- enable you, as teachers, tutors and training providers, to offer a high-quality vocational and applied curriculum that is broad and engaging for all learners
- help you to secure a balanced curriculum overall, so that learners in the 14–19 age group have the opportunity to apply their knowledge, skills and understanding in the context of future development
- provide learners with opportunities to link education and the world of work in engaging, relevant and practical ways
- enable learners to enhance their English and mathematical competence in relevant, applied scenarios
- support learners' development of transferable interpersonal skills, including working with others, problem solving, independent study, and personal, learning and thinking skills
- provide learners with a route through education that has clear progression pathways to further study or an Apprenticeship.

Breadth and progression

These qualifications have a core of underpinning knowledge, skills and understanding, and a range of options to reflect the breadth of pathways within a sector. This gives learners the opportunity to:

- gain a broad understanding and knowledge of a vocational sector
- investigate areas of specific interest
- develop essential skills and attributes prized by employers, further education colleges and higher education institutions.

This suite of qualifications provides opportunities for learners to progress to either academic or more specialised vocational pathways.

Progression from Level 1

These qualifications have been designed to provide progression from the following qualifications, which contain sector-relevant content at Level 1:

- Pearson BTEC Level 1 Certificate in Engineering
- Pearson BTEC Level 1 Diploma in Engineering.

These qualifications are also designed to provide progression from the following qualifications:

- Pearson BTEC Level 1 Certificate in Vocational Studies
- Pearson BTEC Level 1 Diploma in Vocational Studies.

See our website for further details.

2 Key features of the BTEC First suite of qualifications

The BTEC Level 1/Level 2 First qualifications:

- have a range of sizes in the suite
- are Level 2 qualifications; learners who do not achieve at Level 2 may achieve a grade of Level 1 Pass
- have smaller sizes in the suite primarily aimed at learners aged 14 years and over, while the Extended Certificate and Diploma have been designed for those aged 16 years and over
- are available on the Regulated Qualifications Framework (RQF)
- present knowledge in a work-related context
- give learners the opportunity to develop and apply skills in English and mathematics in naturally occurring, work-related contexts
- provide opportunities for synoptic assessment through applying skills, knowledge and understanding gained to realistic or work-related tasks, such as projects and work experience, and to deepen learning through more specialist units.

The Pearson BTEC Level 1/Level 2 First **Award**:

- has mandatory and optional specialist units
- has 25 per cent of the qualification that is externally assessed. Pearson sets and marks these assessments
- is graded from Level 2 P to Level 2 D*. Learners who do not achieve at Level 2 may achieve a grade of Level 1 Pass. Learners whose level of achievement is below Level 1 will receive an Unclassified (U) result.

The Pearson BTEC Level 1/Level 2 First **Certificate**:

- has mandatory and optional specialist units
- has 25 per cent of the qualification that is externally assessed; Pearson sets and marks these assessments
- is graded from Level 2 PP to Level 2 D*D*. Learners who do not achieve at Level 2 may achieve a grade of Level 1 Pass. Learners whose level of achievement is below Level 1 will receive an Unclassified (U) result.

The Pearson BTEC Level 1/Level 2 First **Extended Certificate**:

- has mandatory and optional specialist units
- has 16.67 per cent of the qualification that is externally assessed; Pearson sets and marks these assessments
- is graded from Level 2 PP to Level 2 D*D*. Learners who do not achieve at Level 2 may achieve a grade of Level 1 Pass. Learners whose level of achievement is below Level 1 will receive an Unclassified (U) result.

The Pearson BTEC Level 1/Level 2 First **Diploma**:

- has mandatory and optional specialist units
- has 12.5 per cent of the qualification that is externally assessed; Pearson sets and marks these assessments
- is graded from Level 2 PP to Level 2 D*D*. Learners who do not achieve at Level 2 may achieve a grade of Level 1 Pass. Learners whose level of achievement is below Level 1 will receive an Unclassified (U) result.

Total qualification time (TQT)

For all regulated qualifications, Pearson specifies a total number of hours that it is expected learners will be required to undertake in order to complete and show achievement for the qualification: this is the Total Qualification Time (TQT). The TQT value indicates the size of a qualification.

Within this, Pearson will also identify the number of Guided Learning Hours (GLH) that we expect a centre delivering the qualification will need to provide. Guided learning means activities that directly or immediately involve tutors and assessors in teaching, supervising, and invigilating learners, such as lessons, tutorials, online instruction and supervised study.

In addition to guided learning, other required learning directed by tutors or assessors will include private study, preparation for assessment and undertaking assessment when not under supervision, such as preparatory reading, revision and independent research.

Qualifications can also have a credit value, which is equal to one tenth of TQT, rounded to the nearest whole number.

Qualification sizes for BTEC Firsts in the Engineering sector

This suite of BTEC Level 1/Level 2 Firsts for the Engineering sector is available in the following sizes:

	GLH	TQT
First Award	120	160
First Certificate	240	320
First Extended Certificate	360	480
First Diploma	480	640

Types of units in the qualifications

The BTEC First qualifications have mandatory units and optional specialist units. See *Section 4 Qualification structures* for more detailed information. For these qualifications, learners will need to complete all the mandatory units and, where appropriate, a selection of optional specialist units. This is to ensure that all learners have broad and balanced coverage of the vocational sector.

Mandatory units

Mandatory units are designed to cover the body of content that employers and educators within the sector consider essential for 14–19-year-old learners. These units support the remainder of the learning needed for these qualifications. There will be both internal- and external assessment.

Optional specialist units

The remaining units in these qualifications are sector-specific, optional specialist units. These units focus on a particular area within the vocational sector and give learners an opportunity to demonstrate knowledge, skills and understanding.

Pearson BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma in Engineering

3 Pearson BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma in Engineering

Rationale for the Pearson BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma in Engineering

Aims

The aims of all qualifications in the BTEC First suite in Engineering are to:

- inspire and enthuse learners to consider a career in the Engineering sector
- give learners the opportunity to gain broad knowledge and understanding of, and develop skills in, the Engineering sector
- support progression to specialised Level 3 qualifications in Engineering, or to an Apprenticeship
- give learners the potential opportunity, in due course, to enter employment in a wide range of job roles.

Specific aims of the **BTEC First Certificate** in Engineering are to:

- add breadth to learners' knowledge and understanding of the Engineering sector as part of their career progression and development plans
- support learners who have had some achievement in their Key Stage 4 programme and who wish to 'top up' their Level 2 achievement to progress to employment or other qualifications.

Specific aims of the **BTEC First Extended Certificate** in Engineering are to:

- build on learner achievement and interest developed through related Level 1 or Level 2 qualifications in Engineering, including the Pearson BTEC Level 1/Level 2 First Award and Certificate in Engineering
- allow learners to specialise or to deepen their understanding through the provision of a broad range of optional specialist units
- provide a comprehensive and challenging programme of study related to Engineering that is particularly suited to post-16 learners who have the relevant interest and aptitude to progress in the sector
- give learners the potential opportunity to progress to employment or to employment in a wide range of job roles across the Engineering sector, for example posts in particular areas of engineering such as those involved with the application of technology, including electronics industries, maintenance, manufacturing or mechanical environments.

Specific aims of the **BTEC First Diploma** in Engineering are to:

- allow learners to further specialise by including units that require 60 Guided Learning Hours of study
- give learners opportunities to develop transferable skills related to study and vocational application that provide a platform for success both within Engineering and elsewhere.

The provision for study in the BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma

BTEC First Certificate

This qualification includes four **mandatory units** that form the fundamental knowledge and understanding of engineering principles, and which appear in all four sizes of the qualification. The Certificate includes a choice from **optional specialist units**, thereby providing an opportunity to develop a broader understanding of the Engineering sector. In addition, it introduces a limited number of specialist areas and the opportunity to acquire some of the practical skills identified by employers as the fundamental building blocks for future competence in the workplace. All the units can be viewed in the *Summary of units in the BTEC Level 1/Level 2 First in Engineering* in *Annexe D*.

In addition to the units in the Certificate, the Extended Certificate includes further units with a greater level of depth and specialism, so allowing learners to follow areas of specific interest or to link units to give greater depth of vocational understanding.

In the **First Certificate** and **Extended Certificate** in Engineering, the mandatory units include:

- *Unit 1: The Engineered World* – this unit provides an introduction to the underpinning knowledge and understanding in the world of engineering. It covers engineering processes, developments in engineering materials and technologies and how engineering contributes to a sustainable future. This unit is externally assessed.
- *Unit 3: Health and Safety in Engineering* – this unit looks at safe and effective procedures for working in an engineering workplace and the procedures to undertake a work activity safely. This unit is internally assessed.
- *Unit 5: Engineering Materials* – this unit covers areas such as a range of common materials encountered in engineering, as well as their properties, uses, availability, and how they contribute to a sustainable environment. This unit is internally assessed.
- *Unit 2: Investigating an Engineered Product*, which looks at how a designer's ideas get transformed into a finished article that's fit for purpose. Learners will investigate the form of the product, the function it must fulfil, its performance characteristics and what materials will be most effective in its manufacture. This synoptic unit requires learners to bring together their knowledge, skills and understanding gained from other units of study. Learners will then plan, carry out and reflect on their project, using and developing key skills such as independent investigation and research skills and techniques, data collection, data processing and analysis, valued by employers and supporting progression to Level 3 qualifications. This unit is internally assessed.
- *Unit 9: Interpreting and Using Engineering Information*. This unit is externally assessed, because a good knowledge of engineering information is deemed essential for progression in the engineering sector.
- *Unit 10: Mathematics for Engineering*. This unit is internally assessed. Mathematics is deemed as essential knowledge, it focuses on arithmetic, algebraic and graphical methods, mensuration and trigonometry in engineering contexts.
- *Unit 11: Electrical and Mechanical Science for Engineering*, which looks at the concepts and principles relating to electrical and mechanical science.
- *Unit 12: Engineering Design*, which looks at factors that influence the design of a new product and developing a product design specification (PDS) from a customer brief.

- *Unit 13: Engineering Assembly*, which focuses on components being assembled, their functions and expected operating parameters.
- *Unit 14: Vehicle Engines and Other Systems*, which looks at the fundamental operating principles of internal combustion engines.

These units build on from our Award qualification and cover the broad engineering disciplines. See *Annexe E* for the structure of the Pearson BTEC Level 1/Level 2 First Award in Engineering qualification.

Note: The Pearson BTEC Level 1/Level 2 First Certificate in Engineering can be taken as a stand-alone qualification or can be 'topped up' from the Pearson BTEC Level 1/Level 2 First Award in Engineering qualification with additional units to make up the requisite number of guided learning hours and to fulfil the rules of combination, see Section 4, Qualification Structure. See Annexe E for the structure of the Pearson BTEC Level 1/Level 2 First Award in Engineering qualification.

BTEC First Diploma

In the Diploma, there are additional **mandatory units** that help learners develop the ability to draw together and apply learning in vocational applications.

In the Diploma in Engineering, the additional units include:

- *Unit 3: Health and Safety in Engineering* – this unit looks at safe and effective procedures for working in an engineering workplace and the procedures to undertake a work activity safely. This unit is internally assessed.
- *Unit 5: Engineering Materials* – this unit covers areas such as a range of common materials encountered in engineering, as well as their properties, uses, availability, and how they contribute to a sustainable environment. This unit is internally assessed.
- *Unit 21: Introduction to Communications for Engineering* – this unit looks at the use verbal and written communication methods in engineering contexts, the use of engineering information and the use of information and communication technology (ICT) to present information in engineering contexts. This unit is **internally assessed**.

Optional specialist units

The optional specialist units offer centres flexibility to tailor the programme to the local area and give learners the opportunity to pursue more specialist interests. These units may be selected to:

- extend knowledge and understanding developed in mandatory units:
  - for example, by being able to plan engineering activities or analyse engineering information, or by communicating effectively and using information and engineering documentation.
- deepen and enhance practical application of vocational skills:
  - for example, by applying the problem-solving techniques applicable to engineering, and by using more specialist skills such as fabrication techniques which extend the knowledge of engineering materials.
- provide synopticity:
  - for example, by undertaking engineering design, learners will gain direct experience of the engineering industry in action, giving them the opportunity to apply the learning they have gleaned from other units and to develop knowledge, skills and understanding further within engineering environments.

- develop general work-related skills:
  - for example, by gaining knowledge of health and safety procedures in engineering workplaces, and considering features of material use, maintenance and quality requirements that are important in all applications of engineering in product or processes.

The optional specialist units include.

- *Unit 11: Electrical and Mechanical Science for Engineering*, which looks at the concepts and principles relating to electrical and mechanical science.
- *Unit 12: Engineering Design*, which looks at factors that influence the design of a new product and developing a product design specification (PDS) from a customer brief.
- *Unit 13: Engineering Assembly*, which focuses on components being assembled, their functions and expected operating parameters.
- *Unit 14: Vehicle Engines and Other Systems*, which looks at the fundamental operating principles of internal combustion engines.
- *Unit 15: Operating an Efficient Workplace*, which looks at techniques and the use of workplace organisation methods.
- *Unit 16: Vehicle Electrical Systems*, which looks at performance of vehicle electrical systems and components.
- *Unit 17: Welding*, which looks at the different types of welding processes used in the engineering industry.
- *Unit 18: Computer Numerical Control Programming*, which looks at the types of CNC machines and their uses.
- *Unit 19: Bicycle Servicing and Maintenance*, which looks at servicing and maintenance procedures.
- *Unit 20: Sustainable Vehicle Power and Structure Design*, which looks at servicing and maintenance procedures.
- *Unit 31: Production Planning for Engineering* – aims to give learners a broad knowledge and experience of production planning. Within engineering this process is often very complex, whether because of the number of parts involved, the rate of change of a process or the occurrence of unplanned events. Effective production planning is essential in ensuring that activities and resources are coordinated over time to achieve targets or goals with as little resource consumption as possible, without compromising on product quality.

Endorsed titles

There are no pathways in the Pearson BTEC Level 1/Level 2 First Certificate and Extended Certificate.

The Pearson BTEC Level 1/Level 2 First Diploma in Engineering has pathways that lead to the following endorsed titles:

- Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Technology)
- Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Maintenance)
- Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Manufacturing)
- Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Mechanical).

These pathways cater for learners who are following a selection of units linked to a more specialist focus within the sector. These pathways have been developed in order to allow learners to follow a more specialist route within technology, maintenance, manufacturing and mechanical. These pathways will be of interest to those thinking about potential progression into roles as follows:

- the technology pathway will be of interest to those wishing to progress to roles working within engineering or manufacturing where there is the use of computer and electronic systems
- the maintenance pathway will be of interest to those wishing to progress to roles working within engineering, manufacturing or servicing industries where maintenance activities are being carried out
- the manufacturing pathway will be of interest to those wishing to progress to roles working within engineering or manufacturing industries where efficiency in making engineered products is important
- the mechanical pathway will be of interest to those wishing to progress to roles working within engineering industries where knowledge of mechanical applications in manufacturing is important.

Assessment approach

The Pearson BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma in Engineering include two externally-assessed units. This will help learners as they progress either into higher levels of vocational learning or to related academic qualifications.

The remaining units are internally assessed. Internal assessment allows learners to develop a wider range of skills and provides evidence towards meeting the unit assessment criteria. Evidence for assessment can be generated through a range of activities, including role play, practical performance and verbal presentations.

Delivery strategies should reflect the nature of work in the Engineering sector by encouraging learners to research and carry out assessment in the workplace, or in simulated working conditions, wherever possible. It will be beneficial to learners to use local examples, wherever possible, and for your centre to engage with local employers for support and input. This allows a more realistic and motivating basis for learning and can start to ensure that learning serves the needs of local areas.

Learners should be encouraged to take responsibility for their own learning and achievement, taking account of the industry standards for behaviour and performance.

Progression opportunities

The BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma in Engineering provide the knowledge, skills and understanding for Level 2 learners to progress to:

- other Level 2 vocational qualifications and related competence-based qualifications for the Engineering sector
- Level 3 vocational qualifications, such as BTEC Nationals, specifically the Pearson BTEC Level 3 National in Engineering.

English and mathematics

English and mathematics are essential for progression to further education and employment.

The BTEC First Certificate, Extended Certificate and Diploma in Engineering support the development of Level 2 English and mathematics knowledge and skills. Opportunities to develop skills are indicated within unit assessment criteria grids. These will give learners the opportunity to enhance and reinforce skills related to these areas in naturally occurring relevant contexts.

Developing employability skills

One of the main purposes of BTEC qualifications is to help learners to progress, ultimately, to employment. Employers require learners to have certain technical skills, knowledge and understanding, but they also require employees to demonstrate employability skills. These skills enable learners to adapt to the roles needed to survive in the global economy and enhance their effectiveness in the workplace.

Employability skills include: self-management, teamworking, business and customer awareness, problem solving, communication, basic literacy and numeracy, a positive attitude to work, and the use of IT.

The Pearson BTEC Level 1/Level 2 First Diploma in Engineering includes a mandatory unit that requires learners to apply safe practices and work efficiently and effectively and in a safe manner. This unit is *Unit 3: Health and Safety in Engineering*. This synoptic unit requires learners to bring together the knowledge, skills and understanding they have gained from other units of study and choose an Engineering application of interest to them. Learners will then plan, carry out and reflect on their application, using and developing key skills such as independent investigation and research skills and techniques, data collection and processing and analysis, that are valued by employers and supporting progression to level 3 qualifications.

Throughout the **BTEC First suite** in Engineering, learners should develop a range of employability skills, engage with employers and carry out work-related activities. These opportunities are signposted in the *Suggested assignment* outlines at the end of each unit.

Within the BTEC First Diploma in Engineering, the mandatory synoptic unit requires learners to bring together the knowledge, skills and understanding they have gained from other units of study and choose a subject-related project topic of interest to them. Learners will then plan, carry out and reflect on their project using and developing key skills, such as independent investigative research, data processing and analysis, which are valued by employers and support progression to Level 3 qualifications.

For example, learners can develop:

- project-/self-management and independent-learning skills, through units such as *Unit 2: Investigating an Engineered Product*
- communication skills, through units such as *Unit 21: Introduction to Communications for Engineering*
- business awareness and customer awareness skills, through units such as *Unit 22: Continuous Improvement and Problem-Solving*.

Stakeholder support

These qualifications reflect the needs of employers, further and higher education representatives and professional organisations. Key stakeholders were consulted during the development of these qualifications.

4 Qualification structures

The BTEC First suite of qualifications includes the:

- Award – 120 GLH
- Certificate – 240 GLH
- Extended Certificate – 360 GLH
- Diploma – 480 GLH.

Some units for the BTEC First suite appear only in certain qualification sizes. The *Summary of units* table (see *Annexe D*) lists each unit in the suite and how it is used in the individual qualifications.

The qualification structures show the permitted combinations for the qualifications.

If a learner has already achieved a BTEC Level 1/Level 2 First Award in the same sector, they may carry forward their unit results for use in the larger qualifications. It is the responsibility of the centre to ensure that the required number of guided learning hours and correct unit combination are adhered to.

The qualification structures for the Certificate, Extended Certificate and Diploma are listed on the following pages.

Qualification structure for the Pearson BTEC Level 1/Level 2 First Certificate in Engineering

This qualification is taught over 240 guided learning hours (GLH). It has mandatory and optional specialist units.

Learners must complete the four mandatory units, and a choice of optional specialist units to reach a total of 240 GLH.

If a learner has already achieved a BTEC Level 1/Level 2 First Award qualification, they may carry forward their unit results for use in larger BTEC Level 1/Level 2 First qualifications within the same sector.

The units available in the BTEC Level 1/Level 2 First Award in Engineering qualification are Units 1 to 8. Please see *Annexe E* for the structure of the BTEC Level 1/Level 2 First Award in Engineering qualification.

This BTEC First Certificate has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Certificate in Engineering			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
	Optional specialist units		
3	Health and Safety in Engineering	Internal	30
4	Engineering Maintenance	Internal	30
5	Engineering Materials	Internal	30
6	Computer-aided Engineering	Internal	30
7	Machining Techniques	Internal	60
8	Electronic Circuit Design and Construction	Internal	60
11	Electrical and Mechanical Science for Engineering	Internal	30
12	Engineering Design	Internal	60
13	Engineering Assembly	Internal	30
14	Vehicle Engines and Other Systems	Internal	30

Qualification structure of the Pearson BTEC Level 1/Level 2 First Extended Certificate in Engineering

This qualification is taught over 360 guided learning hours (GLH). It has mandatory and optional specialist units.

Learners must complete the four mandatory units, and a choice of optional specialist units to reach a total of 360 GLH.

If a learner has already achieved a smaller BTEC First qualification in this sector, they do not have to repeat those units but may carry them forward to use in this qualification.

This BTEC First Extended Certificate has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Extended Certificate in Engineering			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
	Optional specialist units		
3	Health and Safety in Engineering	Internal	30
4	Engineering Maintenance	Internal	30
5	Engineering Materials	Internal	30
6	Computer-aided Engineering	Internal	30
7	Machining Techniques	Internal	60
8	Electronic Circuit Design and Construction	Internal	60
11	Electrical and Mechanical Science for Engineering	Internal	30
12	Engineering Design	Internal	60
13	Engineering Assembly	Internal	30
14	Vehicle Engines and Other Systems	Internal	30
15	Operating an Efficient Workplace	Internal	60
16	Vehicle Electrical Systems	Internal	30
17	Welding	Internal	60
18	Computer Numerical Control Programming	Internal	60
19	Bicycle Servicing and Maintenance	Internal	30
20	Sustainable Vehicle Power and Structure Design	Internal	60

Qualification structure of the Pearson BTEC Level 1/Level 2 First Diploma in Engineering

Learners will take a total of 11–14 units to complete this qualification. The number of units taken is dependent on the size of optional units selected, and the combination of all units should total 480 guided learning hours (GLH).

These units will include:

- seven mandatory units (totalling 240 GLH)
- four–six optional specialist units (totalling 240 GLH), of which at least two must be chosen from Group A.

If a learner has already achieved a smaller BTEC First qualification in this sector, they do not have to repeat those units but may carry them forward to use in this qualification.

This BTEC First Diploma has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Diploma in Engineering			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
3	Health and Safety in Engineering	Internal	30
5	Engineering Materials	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
21	Introduction to Communications for Engineering	Internal	60
	Optional specialist units **Group A (minimum two units from this group)**		
7	Machining Techniques	Internal	60
8	Electronic Circuit Design and Construction	Internal	60
12	Engineering Design	Internal	60
15	Operating an Efficient Workplace	Internal	60
18	Computer Numerical Control Programming	Internal	60
	Optional specialist units **Group B**		
4	Engineering Maintenance	Internal	30
6	Computer-aided Engineering	Internal	30
11	Electrical and Mechanical Science for Engineering	Internal	30
13	Engineering Assembly	Internal	30

	Optional specialist units Group B *(continued)*		
14	Vehicle Engines and Other Systems	Internal	30
16	Vehicle Electrical Sytems	Internal	30
17	Welding	Internal	60
19	Bicycle Servicing and Maintenance	Internal	30
20	Sustainable Vehicle Power and Structure Design	Internal	60
22	Continuous Improvement and Problem-Solving	Internal	60
23	Electronic Devices and Communication Applications	Internal	60
24	Operation and Maintenance of Mechanical Systems and Components	Internal	60
25	Operation and Maintenance of Electronic Systems and Components	Internal	60
26	Operation and Maintenance of Electrical Systems and Components	Internal	60
27	Operation and Maintenance of Fluid Power Systems and Components	Internal	60
28	Fabrication Techniques	Internal	60
29	Casting Techniques	Internal	60
30	Vehicle Maintenance Techniques	Internal	60
31	Production Planning for Engineering	Internal	30
32	Engineering Marking Out	Internal	30
33	Preparing and Controlling Engineering Manufacturing Operations	Internal	30
34	PC Software and Hardware in Engineering	Internal	60
35	Application of Quality Control and Measurement in Engineering	Internal	60

Qualification structure of the Pearson BTEC Level 1 / Level 2 First Diploma in Engineering (Technology Pathway)

Learners will take a total of 12–13 units to complete this qualification. The number of units taken is dependent on the size of optional units selected, and the combination of all units should total 480 guided learning hours (GLH).

These units will include:

- seven mandatory units (totalling 240 GLH)
- four–five optional specialist units (totalling 240 GLH), of which at least one must be chosen from Group A.

If a learner has already achieved a smaller BTEC First qualification in this sector, they do not have to repeat those units but may carry them forward to use in this qualification.

This BTEC First Diploma has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1 / Level 2 First Diploma in Engineering (Technology Pathway)			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
3	Health and Safety in Engineering	Internal	30
5	Engineering Materials	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
21	Introduction to Communications for Engineering	Internal	60
	Optional specialist units **Group A (minimum one unit from this group)**		
23	Electronic Devices and Communication Applications	Internal	60
34	PC Software and Hardware in Engineering	Internal	60
	Optional specialist units **Group B (minimum two units from this group)**		
4	Engineering Maintenance	Internal	30
6	Computer-aided Engineering	Internal	30
8	Electronic Circuit Design and Construction	Internal	60
11	Electrical and Mechanical Science for Engineering	Internal	30
12	Engineering Design	Internal	60
18	Computer Numerical Control Programming	Internal	60
20	Sustainable Vehicle Power and Structure Design	Internal	60

Qualification structure of the Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Maintenance Pathway)

Learners will take a total of 12–13 units to complete this qualification. The number of units taken is dependent on the size of optional units selected, and the combination of all units should total 480 guided learning hours (GLH).

These units will include:

- eight mandatory units (totalling 270 GLH)
- four–five optional specialist units (totalling 210 GLH), of which at least one must be chosen from Group A.

If a learner has already achieved a smaller BTEC First qualification in this sector, they do not have to repeat those units but may carry them forward to use in this qualification.

This BTEC First Diploma has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Maintenance Pathway)			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
3	Health and Safety in Engineering	Internal	30
4	Engineering Maintenance	Internal	30
5	Engineering Materials	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
21	Introduction to Communications for Engineering	Internal	60
	Optional specialist units **Group A (minimum one unit from this group)**		
24	Operation and Maintenance of Mechanical Systems and Components	Internal	60
25	Operation and Maintenance of Electronic Systems and Components	Internal	60
26	Operation and Maintenance of Electrical Systems and Components	Internal	60
27	Operation and Maintenance of Fluid Power Systems and Components	Internal	60
	Optional specialist unit **Group C**		
8	Electronic Circuit Design and Construction	Internal	60
11	Electrical and Mechanical Science for Engineering	Internal	30

	Optional specialist unit **Group C** *(continued)*		
13	Engineering Assembly	Internal	30
14	Vehicle Engines and Other Systems	Internal	30
19	Bicycle Servicing and Maintenance	Internal	30
23	Electronic Devices and Communication Applications	Internal	60
30	Vehicle Maintenance Techniques	Internal	60

Qualification structure of the Pearson BTEC Level 1 / Level 2 First Diploma in Engineering (Manufacturing Pathway)

Learners will take a total of 11–12 units to complete this qualification. The number of units taken is dependent on the size of optional units selected, and the combination of all units should total 480 guided learning hours (GLH).

These units will include:

- seven mandatory units (totalling 240 GLH)
- four–five optional specialist units (totalling 240 GLH), of which at least one must be chosen from Group A.

If a learner has already achieved a smaller BTEC First qualification in this sector, they do not have to repeat those units but may carry them forward to use in this qualification.

This BTEC First Diploma has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1 / Level 2 First Diploma in Engineering (Manufacturing Pathway)			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
3	Health and Safety in Engineering	Internal	30
5	Engineering Materials	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
21	Introduction to Communications for Engineering	Internal	60
	Optional specialist units **Group A (minimum one unit from this group)**		
15	Operating an Efficient Workplace	Internal	60
22	Continuous Improvement and Problem-Solving	Internal	60
23	Electronic Devices and Communication Applications	Internal	60
	Optional specialist units **Group B (minimum one unit from this group)**		
4	Engineering Maintenance	Internal	30
6	Computer-aided Engineering	Internal	30
7	Machining Techniques	Internal	60
11	Electrical and Mechanical Science for Engineering	Internal	30
12	Engineering Design	Internal	60
13	Engineering Assembly	Internal	30

	Optional specialist units **Group B (minimum one unit from this group)** *(continued)*		
17	Welding	Internal	60
18	Computer Numerical Control Programming	Internal	60
28	Fabrication Techniques	Internal	60
29	Casting Techniques	Internal	60
31	Production Planning for Engineering	Internal	30
35	Application of Quality Control and Measurement in Engineering	Internal	60

Qualification structure of the Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Mechanical Pathway)

Learners will take a total of 11–13 units to complete this qualification. The number of units taken is dependent on the size of optional units selected, and the combination of all units should total 480 guided learning hours (GLH).

These units will include:

- seven mandatory units (totalling 240 GLH)
- four–six optional specialist units (totalling 240 GLH), of which at least one must be chosen from Group A.

If a learner has already achieved a smaller BTEC First qualification in this sector, they do not have to repeat those units but may carry them forward to use in this qualification.

This BTEC First Diploma has units that your centre assesses (internal) and units that Pearson sets and marks (external).

Pearson BTEC Level 1/Level 2 First Diploma in Engineering (Mechanical Pathway)			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
3	Health and Safety in Engineering	Internal	30
5	Engineering Materials	Internal	30
9	Interpreting and Using Engineering Information	External	30
10	Mathematics for Engineering	Internal	30
21	Introduction to Communications for Engineering	Internal	60
	Optional specialist units **Group A (minimum one units from this group)**		
7	Machining Techniques	Internal	60
28	Fabrication Techniques	Internal	60
29	Casting Techniques	Internal	60
	Optional specialist units **Group B (minimum one unit from this group)**		
4	Engineering Maintenance	Internal	30
6	Computer-aided Engineering	Internal	30
11	Electrical and Mechanical Science for Engineering	Internal	30
12	Engineering Design	Internal	60
13	Engineering Assembly	Internal	30
14	Vehicle Engines and Other Systems	Internal	30

	Optional specialist units **Group B (minimum one unit from this group)** *(continued)*		
17	Welding	Internal	60
18	Computer Numerical Control Programming	Internal	60
31	Production Planning for Engineering	Internal	30
32	Engineering Marking Out	Internal	30
35	Application of Quality Control and Measurement in Engineering	Internal	60

5 Programme delivery

Pearson does not define the mode of study for BTEC qualifications. Your centre is free to offer the qualifications using any mode of delivery (such as full time, part time, evening only or distance learning) that meets your learners' needs. As such, those already employed in the Engineering sector could study this qualification on a part-time basis, using industry knowledge and expertise gained from the workplace to develop evidence towards meeting the unit assessment criteria.

Whichever mode of delivery is used, your centre must ensure that learners have appropriate access to the resources identified in the specification and to the subject specialists who are delivering the units. This is particularly important for learners studying for the qualifications through open or distance learning.

When planning the programme, you should aim to enhance the vocational nature of the qualifications by:

- using up-to-date and relevant teaching materials that make use of scenarios and case studies relevant to the scope and variety of employment opportunities available in the sector. These materials may be drawn from workplace settings, where feasible. For example, you can use promotional materials that have been developed by the Engineering
- giving learners the opportunity to apply their learning through practical activities to be found in the workplace through volunteering, for example
- including employers in the delivery of the programme. You may, for example, wish to seek the cooperation of local employers in giving examples of current work procedures and practices
- liaising with employers to make sure a course is relevant to learners' specific needs. You may, for example, wish to seek employers' help in stressing the importance of English and mathematical skills, and of wider skills in the world of work.

Resources

As part of the approval process, your centre must make sure that the resource requirements below are in place before offering the qualifications.

- Centres must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualifications.
- Staff involved in the assessment process must have relevant expertise and/or occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualifications.
- Centres must have appropriate health and safety policies in place relating to the use of equipment by learners.
- Centres must deliver the qualifications in accordance with current equality legislation.

Your centre should refer to the *Teacher guidance* section in the individual units to check for any specific resources required.

Delivery approach

Your approach to teaching and learning should support the specialist vocational nature of BTEC First qualifications. These BTEC Firsts give a balance of practical skill development and knowledge requirements, some of which can be theoretical in nature.

Instruction in the classroom is only part of the learning process. You need to reinforce the links between the theory and practical application, and make sure that the knowledge base is relevant and up to date by using teaching methods and materials that allow learners to apply their learning to actual events and activities within the sector. Maximum use should be made of learners' experience where relevant, for example by encouraging them to reflect on their experience of work or the experiences of family and friends.

One of the important aspects of your approach to delivery should be to instil in learners who have a limited experience of the world of work, insight of the daily operations that are met in the vocational area being studied. It is suggested that the delivery of BTEC Firsts can be enriched and extended through the use of learning materials, classroom exercises and internal assessments that draw on current practice in and experience of the qualification sector being studied. This may include:

- vocationally specific workplace case-study materials
- visiting speakers and the assistance of local employers
- visits to local workplaces
- inviting relevant experts or contacts to come to speak to learners about their involvement in the engineering sector
- visits to employers in the engineering
- asking a local employer to set learners a problem-solving activity to be carried out in groups
- referring to trade journals, magazines or newspaper articles relevant to the sector.

Personal, learning and thinking skills

Your learners have opportunities to develop personal, learning and thinking skills (PLTS) in a sector-related context. See *Annexe A* for detailed information about PLTS, and mapping to the units in this specification.

English and mathematics knowledge and skills

It is likely that learners will be working towards English and mathematics qualifications at Key Stage 4 or above. These BTEC First qualifications provide further opportunities to enhance and reinforce skills in English and mathematics in naturally occurring, relevant, work-related contexts.

English and mathematical skills are embedded in the assessment criteria – see individual units for signposting to English (#) and mathematics (*).

Functional Skills at Level 2

Your learners can use opportunities in their learning programme to develop and practise Functional Skills. *Annexe B* sets out where units and learning aims are of particular relevance for learners being prepared for assessment in Functional Skills in English, mathematics and/or ICT at Level 2. There may also be other opportunities to develop functional skills in programmes, for example through group work, research, employment-related activities and work experience.

6 Access and recruitment

Our policy regarding access to our qualifications is that:

- they should be available to everyone who is capable of reaching the required standards
- they should be free from any barriers that restrict access and progression
- there should be equal opportunities for all those wishing to access the qualifications.

These are qualifications aimed at Level 2 learners. Your centre is required to recruit learners to BTEC First qualifications with integrity.

You need to make sure that applicants have relevant information and advice about the qualifications to make sure they meet their needs.

Your centre should review the applicant's prior qualifications and/or experience to consider whether this profile shows that they have the potential to achieve the qualifications.

For learners with disabilities and specific needs, this review will need to take account of the support available to the learner during the teaching and assessment of the qualifications.

Prior knowledge, skills and understanding

Learners do not need to achieve any other qualifications before registering for a BTEC First.

These qualifications can be taken as stand-alone qualifications or can extend the achievement that learners have demonstrated through the Pearson BTEC Level 1/Level 2 First Award in Engineering qualification. Learners do this by taking additional units (see the *Information Manual* for further details) to make up the requisite number of Guided Learning Hours, ensuring the correct unit combination is adhered to, to fulfil the rules of combination. See *Section 4 Qualification structures.*

Please see *Annexe E* for the structure of the Pearson BTEC Level 1/Level 2 First Award in Engineering qualification.

Access to qualifications for learners with disabilities or specific needs

Equality and fairness are central to our work. Pearson's equality policy requires all learners to have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every learner.

We are committed to making sure that:

- learners with a protected characteristic (as defined by equality legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison with learners who do not share that characteristic
- all learners achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document *Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational qualifications*.

Details on how to make adjustments for learners with protected characteristics are given in the document *Pearson Supplementary Guidance for Reasonable Adjustment and Special Consideration in Vocational Internally Assessed Units.*

Both documents are on our website.

Special consideration

You must operate special consideration in line with the Joint Council for Qualifications (JCQ) document *Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational qualifications* and the *Pearson Supplementary Guidance for Reasonable Adjustment and Special Consideration in Vocational Internally Assessed Units*.

You can provide special consideration only in the time given for evidence to be provided or for the format of the assessment if it is equally valid. You may not substitute alternative forms of evidence to that required in a unit, or omit the application of any assessment criteria to judge attainment. Pearson can consider applications for special consideration in line with the policy.

7 The layout of units in the specification

Each unit is laid out using the headings given below. Unit X below is for **illustrative purposes only**.

UNIT X: TITLE

Unit X: Title

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

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Learning aims

In this unit you will:

A ulla laoreet enim eget et lectus mauris aptent nullam

B erat augue nulla turpis justo eget elementum metus ligula Tellus in cursus erat amet odio illo

C eu feugiat vestibulum ipsum pellentesque ipsum lacus nulla ectus bibendum eget wisi nibh ullamcorper nisl.

Unit title
The title reflects the content of the unit.

Level
All units and qualifications have a level assigned to them that represents the level of achievement. The National Qualifications Framework level descriptors and similar qualifications at this level inform the allocation of the unit level.

Unit type
This shows if the unit is mandatory or optional specialist.

Guided learning hours
All units have guided learning hours assigned to them. This is the time when you (as a teacher, tutor, trainer or facilitator) are present to give specific guidance to learners on the unit content.

Assessment type
Units are either internally or externally assessed. Your centre designs and assesses the internal assessments. Pearson sets and marks the external assessments.

Unit introduction
The unit introduction is addressed to the learner and gives the learner a snapshot of the purpose of the unit.

Learning aims
The learning aims are statements indicating the scope of learning for the unit. They provide a holistic overview of the unit when considered alongside the unit content.

UNIT X: TITLE

Learning aims and unit content

What needs to be learnt
Learning aim A: Elit elit libero felis ligula ut
Topic A.1 Neque magna consectetuer scelerisque nec in ut orci arcu: In cursus ac sem in urna: • erat dignissim eros sed • ornare condimentum condimentum • quis risus duis • lutate magnis pede dui nibh aliquam • scelerisque nec in ut orci arcu. Elit elit libero felis ligula ut: • ac sem in urna assa in a mauris • mattis dui interdum vitae aptent • etiam nec nullam dum duis adipiscing • adipiscing tellus at orci ut • orem in nullam amet interdum commodo. Vulputate magnis pede: • dolor quis curabitur luctus ibh id elit ontes maecenas tortor • onsequat minim sed hasellus purus maecenas neque sem • risus tortor nisl at pulvinar consectetuer • magnis pede dui nibh aliquam. **Topic A.2 Phasellus purus maecenas neque sem risus tortor nisl at pulvinar consectetuer:** • eleifend ellus in cursus erat • amet odio illo eu feugiat vestibulum ipsum • pellentesque ipsum lacus nulla velit du ectus bibendum eget

Learning aims and unit content

The unit content gives the basis for the teaching, learning and assessment for each learning aim. Topic headings are given, where appropriate.

Content covers:

- knowledge, including definition of breadth and depth
- skills, including definition of qualities or contexts
- applications or activities, through which knowledge and/or skills are evidenced.

Content should normally be treated as compulsory for teaching the unit. Definition of content sometimes includes examples prefixed with 'e.g.'. These are provided as examples and centres

Assessment criteria

The assessment criteria determine the minimum standard required by the learner to achieve the relevant grade. The learner must provide sufficient and valid evidence to achieve the grade.

UNIT X: TITLE

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Enim lorem et elit libero felis ligula ut			
1A.1 Amet interdum commodo sed facilisis.	2A.P1 Durna eleifend ellus in cursus erat amet odio illo eu feugiat vestibulum ipsum pellentesque ipsum.	2A.M1 A lacus nulla velit dui ectus.	2A.D1 Ultrices ultrices ut cursus ac sem in urna assa in a mauris mattis ut. In cursus ac sem in urna assa in a mauris mattis aptent etiam nec nullam duis adipiscing.
1A.2 Iorem in nullam amet interdum commodo. empor sed facilisis.	2A.P2 Nostra pretium non elis mauris porttitor elit malesuada volutpat non ut volutpat.	2A.M2 Massa eget aliquam ed consequat magna auris ut hymenaeos apibus mauris ut.	
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Teacher guidance

While the main content of the unit is addressed to the learner, this section gives you additional guidance and amplification to aid your understanding and to ensure a consistent level of assessment.

UNIT X: TITLE

Teacher guidance

Resources

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Assessment guidance

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Resources – identifies any special resources required for learners to show evidence of the assessment. Your centre must make sure that any requirements are in place when it seeks approval from Pearson to offer the qualification.

Assessment guidance – gives examples of the quality of work needed to differentiate the standard of work submitted. It also offers suggestions for creative and innovative ways in which learners can produce evidence to meet the criteria. The guidance highlights approaches and strategies for developing appropriate evidence.

Suggested assignment outlines – gives examples of possible assignment ideas. These are not mandatory. Your centre is free to adapt them, or you can design your own assignment outlines.

UNIT X: TITLE

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance, and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	The local community magazine is running an article to introduce learners to the essential role played by the public services in protecting the community. You have been asked to write the article. You will research selected 'communities' and what their individual needs are. Use your research to support your article, which must provide an analysis of how two contrasting selected public services have worked to protect the communities you identified. You must consider the advantages gained through public services working together.	They types of evidence that you will produce include: • a magazine article that addresses the way in which two contrasting public services work to protect the community, and the advantages and disadvantages of public services working together • individual preparation notes to support your article, including research notes, interviews, questionnaires etc. • illustrations, where relevant, to support the article.

8 Internal assessment

Language of assessment

Assessment of the internal and external units for this qualification will be available in English. All learner work must be in English. This qualification can also be made available through the medium of Welsh, in which case learners may submit work in Welsh and/or English.

A learner taking the qualification may be assessed in British or Irish Sign Language where it is permitted for the purpose of reasonable adjustment.

Summary of internal assessment

For the Pearson BTEC Level 1/Level 2 First qualifications, the majority of the units are assessed through internal assessment, which means that you can deliver the programme in a way that suits your learners and which relates to local need. The way in which you deliver the programme must also ensure that assessment is fair and that standards are nationally consistent over time.

To achieve this, it is important that you:

- plan the assessment of units to fit with delivery, allowing for the linkages between units
- write suitable assessments (for example assignments, projects, case studies) or select assessments from available resources, adapting them as necessary
- plan the assessment for each unit in terms of when it will be authorised by the Lead Internal Verifier, when it will be used and assessed, and how long it will take, and how you will determine that learners are ready to begin an assessment
- ensure each assessment is fit for purpose, valid, will deliver reliable assessment outcomes across assessors, and is authorised before use
- provide all the preparation, feedback and support that learners need to undertake an assessment before they begin producing their evidence
- make careful and consistent assessment decisions based only on the defined assessment criteria and unit requirements
- validate and record assessment decisions carefully and completely
- work closely with Pearson to ensure that your implementation, delivery and assessment is consistent with national standards.

Assessment and verification roles

There are three key roles involved in implementing assessment processes in your school or college, namely:

- Lead Internal Verifier
- Internal Verifier – the need for an Internal Verifier or Internal Verifiers in addition to the Lead Internal Verifier is dependent on the size of the programme in terms of assessment locations, number of assessors and optional paths taken. Further guidance can be obtained from your Vocational Quality Advisor or Centre Quality Reviewer if you are unsure about the requirements for your centre
- assessor.

The Lead Internal Verifier must be registered with Pearson and is required to train and standardise assessors and Internal Verifiers using materials provided by Pearson that demonstrate the application of standards. In addition, the Lead Internal Verifier should provide general support. The Lead Internal Verifier:

- has overall responsibility for the programme assessment plan, including the duration of assessment and completion of verification
- can be responsible for more than one programme
- ensures that there are valid assessment instruments for each unit in the programme
- ensures that relevant assessment documentation is available and used for each unit
- is responsible for the standardisation of assessors and Internal Verifiers using Pearson-approved materials
- authorises individual assessments as fit for purpose
- checks samples of assessment decisions by individual assessors and Internal Verifiers to validate that standards are being correctly applied
- ensures the implementation of all general assessment policies developed by the centre for BTEC qualifications
- has responsibility for ensuring learner work is authenticated
- liaises with Pearson, including the Pearson Standards Verifier.

Internal Verifiers must oversee all assessment activity to make sure that individual assessors do not misinterpret the specification or undertake assessment that is not consistent with the national standard in respect of level, content or duration of assessment. The process for ensuring that assessment is being conducted correctly is called internal verification. Normally, a programme team will work together with individuals being both assessors and Internal Verifiers, with the team leader or programme manager often being the registered Lead Internal Verifier.

Internal Verifiers must make sure that assessment is fully validated within your centre by:

- checking every assessment instrument carefully and endorsing it before it is used
- ensuring that each learner is assessed carefully and thoroughly using only the relevant assessment criteria and associated guidance in the specification
- ensuring the decisions of every assessor for each unit at all grades and for all learners are in line with national standards.

Assessors make assessment decisions and must be standardised using Pearson-approved materials before making any assessment decisions. They are usually the teachers in your school or college but the term ‘assessor’ refers to the specific responsibility for carrying out assessment and making sure that it is done in a way that is correct and consistent with national standards. Assessors may also draft or adapt internal assessment instruments.

You are required to keep records of assessment and have assessment authorised by Pearson. The main records are:

- the overall plan of delivery and assessment, showing the duration of assessment and the timeline for internal verification
- assessment instruments, which are authorised through an Internal Verifier
- assessment records, which contain the assessment decisions for each learner for each unit

- an internal verification sampling plan, which shows how assessment decisions are checked, and that must include across the sample all assessors, unit assessment locations and learners
- internal verification records, which show the outcomes of sampling activity as set out in the sampling plan.

Learner preparation

Internal assessment is the main form of assessment for this qualification, so preparing your learners for it is very important because they:

- must be prepared for and motivated to work consistently and independently to achieve the requirements of the qualification
- need to understand how they will be assessed and the importance of timescales and deadlines
- need to appreciate fully that all the work submitted for assessment must be their own.

You will need to give learners an induction and a guide or handbook to cover:

- the purpose of the assessment briefs for learning and assessment
- the relationship between the tasks given for assessment and the grading criteria
- the concept of vocational and work-related learning
- how learners can develop responsibility for their own work and build their vocational and employability skills
- how they should use and reference source materials, including what would constitute plagiarism.

Designing assessment instruments

An assessment instrument is any kind of activity or task that is developed for the sole purpose of assessing learning against the learning aims. When you develop assessment instruments you will often be planning them as a way to develop learners' skills and understanding. However, they must be fit for purpose as a tool to measure learning against the defined content and assessment criteria to ensure your final assessment decisions meet the national standard.

You should make sure that assessment tasks and activities enable learners to produce valid, sufficient, authentic and appropriate evidence that relates directly to the specified criteria within the context of the learning aims and unit content. You need to ensure that the generation of evidence is carefully monitored, controlled and produced in an appropriate timescale. This will help you to make sure that learners are achieving to the best of their ability and at the same time that the evidence is genuinely their own.

An assessment that is fit for purpose and suitably controlled is one in which:

- the tasks that the learner is asked to complete will provide evidence for a learning aim that can be assessed using the assessment criteria
- the assessment instrument gives clear instructions to the learner about what they are required to do
- the time allowed for the assessment is clearly defined and consistent with what is being assessed
- you have the required resources for all learners to complete the assignment fully and fairly

- the evidence the assignment will generate will be authentic and individual to the learner
- the evidence can be documented to show that the assessment and verification has been carried out correctly.

You may develop assessments that cover a whole unit, parts of a unit or several units, provided that all units and their associated learning aims are fully addressed through the programme overall. A learning aim **must** be covered completely in an assessment. Learning aim coverage must not be split between assignments. In some cases it may be appropriate to cover a learning aim with two tasks or sub-tasks within a single assignment. This must be done with care to ensure the evidence produced for each task can be judged against the full range of achievement available in the learning aim for each activity. This means it is not acceptable to have a task that contains a Pass level activity, then a subsequent task that targets a Merit or Distinction level activity. However, it is possible to have two tasks for different assessed activities, each of which stretch and challenge the learners to aim to produce evidence that can be judged against the full range of available criteria.

When you give an assessment to learners, it must include:

- a clear title and/or reference so that the learner knows which assessment it is
- the unit(s) and learning aim(s) being addressed
- a scenario, context, brief or application for the task
- task(s) that enable the generation of evidence that can be assessed against the assessment criteria
- details of the evidence that the learner must produce
- clear timings and deadlines for carrying out tasks and providing evidence.

Your assessment tasks should enable the evidence generated to be judged against the full range of assessment criteria; it is important the learners are given the opportunity for stretch and challenge.

The units include guidance on appropriate approaches to assessment. Central features of vocational assessment are that it should be:

- current, i.e. it reflects the most recent developments and issues
- local, i.e. it reflects the employment context of your area
- flexible, i.e. it allows you as a centre to deliver the programme, making best use of the vocational resources that you have
- consistent with national standards, with regard to the level of demand.

Your centre should use the assessment guidance within units along with your local resource availability and guidance to develop appropriate assessments. It is acceptable to use and adapt resources to meet learner needs and the local employment context.

You need to make sure that the type of evidence generated fits with the unit requirement, that it is vocational in nature, and that the context in which the assessment is set is in line with unit assessment guidance and content. For many units, this will mean providing for the practical demonstration of skills. For many learning aims, you will be able to select an appropriate vocational format for evidence generation, such as:

- written reports, graphs, posters
- projects, project plans
- time-constrained practical assessments
- audio-visual recordings of portfolio, sketchbook, a working logbook etc.
- presentations.

Authenticity and authentication

You can accept only evidence for assessment that is authentic, i.e. that is the learner's own and that can be judged fully to see whether it meets the assessment criteria.

You should ensure that authenticity is considered when setting assignments. For example, ensuring that each learner has a different focus for research will reduce opportunities for copying or collaboration. On some occasions it will be useful to include supervised production of evidence. Where appropriate, practical activities or performance observed by the assessor should be included.

Learners must authenticate the evidence that they provide for assessment. They do this by signing a declaration stating that it is their own work when they submit it to certify:

- the evidence submitted for this assignment is the learner's own
- the learner has clearly referenced any sources used in the work
- they understand that false declaration is a form of malpractice.

Your assessors should assess only learner evidence that is authentic. If they find through the assessment process that some or all of the evidence is not authentic, they need to take appropriate action, including invoking malpractice policies as required.

It is important that all evidence can be validated through verification. This means that it must be capable of being reassessed in full by another person. When you are using practical and performance evidence, you need to think about how supporting evidence can be captured through using, for example, videos, recordings, photographs, handouts, task sheets, etc. This should be submitted as part of the learner's evidence.

The authentication of learner evidence is the responsibility of your centre. If during external sampling a Pearson Standards Verifier raises concerns about the authenticity of evidence, your centre will be required to investigate further. Depending on the outcomes, penalties may be applied. At the end of this section, you can find an example of a template that can be used to record the declaration of learners in relation to the authenticity of the evidence presented for assessment.

Applying criteria to internal assessments

Each unit and learning aim has specified assessment criteria. Your centre should use these criteria for assessing the quality of the evidence provided. This determines the grade awarded.

Unless specifically indicated by the assessment guidance, assessment criteria are not a set of sequential activities but a way of making a judgement. For example, if a Level 2 Pass specifies a 'description' and a Merit an 'analysis', these do not require two different activities but rather one activity through which some learners will provide only description evidence and others will also provide analysis evidence. The assessment criteria are hierarchical. A learner can achieve a Merit only if they provide sufficient evidence for the Level 2 Pass and Merit criteria. Similarly, a learner can achieve a Distinction only if they give sufficient evidence for the Level 2 Pass, Merit and Distinction criteria.

A final unit grade is awarded after all opportunities for achievement are given.
A learner must achieve all the assessment criteria for that grade. Therefore:

- to achieve a Level 2 Distinction, a learner must have satisfied all the Distinction criteria in a way that encompasses all the Level 2 Pass, Merit and Distinction criteria, providing evidence of performance of outstanding depth, quality or application
- to achieve a Level 2 Merit, a learner must have satisfied all the Merit criteria in a way that encompasses all the Level 2 Pass and Merit criteria, providing performance of enhanced depth or quality
- to achieve a Level 2 Pass, a learner must have satisfied all the Level 2 Pass criteria, showing breadth of coverage of the required unit content and having relevant knowledge, understanding and skills
- a learner can be awarded a Level 1 if the Level 1 criteria are fully met. A Level 1 criterion is not achieved through failure to meet the Level 2 Pass criteria.

A learner who does not achieve all the assessment criteria at Level 1 has not passed the unit and should be given a grade of U (Unclassified).

A learner must achieve all the defined learning aims to pass the internally assessed units. There is no compensation within the unit.

Assessment decisions

Final assessment is the culmination of the learning and assessment process. Learners should be given a full opportunity to show how they have achieved the learning aims covered by a final assessment. This is achieved by ensuring that learners have received all necessary learning, preparation and feedback on their performance and then confirming that they understand the requirements of an assessment, before any assessed activities begin.

There will then be a clear assessment outcome based on the defined assessment criteria. Your assessment plan will set a clear timeline for assessment decisions to be reached. Once an assessment has begun, learners must not be given feedback on progress towards criteria. After the final assignment is submitted, an assessment decision must be given.

An assessment decision:

- must be made with reference to the assessment criteria
- should record how it has been reached, indicating how or where criteria have been achieved
- may indicate why attainment against criteria has not been demonstrated
- must not provide feedback on how to improve evidence to meet higher criteria.

Your Internal Verifiers and assessors must work together to ensure that assessment decisions are reached promptly and validated before they are given to the learner.

Late submission

You should encourage learners to understand the importance of deadlines and of handing work in on time. For assessment purposes it is important that learners are assessed fairly and consistently according to the assessment plan that the Lead Internal Verifier has authorised and that some learners are not advantaged by having additional time to complete assignments. You are not required to accept for assessment work that was not completed by the date in the assessment plan.

Learners may be given authorised extensions for legitimate reasons, such as illness at the time of submission. If you accept a late completion by a learner, the evidence should be assessed normally, unless it is judged to not meet the requirements for authenticity. It is not appropriate, however, to give automatic downgrades on assessment decisions as ‘punishment’ for late submission.

Resubmission of improved evidence

Once an assessment decision is given to a learner, it is final in all cases except where the Lead Internal Verifier approves **one** opportunity to resubmit improved evidence.

The criteria used to authorise a resubmission opportunity are always:

- initial deadlines or agreed extensions have been met
- the tutor considers that the learner will be able to provide improved evidence without further guidance
- the evidence submitted for assessment has been authenticated by the learner and the assessor
- the original assessment can remain valid
- the original evidence can be extended and re-authenticated.

Your centre will need to provide a specific resubmission opportunity that is authorised by the Lead Internal Verifier. Any resubmission opportunity must have a deadline that is within 15 working days of the assessment decision being given to the learner, and within the same academic year. You should make arrangements for resubmitting the evidence for assessment in such a way that it does not adversely affect other assessments and does not give the learner an unfair advantage over other learners.

You need to consider how the further assessment opportunity ensures that assessment remains fit for purpose and in line with the original requirements; for example, you may opt for learners to improve their evidence under supervised conditions, even if this was not necessary for the original assessment, to ensure that plagiarism cannot take place. How you provide opportunities to improve and resubmit evidence for assessment needs to be fair to all learners. Care must be taken when setting assignments and at the point of final assessment to ensure that the original evidence for assessment can remain valid and can be extended. The learner must not have further guidance and support in producing further evidence. The Standards Verifier will want to include evidence that has been resubmitted as part of the sample they will review.

Appeals

Your centre must have a policy for dealing with appeals from learners. These appeals may relate to assessment decisions being incorrect or assessment not being conducted fairly. The first step in such a policy would be a consideration of the evidence by a Lead Internal Verifier or other member of the programme team. The assessment plan should allow time for potential appeals after assessment decisions have been given to learners.

If there is an appeal by a learner you must document the appeal and its resolution.

Dealing with malpractice

Learner Malpractice

Heads of Centres are required to report incidents of any suspected learner malpractice that occur during Pearson external assessments. We ask that centres do so by completing a JCQ Form M1 (available at www.jcq.org.uk/exams-office/malpractice) and emailing it and any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc.) to the Investigations Team at pqsmalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on learners lies with Pearson.

Learners must be informed at the earliest opportunity of the specific allegation and the centre's malpractice policy, including the right of appeal. Learners found guilty of malpractice may be disqualified from the qualification for which they have been entered with Pearson.

Teacher/centre Malpractice

Heads of Centres are required to inform Pearson's Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. Heads of Centres are requested to inform the Investigations Team by submitting a JCQ Form M2(a) (available at www.jcq.org.uk/exams-office/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff or anonymous informants), the Investigations Team will conduct the investigation directly or may ask the head of centre to assist. Incidents of maladministration (accidental errors in the delivery of Pearson qualifications that may affect the assessment of learners) should also be reported to the Investigations Team using the same method.

Reasonable adjustments to assessment

You are able to make adjustments to assessments to take account of the needs of individual learners in line with Pearson's Reasonable Adjustments and Special Considerations policy. In most instances this can be achieved simply by application of the policy, for example to extend time or adjust the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable.

Special consideration

You must operate special consideration in line with Pearson's Reasonable Adjustments and Special Considerations policy. You can provide special consideration only in the time given for evidence to be provided or for the format of the assessment if it is equally valid. You may not substitute alternative forms of evidence to that required in a unit, or omit the application of any assessment criteria to judge attainment. Pearson can consider applications for special consideration in line with the policy.

Exemplar for centres
Learner Assessment Submission and Declaration

This sheet or a sheet fulfilling the same function must be completed by the learner and be provided for work submitted for assessment.

Learner name:		Assessor name:
Issue date:	Submission date:	Submitted on:
Programme:		
Unit:		
Assignment reference and title:		

Please list the evidence submitted for each task. Indicate the page numbers where the evidence can be found or describe the nature of the evidence (e.g. video, illustration).

Assignment task reference	**Evidence submitted**	**Page numbers or description**
Additional comments to the Assessor:		

Learner declaration
I certify that the work submitted for this assignment is my own. I have clearly referenced any sources used in the work. I understand that false declaration is a form of malpractice.
Learner signature: Date:

9 External assessment

Externally-assessed units have the same grades as internally-assessed units:

- Level 2 – Pass, Merit, Distinction
- Level 1
- Unclassified.

The tables below show the type of external assessment and assessment availability for these qualifications.

Unit 1: The Engineered World	
Type of external assessment	This unit is externally assessed using an onscreen test. Pearson sets and marks the test. The assessment must be taken by the learner under examination conditions.
Length of assessment	The external assessment will be one hour.
No. of marks	50
Assessment availability	On-demand
First assessment availability	November 2013

Unit 9: Interpreting and Using Engineering Information	
Type of external assessment	This unit is externally assessed using a paper-based test. Pearson sets and marks the test. The assessment must be taken by the learner under examination conditions.
Length of assessment	The external assessment will be one hour.
No. of marks	50
Assessment availability	January and June
First assessment availability	June 2015

Your centre needs to make sure that learners are:

- fully prepared to sit the external assessment
- entered for assessments at appropriate times, with due regard for resit opportunities as necessary.

Sample assessment materials will be available to help centres prepare learners for assessment. Specific arrangements for external assessment are available before the start of each academic year on our website qualifications.pearson.com.

Grade descriptors for the internal and external units

Internal units

Each internally-assessed unit has specific assessment criteria that your centre must use to judge learner work in order to arrive at a grading decision for the unit as a whole. For internally-assessed units, the assessor judges the evidence that the learner has presented to determine whether it meets all the relevant criteria, and then awards a grade at the appropriate level.

The criteria are arrived at with reference to the following grading characteristics:

- applying knowledge and understanding in vocational and realistic contexts, with reference to relevant concepts and processes, to achieve tasks, produce outcomes and review the success of outcomes
- developing and applying practical and technical skills, acting with increasing independence to select and apply skills through processes and with effective use of resources to achieve, explain and review the success of intended outcomes
- developing generic skills for work through management of self, working in a team, the use of a variety of relevant communication and presentation skills, and the development of critical thinking skills relevant to vocational contexts.

External units

The externally-assessed units are assessed using both marks-based and levels-based schemes. For each external assessment, grade boundaries, based on learner performance, will be set by the awarding organisation.

The following criteria are used in the setting and awarding of the external units.

Unit 1: The Engineered World

Level 2 Pass

Learners will be able to recall and apply knowledge in familiar situations including everyday uses of engineered products. They will have a sound understanding of key terms, processes, equipment and technologies. They will be able to interpret information in order to select and apply knowledge of engineering products, processes, materials and technologies. They will be able to define and communicate key aspects of engineering processes, selecting appropriate actions in more simple and familiar contexts. They will be able to relate knowledge of engineering and the way in which engineering relates to sustainability in vocational and realistic situations making some decisions about valid applications and impact. They will be able to relate the use of engineering processes and modern products to users and purposes.

Level 2 Distinction

Learners will be able to synthesise knowledge of engineered products, the materials used to make them and engineering processes, bringing together understanding of technologies. They will be able to apply understanding of engineering processes to sometimes complex contexts such as modern manufacturing techniques. They will show depth of knowledge and development of understanding of engineering processes and technologies in different situations, being able to make effective judgements based on analysis of given information. They will be able to analyse engineering products, selecting appropriate materials and making recommendations about applications of processes and their environmental impact. They will be able to make judgements about the efficiency of manufacturing systems and potential impacts on product quality and the environment, and make recommendations about solutions, controls and future planning. They will be able to compare techniques, processes, products and materials to evaluate alternatives against defined criteria.

Unit 9: Interpreting and Using Engineering Information

Level 2 Pass

Learners will be able to recall and apply knowledge in familiar situations including the types and characteristics of engineering drawings, documentation and health and safety information. They will have a sound understanding of the applications and value of engineering drawing and other engineering-related information in routine processes and situations. They will be able to interpret engineering drawings and engineering-related information and select appropriate applications. They will be able to define details, symbols and abbreviations used in engineering drawings and engineering-related information, and health and safety signage. They will be able to describe the use of engineering drawings, engineering information, work output and production documentation in more simple and familiar contexts than at Merit and Distinction levels. They will be able to comment on implications of using and interpretating drawings, information and documentation in simple situations. They will show some understanding of the importance of accuracy, document control and sound document handling for engineering.

Level 2 Distinction

Learners will be able to interpret drawings and other engineering-information in realistic situations to select uses, importance and limitations. Learners will be able to analyse detailed information related to engineering drawings and other engineering-related information, drawing appropriate conclusions. They will be able to make judgements about the consequences of the application of techniques and processes. They will show depth of understanding of the uses and applications of engineering drawing, and other engineering-related information, through defining their advantages and disadvantages in particular contexts. They will be able to compare the characteristics, uses and value of engineering drawings and engineering-related information to evaluate alternatives against defined criteria. They will be able to make recommendations related to the effective interpretation and use of relevant documentation.

10 Awarding and reporting for the qualifications

The awarding and certification of these qualifications will comply with the requirements of the Office of Qualifications and Examinations Regulation (Ofqual).

Calculation of the qualification grade

This qualification is a Level 1/Level 2 qualification and the certification may show a grade ranging from Level 2 P to Level 2 D*. Please refer to the Calculation of qualification grade table for the full list of grades. If these grades are not achieved, a Level 1 grade may be awarded. Learners whose level of achievement is below a Level 1 will receive an unclassified (U) result. Each individual unit will be awarded a grade of Level 2 Pass, Merit, Distinction or Level 1. Distinction* is not available at unit level. Learners whose level of achievement is below a Level 1 will receive an unclassified (U) for that unit. Award of Distinction* (D*) D* is an aggregated grade for the qualification, based on the learner's overall performance. In order to achieve this grade, learners will have to demonstrate a strong performance across the qualification as a whole. To achieve a Level 2 qualification, learners must:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome)
- have sufficient points across the mandatory units, i.e. 24 points
- achieve the minimum number of points at a grade threshold from the permitted combination, see the Calculation of qualification grade table.

Learners who do not achieve a Level 2 may be entitled to achieve a Level 1 where they:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome)
- have sufficient points across the mandatory units, i.e. 12 points
- achieve the minimum number of points for a Level 1, see the *Calculation of qualification grade* table.

For the Certificate

To achieve a Level 2 qualification, learners must:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome) and
- achieve the minimum number of points at a grade threshold from the permitted combination, see the *Calculation of qualification grade* table.

Learners who do not achieve a grade at Level 2 may be entitled to achieve a grade of Level 1 Pass where they:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome) and
- achieve the minimum number of points for a Level 1, see the *Calculation of qualification grade* table.

For the Extended Certificate

To achieve a Level 2 qualification, learners must:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome) and
- achieve the minimum number of points at a grade threshold from the permitted combination, see the *Calculation of qualification grade* table.

Learners who do not achieve a grade at Level 2 may be entitled to achieve a grade of Level 1 Pass where they:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome) and
- achieve the minimum number of points for a Level 1, see the *Calculation of qualification grade* table.

For the Diploma

To achieve a Level 2 qualification, learners must:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome) and
- achieve the minimum number of points at a grade threshold from the permitted combination, see the *Calculation of qualification grade* table.

Learners who do not achieve a grade at Level 2 may be entitled to achieve a grade of Level 1 Pass where they:

- complete and report an outcome for all units within the permitted combination (NB Unclassified is a permitted unit outcome) and
- achieve the minimum number of points for a Level 1, see the *Calculation of qualification grade* table.

Learners who do not achieve sufficient points for the Certificate, Extended Certificate or Diploma qualification may be eligible to achieve the Award provided they have completed the correct combination of units and meet the appropriate qualification grade points threshold.

Points available for unit size and grades

The table below shows the **number of points scored per 10 guided learning hours** at each grade.

Points per grade per 10 guided learning hours				
Unclassified	**Level 1**	**Level 2 Pass (P)**	**Level 2 Merit (M)**	**Level 2 Distinction (D)**
0	2	4	6	8

We will automatically calculate the qualification grade for your learners when your learner unit grades are submitted. Learners will be awarded qualification grades for achieving the sufficient number of points within the ranges shown in the *Calculation of qualification grade* table.

Example

A learner achieves a Level 2 Pass grade for a unit. The unit size is 30 guided learning hours (GLH). Therefore, they gain 12 points for that unit, i.e. 4 points for each 10 GLH, so 12 points for 30 GLH.

Calculation of qualification grade

Award (120 GLH)		Certificate (240 GLH)		Extended Certificate (360 GLH)		Diploma (480 GLH)	
Grade	Points threshold	Grade	Points threshold	Grade	Points threshold	Grade	Points threshold
U	0	U	0	U	0	U	0
Level 1	24	Level 1	48	Level 1	72	Level 1	96
Level 2 Pass	48	Level 2 PP	96	Level 2 PP	144	Level 2 PP	192
		Level 2 MP	114	Level 2 MP	174	Level 2 MP	234
Level 2 Merit	66	Level 2 MM	132	Level 2 MM	204	Level 2 MM	276
		Level 2 DM	150	Level 2 DM	234	Level 2 DM	318
Level 2 Distinction	84	Level 2 DD	168	Level 2 DD	264	Level 2 DD	360
		Level 2 D*D	174	Level 2 D*D	270	Level 2 D*D	366
Level 2 Distinction*	90	Level 2 D*D*	180	Level 2 D*D*	276	Level 2 D*D*	372

This table shows the minimum thresholds for calculating grades. The table will be kept under review over the lifetime of the qualification. The most up to date table will be issued on our website.

Pearson will monitor the qualification standard and reserves the right to make appropriate adjustments.

The tables below give examples of how the overall grade is determined.

Examples used are for illustrative purposes only. Other unit combinations are possible, see *Section 4 Qualification structures*.

Example 1

Achievement of a Certificate with a Level 2 MM grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Pass	4	12
Unit 4	30	3	Level 2 Merit	6	18
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Pass	4	12
Unit 7	60	6	Level 2 Distinction	8	48
Unit 10	30	3	Level 2 Merit	6	18
Qualification grade totals	**240**	**24**	**Level 2 MM**		**144**

The learner has gained enough points overall for a Level 2 MM grade.

Example 2

Achievement of an Extended Certificate with a Level 2 D*D grade

	GLH	Weighting (GLH/10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Distinction	8	24
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Distinction	8	24
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Distinction	8	24
Unit 7	60	6	Level 2 Distinction	8	48
Qualification grade totals	**240**	**24**	**Level 2 D*D**		**174**

The learner has sufficient points for a Level 2 D*D grade.

Example 3

Achievement of an Extended Certificate with a Level 2 MP grade

	GLH	Weighting (GLH / 10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Pass	4	12
Unit 2	30	3	Level 2 Pass	4	12
Unit 3	30	3	Level 2 Merit	6	18
Unit 4	30	3	Level 2 Pass	4	12
Unit 5	30	3	Level 2 Merit	6	18
Unit 6	30	3	Level 2 Distinction	8	24
Unit 7	60	6	Level 2 Pass	4	24
Unit 8	30	3	Level 2 Merit	6	18
Unit 9	30	3	Level 2 Merit	6	18
Unit 10	60	6	Level 2 Pass	4	24
Qualification grade totals	**360**	**36**	**Level 2 MP**		**180**

The learner has sufficient points for a Level 2 MP grade.

Example 4

Achievement of a Diploma with a Level 2 DD grade

	GLH	Weighting (GLH / 10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Merit	6	18
Unit 2	30	3	Level 2 Distinction	8	24
Unit 21	60	6	Level 2 Merit	6	36
Unit 3	30	3	Level 2 Distinction	8	24
Unit 5	30	3	Level 2 Merit	6	18
Unit 9	30	3	Level 2 Distinction	8	24
Unit 10	30	3	Level 2 Distinction	8	24
Unit 7	60	6	Level 2 Distinction	8	48
Unit 8	60	6	Level 2 Distinction	8	48
Unit 12	60	6	Level 2 Distinction	8	48
Unit 15	60	6	Level 2 Distinction	8	48
Qualification grade totals	**480**	**48**	**Level 2 DD**		**360**

The learner has sufficient points for a Level 2 DD grade.

Example 5

Achievement of a Diploma at Level 2 PP grade

	GLH	Weighting (GLH / 10)	Grade	Grade points	Points per unit (weighting × grade points)
Unit 1	30	3	Level 2 Pass	4	12
Unit 2	30	3	Level 1	2	6
Unit 21	60	6	Level 2 Merit	6	36
Unit 3	30	3	Level 2 Merit	6	18
Unit 5	30	3	Level 2 Pass	4	12
Unit 9	30	3	Level 2 Merit	6	18
Unit 10	30	3	Level 2 Pass	4	12
Unit 7	60	6	Level 2 Pass	4	24
Unit 8	60	6	Level 2 Pass	4	24
Unit 12	60	6	Level 1	2	12
Unit 15	60	6	Level 2 Pass	4	24
Qualification grade totals	**480**	**48**	**Level 1**		**198**

The learner has gained enough points overall for a Level 2 PP grade.

11 Quality assurance of centres

Pearson will produce on an annual basis the *UK Vocational Quality Assurance Handbook*, which will contain detailed guidance on the quality processes required to underpin robust assessment and internal verification.

The key principles of quality assurance are that:

- a centre delivering BTEC programmes must be an approved centre, and must have approval for the programmes or groups of programmes that it is delivering
- the centre agrees, as part of gaining approval, to abide by specific terms and conditions around the effective delivery and quality assurance of assessment; it must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres a range of materials and opportunities, through online standardisation, intended to exemplify the processes required for effective assessment, and examples of effective standards. Approved centres must use the materials and services to ensure that all staff delivering BTEC qualifications keep up to date with the guidance on assessment
- an approved centre must follow agreed protocols for standardisation of assessors and verifiers, for the planning, monitoring and recording of assessment processes, and for dealing with special circumstances, appeals and malpractice.

The approach of quality-assured assessment is through a partnership between an approved centre and Pearson. We will make sure that each centre follows best practice and employs appropriate technology to support quality-assurance processes, where practicable. We work to support centres and seek to make sure that our quality-assurance processes do not place undue bureaucratic processes on centres.

We monitor and support centres in the effective operation of assessment and quality assurance. The methods we use to do this for BTEC First programmes include:

- making sure that all centres complete appropriate declarations at the time of approval
- undertaking approval visits to centres
- making sure that centres have effective teams of assessors and verifiers who are trained to undertake assessment
- assessment sampling and verification, through requested samples of assessments, completed assessed learner work and associated documentation
- an overarching review and assessment of a centre’s strategy for assessing and quality assuring its BTEC programmes.

An approved centre must make certification claims only when authorised by us and strictly in accordance with requirements for reporting.

Centres that do not fully address and maintain rigorous approaches to quality assurance cannot seek certification for individual programmes or for all BTEC First programmes. Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

12 Further information and useful publications

To get in touch with us visit our 'Contact us' pages:

- Edexcel: qualifications.pearson.com/contactus
- BTEC Firsts: qualifications.pearson.com/en/qualifications/btec-firsts.html
- Pearson Work Based Learning and Colleges: qualifications.pearson.com/en/support/support-for-you/work-based-learning.html
- books, software and online resources for UK schools and colleges: www.pearsonschoolsandfecolleges.co.uk

Key publications:

- Adjustments for candidates with disabilities and learning difficulties – Access and Arrangements and Reasonable Adjustments, General and Vocational qualifications (Joint Council for Qualifications (JCQ))
- Equality Policy (Pearson)
- Recognition of Prior Learning Policy and Process (Pearson)
- UK Information Manual (Pearson)
- UK Quality Vocational Assurance Handbook (Pearson).

All of these publications are available on our website.

Publications on the quality assurance of BTEC qualifications are on our website at qualifications.pearson.com/en/support/support-topics/quality-assurance/quality-assurance-overview.html

Our publications catalogue lists all the material available to support our qualifications. To access the catalogue and order publications, please go to qualifications.pearson.com/en/support/published-resources.html#step1

Additional documentation

Additional materials include:

- Sample Assessment Material (for the external units)
- a guide to getting started with BTEC
- guides to our support for planning, delivery and assessment (including sample assignment briefs).

Additional resources

If you need to source further learning and teaching material to support planning and delivery for your learners, there is a wide range of BTEC resources available to you.

Any publisher can seek endorsement for their resources, and, if they are successful, we will list their BTEC resources on our website: qualifications.pearson.com/en/support/published-resources/about-endorsed-resources.html

13 Professional development and support

Pearson supports UK and international customers with training related to BTEC qualifications. This support is available through a choice of training options offered on our website: qualifications.pearson.com/en/support/training-from-pearson.

The support we offer focuses on a range of issues, such as:

- planning for the delivery of a new programme
- planning for assessment and grading
- developing effective assignments
- building your team and teamwork skills
- developing learner-centred learning and teaching approaches
- building in effective and efficient quality assurance systems.

The national programme of training we offer is on our website at: qualifications.pearson.com/en/support/training-from-pearson. You can request centre-based training through the website or you can contact one of our advisers in the Training from Pearson UK team via Customer Services to discuss your training needs.

BTEC training and support for the lifetime of the qualifications

Training and networks: our training programme ranges from free introductory events through sector-specific opportunities to detailed training on all aspects of delivery, assignments and assessment. We also host some regional network events to allow you to share your experiences, ideas and best practice with other BTEC colleagues in your region.

Regional support: our team of Curriculum Development Managers and Curriculum Support Consultants, based around the country, are responsible for providing advice and support in centres. They can help you with planning and curriculum developments.

To get in touch with our dedicated support teams please visit: qualifications.pearson.com/en/contact-us.html

Your BTEC Support team

Whether you want to talk to a sector specialist, browse online or submit your query for an individual response, there is someone in our BTEC Support team to help you whenever – and however – you need, with:

- Welcome Packs for new BTEC centres: if you are delivering BTEC for the first time, we will send you a sector-specific Welcome Pack designed to help you get started with these qualifications
- Subject Advisers: find out more about our subject adviser team – immediate, reliable support from a fellow subject expert – at: qualifications.pearson.com/en/contact-us.html
- Ask the Expert: submit your question online to our Ask the Expert online service (qualifications.pearson.com/en/contact-us/teachers.html) and we will make sure your query is handled by a subject specialist.

Units

Unit 1: The Engineered World

Level: **1 and 2**

Unit type: **Core**

Guided learning hours: **30**

Assessment type: **External**

Unit introduction

What is ‘engineering’? Is it using materials and processes to manufacture a single item? Is it applying new technologies to the mass production of well-known products? Or is it implementing methods to reduce waste and improve the sustainability of energy sources? Engineering is all of these things and many more. It affects all aspects of our lives, from the daily use of time-saving appliances to performance materials applied in ways we may never have imagined.

In this unit, you will discover the world of engineering. You will investigate the processes used to manufacture modern products within different engineering sectors. You will also study some of the new developments in materials and engineering technology that have an impact on life today – or will have in the very near future.

Engineers must be aware that products and processes may require the use of scarce resources that could have an impact on the environment. When an engineered product is made, used and disposed of, any waste of energy and environmental damage must be minimised at all stages. Therefore, you will also investigate waste reduction and sustainability issues from an engineering perspective, discovering how engineers can help control and reduce environmental damage.

Learning aims

In this unit you will:

A know about engineering processes used to produce modern engineered products

B know about developments in engineering materials and technologies

C understand how engineering contributes to a sustainable future.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about engineering processes used to produce modern engineered products
Topic A1: Engineering sectors and products Types of products from the following engineering sectors: ● aerospace, automotive, communications, electrical/electronic, mechanical, biomedical, chemical. **Topic A2: Mechanical and electrical / electronic engineering processes** Processes including health and safety issues, characteristics, applications and advantages/disadvantages of the following engineering processes: ● machining – turning, milling, drilling ● forming – casting, forging ● fabrication – welding, shearing ● electrical/electronic – PCB manufacture, surface mount technology. **Topic A3: Scales of production** Characteristics and advantages/disadvantages of the following scales of production used in engineering manufacture: ● one-off/jobbing production ● batch production ● mass production ● continuous production. **Topic A4: Modern production methods** Applications and advantages/disadvantages of the following modern production methods for production/assembly lines: ● robots ● Computer Numerically Controlled (CNC) machinery.

What needs to be learnt

Learning aim B: Know about developments in engineering materials and technologies

Topic B1: Modern and smart materials in engineering

Applications, characteristics, properties and advantages/disadvantages of the following modern and smart materials used in engineering:

- modern composite materials – glass reinforced plastic (GRP), carbon fibre, Kevlar®
- modern high-performance materials – tungsten, titanium, superalloys (nickel based, cobalt based), ceramics (boron carbide, cubic boron nitride, zirconia)
- smart materials – shape memory alloys (SMAs), shape memory polymers, electrochromic, piezoelectric actuators and transducers.

Topic B2: Modern material foams in engineering

Applications, characteristics and advantages/disadvantages of metallic foams as used in the automotive, biomedical and aerospace sectors e.g. aluminium, steel.

Topic B3: Modern material processes in engineering

Process, applications, characteristics and advantages/disadvantages of powder metallurgy: powder mixing/blending, pressing/compacting, sintering.

Topic B4: New technologies in engineering

Applications, characteristics and advantages/disadvantages of the following new technologies used in engineering sectors:

- optical fibres as used in the communications sector
- hydrogen fuel cells, surface nanotechnology and telematics as used in the automotive sector
- blended wing bodies as used in the aerospace sector
- bionics as used in the biomedical sector.

What needs to be learnt
Learning aim C: Understand how engineering contributes to a sustainable future
Topic C1: Sustainable engineered products Characteristics, applications and advantages/disadvantages of Life Cycle Assessment (LCA) at the following stages for engineered products: ● raw materials extraction ● material production ● production of parts ● assembly ● use ● disposal/recycling. **Topic C2: Minimising waste production in engineering** Characteristics, applications and advantages/disadvantages of minimising waste production throughout the life cycle of engineered products, using the four Rs: ● Reduce materials and energy. ● Reuse materials and products where applicable. ● Recover energy from waste. ● Recycle materials and products or use recycled materials. **Topic C3: Lean manufacturing** Characteristics, applications and advantages/disadvantages of minimising waste at the production stage in engineering, using the following lean manufacturing techniques: ● Just-in-Time (JIT) ● Kaizen ● poka-yoke. **Topic C4: Renewable sources of energy in engineering** Processes, characteristics, applications and advantages/disadvantages of using the following renewable sources of energy in engineering: ● wind energy using turbines and wind farms ● solar energy using photovoltaic cells and solar water heaters ● hydro energy using dams, barrages and wave power ● geothermal energy using heat pumps and exchangers.

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is externally assessed using an onscreen test. Pearson sets and marks the test. The test lasts for one hour and has 50 marks. The assessment is available on demand.

Learners will complete an onscreen test that has different types of questions including objective and short-answer questions. Where appropriate, questions contain graphics, photos, animations or videos. An onscreen calculator is available for questions requiring calculations. An onscreen notepad is available for making notes. Each item will have an accessibility panel that allows a learner to zoom in and out and apply a colour filter.

Unit 2: Investigating an Engineering Product

Level: **1 and 2**

Unit type: **Core**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how engineered products progress from an idea in a designer's head to the finished article ready for use? When a product is being designed to meet a need, crucial decisions must be taken. The designer must ask key questions about the product, for example what form might it take; what functions must it fulfil; what user and performance requirements must be included; and what materials should be used to make it fit for purpose.

Materials used in a product are not selected at random. From the thousands of options available, materials are chosen on the basis of their specific properties and whether they match the needs of the product.

When a product is manufactured, particular production processes are used so that component parts are made accurately, quickly and to the same high quality standards time after time. As part of the quality assurance (QA) process, quality control (QC) checks are carried out during manufacture on materials and component parts to ensure the finished product reaches users in the best possible condition.

In this unit you will investigate a manufactured product to learn what considerations a designer would keep in mind when writing a technical specification.

You will investigate the materials and commercial production processes used to manufacture the product, in order to learn why they were used in preference to others that might also have been appropriate. You will also learn how certain materials and processes can affect the environment.

In studying quality issues, you will come to understand how the quality of a product is assured throughout its manufacture, and you will learn how specific forms of quality control contribute to overall quality assurance.

Learning aims

In this unit you will:

A understand the performance requirements of an engineered product

B understand the selection of specific materials for use in the components that make up an engineered product

C understand the selection and use of manufacturing processes in an engineered product

D understand the quality issues related to an engineered product.

Learning aims and unit content

What needs to be learnt
Learning aim A: Understand the performance requirements of an engineered product
Topic A1: Technical specification Analysis of the chosen engineered product consisting of at least two components and production of technical specification criteria that covers the following key headings: Basic specification criteria: ● form (why is the product shaped/styled as it is?) ● function (what is the purpose of the product?) ● user requirements (what qualities make the product attractive to potential users?) Advanced specification criteria: ● performance requirements (what are the technical considerations that must be achieved within the product?) ● material and component requirements (how should materials and components perform within the product?) ● ease of manufacture ● ease of maintenance ● legal and safety requirements.
Learning aim B: Understand the selection of specific materials for use in the components that make up an engineered product
Topic B1: Selection of materials and components The materials used in the components of a chosen product and reasons for their selection for use, including: ● properties, e.g. aesthetic, mechanical, electrical, chemical ● qualities, e.g. cost, availability, durability, reusability, safety. **Topic B2: Environmental impact** Sustainability issues of using the materials identified in the chosen product in relation to the following: ● extraction and processing of raw materials ● disposal of products after their useful lifespan. **Topic B3: Alternative materials** Suitable alternative materials that could be used in the chosen product, including: ● advantages and disadvantages of alternatives ● comparison and contrast with the materials actually used.

What needs to be learnt
Learning aim C: Understand the selection and use of manufacturing processes in an engineered product
Topic C1: Selection of production processes The production processes involved in the manufacture of components in a chosen product, including: ● processes in reference to the manufacturing needs of the product ● how each process meets the manufacturing need. **Topic C2: Environmental impact** The impact on the environment of the production processes used in the manufacture of components in the product including: ● energy and resources used during production ● waste production and pollution as a result of production. **Topic C3: Comparing production processes** Comparison between two processes used in the manufacture of components in the product including: ● advantages and disadvantages of each process.
Learning aim D: Understand the quality issues related to an engineered product
Topic D1: Quality control (QC) The specific quality-control checks that could have been used on an engineered product to ensure its quality and performance at one or more of the following stages: ● materials supply ● production ● assembly. **Topic D2: Quality assurance (QA)** The quality assurance system that could have been used on an engineered product, including: ● when and where quality-control checks take place ● what the checks consist of ● how they form part of the overall quality-assurance system ● fitness for purpose in terms of product meeting specification criteria.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Understand the performance requirements of an engineered product			
1A.1 Identify relevant basic specification criteria for an engineered product.	2A.P1 Outline relevant basic and advanced specification criteria for an engineered product.	2A.M1 Explain the importance of basic and advanced specification criteria for an engineered product.	
Learning aim B: Understand the selection of specific materials for use in the components that make up an engineered product			
1B.2 Identify materials used in two component parts of an engineered product, stating engineering properties for each.	2B.P2 Describe the engineering properties, qualities and environmental impact of materials in two components of an engineered product and suggest alternatives.	2B.M2 Compare and contrast the materials used in two components in an engineered product with reference to engineering properties, qualities, environmental impact and alternatives.	2B.D1 Evaluate the fitness for purpose of materials used in two components of an engineered product in relation to possible alternative materials making reference to properties, qualities, environmental impact and alternatives.
Learning aim C: Understand the selection and use of manufacturing processes in an engineered product			
1C.3 Outline two production processes used in the manufacture of components in an engineered product.	2C.P3 Describe two production processes used in the manufacture of components in an engineered product.	2C.M3 Explain reasons for the selection and use of two production processes used in the manufacture of components in an engineered product.	2C.D2 Compare and contrast the production processes used in the manufacture of components in an engineered product in terms of their environmental impact and the manufacturing need.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim D: Understand the quality issues related to an engineered product			
1D.4 Identify quality-control (QC) checks that could be made during the manufacture of an engineered product.	2D.P4 Explain how quality control (QC) checks can help to improve the quality of an engineered product.		
1D.5 Outline the quality-assurance (QA) system that could be used during the manufacture of an engineered product.	2D.P5 Explain why a specific quality-assurance (QA) system should be used during the manufacture of an engineered product.	2D.M4 Analyse the fitness for purpose of a quality-assurance (QA) system for an engineered product.	2D.D3 Evaluate the use of the quality-control (QC) checks and quality-assurance (QA) systems for an engineered product.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

Learners will need access to engineered products to complete this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Learners should either choose, or be provided with, a modern engineered product to enable them to complete the assessment of this unit. Products must have two or more components which provide the potential to understand different materials and processes.

Level 2 learners will be able to fully describe basic and advanced specification criteria, and describe material properties and manufacturing processes suggesting alternatives. Quality checks, and how they coordinate in a quality assurance process, should also be understood. Merit criteria require learners to explain reasons for their choices. For Distinction, learners will be able to compare and contrast materials and processes against fitness for purpose criteria.

Learners producing level 1 evidence will be able to identify basic specification criteria for their product, as well as the materials used and their properties. Learners should be able to outline the production processes and quality-assurance checks used.

Evidence is likely to be in the form of assignment work but could also be oral evidence accompanied by an observation record, and may include, for example, photographic evidence of the disassembly and labelling of products.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1	Product Performance	A local engineering company has asked you/your group to investigate an appropriate engineered product and identify, outline and explain: ● why it is shaped as it is ● what its function is – whether it works ● what would make users choose the product and why ● the technical attributes that the product has that make it fit for purpose.	An investigation of the product's performance using information presented under formal headings. (One side of A3)
1B.2, 2B.P2, 2B.M2, 2B.D1	Materials and Components	The manager of the company has asked you to develop your investigation by disassembling the product and discussing component parts, describing qualities and properties, environmental impact and possible alternatives.	An investigation of the product's materials and components using technical information. Photographic evidence of any product disassembly/labelling of components. (One side of A3)
1C.3, 2C.P3, 2C.M3, 2C.D2	Manufacturing Processes	The manager is happy with your work and would also like you to discuss manufacturing processes to determine which ones were used during manufacture of the product components.	An investigation of the product's manufacturing processes using technical information and diagrams of processes. (One side of A3)
1D.4, 2D.P4, 1D.5, 2D.P5, 2D.M4, 2D.D3	Quality	You have been asked to explain reasons for quality control checks and quality assurance, suggesting what checks would be made on your product and how checks could improve quality.	An investigation of the product's quality issues using technical information. (One side of A3)

Unit 3: Health and Safety in Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

The ability to work safely in an engineering environment is essential for your own wellbeing and that of others. This unit will help you to understand health and safety requirements and to know how to prepare and carry out an activity safely in your engineering work space. In this way, you can enjoy all the challenges that engineering activities can offer without undue fear for your own safety or for that of others.

The initial focus of the unit is on gaining awareness of the dangers of not working within appropriate legislation and procedures. In the event of an incident, it is essential that you know how to respond. This unit will take you through the important legislation and policies that you need to know.

You will then consider how materials and equipment should be handled and the most appropriate personal protective equipment (PPE) to use when undertaking particular engineering activities. Identifying risks is an important activity here.

The knowledge and understanding gained through studying this unit will be put to good use in other areas of engineering study and working life.

Learning aims

In this unit you will:

A understand safe and effective working in an engineering workplace

B know how to follow procedures and undertake a work activity safely.

Learning aims and unit content

What needs to be learnt
Learning aim A: Understand safe and effective working in an engineering workplace
Topic A1: Accident and emergency procedures Understand the accident and emergency procedures to be followed in response to an incident in an engineering workplace, including: ● identification of appropriately qualified persons, including first aider, fire warden ● actions in the event of an accident or emergency, including use of fire extinguishers (types and applications), types and sounding/initiating of emergency alarm, evacuation procedure and escape routes, location of first-aid facilities ● identifying and using procedures to be followed in the event of dangerous occurrences or hazardous malfunctions of equipment, processes or machinery ● reporting routines, e.g. assembly points, hazards and malfunctions, injury, near-miss occurrences ● accident and emergency procedure document, including brief summation of contents, purpose, legal requirements, possible improvements, e.g. in usage, format, visibility. **Topic A2: Working safely in an engineering organisation** Understand safety procedures to be followed in an engineering working environment, including: ● handling materials and equipment in an approved manner and in line with the most current legislation/regulations: Health & Safety at Work Act and related legislation, Personal Protective Equipment at Work Regulations, Manual Handling Operations Regulations, Use of Work Equipment Regulations, Display Screen at Work Regulations, Control of Substances Hazardous to Health (COSHH), Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), relevant workplace policies and procedures ● the roles and responsibilities of the employer, including compliance with legislation, policy and procedures, health, safety and wellbeing of employees ● the roles and responsibilities of employees, including own and others' health, safety and security; compliance of the workplace with legislation, policy and procedures.

What needs to be learnt
Learning aim B: Know how to follow procedures and undertake a work activity safely
Topic B1: Materials and equipment handling Know how personal and protective equipment should be used for an engineering activity, including: ● Personal Protective Equipment at Work Regulations ● personal protective equipment (PPE): overalls for general workshop activities, eye protection for a range of machinery and equipment, skin care (barrier creams, gloves), protective hat where required, protective footwear for general workshop activities, masks/respirators for areas with poor ventilation or dust, hearing protection (ear plugs, ear defenders), PPE manufacturers' guidelines for use. **Topic B2: Risks and risk assessment** Defining a hazard: ● A hazard is something that can cause an adverse effect. The hazard could be an object, a property of a substance, a phenomenon, or an activity, e.g. moving parts of machinery, sharp objects, electricity, slippage and uneven surfaces, dust and fumes, handling and transporting, contaminants and irritation, material ejection, fire, working at height, environment, pressure/stored energy systems, volatile or toxic materials, unshielded processes. Defining risk: ● A risk is the likelihood that a hazard will actually cause its adverse effect, together with a measure of the effect, e.g. tools, materials or equipment in use, spillages of oil and chemicals, not reporting accidental breakages of tools or equipment, and not following working practices and procedures. Steps of a risk assessment are to: ● identify the hazard ● decide who might be harmed ● evaluate the risk and decide on precautionary measures ● record findings and prepare to implement them ● review and update the assessment. *continued*

What needs to be learnt
Topic B3: Engineering work activity Preparing the working environment prior to an engineering activity and completing an engineering activity safely. Preparing the working environment, including: ● ensuring that work area is free from hazards ● selecting and using, correct and appropriate personal protective equipment (PPE), and hygiene procedures ● obtaining and understanding drawings/work instructions and manufacturers' instructions ● obtaining suitable tools and carrying out checks to ensure that they are safe and in a usable condition. Completing an engineering activity safely in a working environment, including: ● implementing safety procedures ● completing all tasks and documentation ● using tools and equipment safely, and only for the purpose intended ● maintaining a tidy workplace, with exits and gangways free from obstruction ● taking measures to protect others from harm resulting from any work that they are carrying out ● returning drawings/work instructions and tools upon completion ● disposing of unusable tools, equipment, components and waste materials (oil, soiled rags, swarf/offcuts, etc).

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Understand safe and effective working in an engineering workplace			
1A.1 Outline the actions that need to be taken if there is an accident in an engineering workplace.	2A.P1 Explain how accident and emergency procedures are used in an engineering workplace.	2A.M1 Explain the importance of following accident and emergency procedures in response to an incident in an engineering workplace.	
1A.2 Identify the key features of legislation, policy and procedures for an engineering workplace. #	2A.P2 Outline the roles and responsibilities of self and others under the legislation, policy and procedures required for an engineering workplace. #	2A.M2 Explain the roles and responsibilities of self and others under the legislation, policy and procedures required for an engineering workplace. #	2A.D1 Explain the importance of employees and employers adhering to correct legislation, policy and procedures in an engineering workplace. #

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Know how to follow procedures and undertake a work activity safely			
1B.3 Outline procedures for handling materials and equipment for a given engineering activity.	2B.P3 Describe the personal protective equipment to be used when handling materials and equipment in an engineering workplace.	2B.M3 Explain why personal protective equipment is required for different processes in an engineering workplace.	2B.D2 Evaluate personal protective equipment in an engineering workplace, reporting how well the PPE manufacturer's guidelines adhere to the appropriate regulations.
1B.4 Identify risks associated with one engineering activity.	2B.P4 Complete an accurate risk assessment for one engineering activity. #		
1B.5 Prepare the work area appropriately for a given engineering activity.	2B.P5 Prepare for, and carry out, an engineering activity safely.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a workshop environment and the range of tools required to carry out engineering work activities (essential)
- access to relevant legislation and regulations applicable to the working environment, emergency procedures and policies, including access to computers and the internet to enable learners to research current legislation and regulations (as required).

Assessment guidance

This unit is assessed internally by the centre, and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Much of the assessment evidence for this unit could come from practical activities. These can be carried out solely for the purpose of this unit but, equally, could be the activities associated with other units.

Risk assessment evidence should come from an assessment of an engineering work activity. It is important for learners to understand that risk assessment should be undertaken prior to all new work activities. However, if learners are undertaking practical units in this qualification, which also require assessment of risk, they should **not** use the same evidence for this unit.

Learners could assess the policies and procedures related to an engineering workplace in the educational context, or that of an engineering employer.

Level 2 learners should be able to act independently when assessing risks, outlining procedures and undertaking activities. Evidence for a risk assessment could come from completion of a Health and Safety Executive (HSE) template. Learners should show that they are aware of the main points included in procedures; they do not need to reproduce documents. At Merit and Distinction level, learners should be able to develop a critical perspective on procedures, explaining their importance and making suggestions for improvements, either in content or usage. They should also be able to report on the effectiveness of PPE manufacturers' guidelines.

At level 1, learners will produce evidence that shows their basic knowledge and understanding of health, safety, accident and emergency procedures. They should be able to prepare a workplace for an activity.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	Accident and Emergency Procedures and Workplace Roles and Responsibilities	You have just started work in an engineering workplace and have been asked by your team leader to investigate: relevant workplace legislation, policy and procedures, your own responsibilities and those of others.	A written report or presentation.
1B.3, 1B.4, 1B.5, 2B.P3, 2B.P4, 2B.P5, 2B.M3, 2B.D2	Preparing for and Carrying Out an Engineering Activity	You have been asked to prepare for and carry out a new engineering work activity. You need to investigate the personal protective equipment (PPE) needed, complete an assessment of risks and carry out the activity safely.	Teacher observation record of the preparation and execution of the task. A written report that evaluates PPE requirements.

Unit 4: Engineering Maintenance

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

When a car breaks down, or will not start, it is often because it has been poorly maintained. Similarly, if the central heating at a school or college fails to heat the rooms properly or leaks water, it is probably down to insufficient maintenance. A lack of maintenance can be dangerous – and it can also be very expensive; if a car manufacturing production line stops, the costs can be in excess of £20,000 per minute until production resumes. It is therefore vital for modern manufacturing organisations to have effective maintenance planning and procedures in place to guarantee reliable and safe operation of the plant and equipment.

In this unit you will learn about engineering maintenance, including the different strategies that organisations use when maintaining their plant and equipment. You will also investigate the causes of engineering equipment failure and the effects this failure can have.

The repair and adjustment of an engineering plant and its equipment and machinery is vitally important, in order to ensure that they continue to perform their intended functions.

You will be introduced to the features of engineering systems that determine reliability, safety and maintainability. In order to demonstrate the principles, you will resource, plan and carry out a practical maintenance activity on an engineering product or system.

Learning aims

In this unit you will:

A know about causes and effects of equipment failure and types of maintenance procedures

B be able to resource and plan a maintenance activity on an engineering product or system

C be able to carry out a maintenance activity safely on an engineering product or system.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about causes and effects of equipment failure and types of maintenance procedures
Topic A1: Causes and effects Causes and effects, including: ● causes – age, wear, vibration, corrosion, fouling, environment, lack of maintenance ● effects – decreased productivity, increased cost, health and safety of users, environmental impacts. **Topic A2: Types of planned maintenance procedures, their features and benefits** Recognition of planned maintenance procedures, including: ● routine maintenance ● total preventative maintenance (TPM) ● predictive maintenance ● condition monitoring ● calibration. Benefits, e.g. increased productivity, health and safety of users, better fuel use. **Topic A3: Types of unplanned maintenance procedures, their features and impacts** Recognition of unplanned maintenance procedures, including: ● emergency ● run to failure ● condition-based ● post-fault. Impacts, e.g. cost, increased risk of further unplanned maintenance.

What needs to be learnt
Learning aim B: Be able to resource and plan a maintenance activity on an engineering product or system
Topic B1: Identification of resources Identification and selection of appropriate resources for a planned maintenance activity, e.g.: ● permit to work ● personal protective equipment/health and safety considerations ● maintenance checklists ● equipment manuals ● fault-finding aids ● appropriate spares/materials/consumables ● appropriate test equipment and tools ● machine/process records ● production schedules ● handover documents. **Topic B2: Maintenance planning** The purpose and features of elements of a straightforward and detailed maintenance plan for a planned maintenance activity on an engineering product or system. Straightforward maintenance plan, including: ● frequency of maintenance ● identification of planned repairs/replacements ● identification of risks and associated hazards, identification of and inclusion of controls. Detailed maintenance plan (in addition to the straightforward maintenance plan), e.g.: ● environmental issues ● estimation of costs ● reasons for selecting different frequency rates for specific maintenance – on shift/daily/weekly/monthly/yearly routines ● downtime for maintenance ● impact on other systems. Engineering product, e.g.: ● garden machinery (mower, strimmer or hedge cutter) ● bench drill ● lathe ● compressor. Engineering system, e.g.: ● lighting system ● fluid/plumbing system ● safety system ● computer network.

What needs to be learnt
Learning aim C: Be able to carry out a maintenance activity safely on an engineering product or system
Topic C1: Maintenance activity Safely undertake a maintenance activity, using maintenance documentation to plan the activity, on an engineering product or system. Use maintenance documentation to carry out a maintenance activity, including: ● identifying risks and associated hazards and implementing controls ● manufacturers' manuals, drawings, charts and diagrams, checklists, planning sheets, instructions, schedules ● using and recording information, e.g. maintenance logs, manufacturers' records, other records ● handover documents ● fault-finding aids. Types of checks, e.g.: ● visual checks, e.g. leakage, damage, missing parts, overheating, wear/deterioration ● fault-finding techniques, e.g. six point, half split, input/output, unit substitution ● mechanical checks, e.g. correct operation of moving parts, correct working clearance of parts, belt/chain tension, bearing loading, torque loading of fasteners ● electrical checks, e.g. continuity, polarity, protective conductor resistance value, voltage levels, load current, inductance; electronic checks such as resistance, capacitance, waveform, frequency values, amplification, signal.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about causes and effects of equipment failure and types of maintenance procedures			
1A.1 Describe the causes of engineering equipment failures.	2A.P1 Explain the causes and effects of engineering equipment failures.		
1A.2 Outline the key differences between planned and unplanned maintenance procedures.	2A.P2 Describe types of planned and unplanned maintenance procedures.	2A.M1 Explain the benefits of planned maintenance procedures and the impact of unplanned maintenance procedures.	
Learning aim B: Be able to resource and plan a maintenance activity on an engineering product or system			
1B.3 Identify the resources required to carry out a planned maintenance activity on an engineering product or system.	2B.P3 Describe the resources required to carry out a planned maintenance activity on an engineering product or system.	2B.M2 Explain why resources are required to carry out a planned maintenance activity on an engineering product or system.	2B.D1 Justify the resources and planning used to carry out a planned maintenance activity on an engineering product or system.
1B.4 Produce a straightforward maintenance plan for an engineering product or system.	2B.P4 Produce a detailed maintenance plan for an engineering product or system.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to carry out a maintenance activity safely on an engineering product or system			
1C.5 Carry out a maintenance activity on an engineering product or system. *	2C.P5 Carry out a maintenance activity on an engineering product or system and complete documentation. *#	2C.M3 Carry out a maintenance activity on an engineering product or system accurately, complete detailed documentation and describe the types of checks necessary. *#	2C.D2 Justify the use of documentation and checks carried out during a maintenance activity. *#

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- access to a workshop environment and appropriate equipment, systems, devices and components required to carry out engineering maintenance activities (essential)
- relevant manufacturers' service manuals, data sheets, parts lists, diagrams and drawings
- relevant test instruments, tools and safety equipment (as appropriate equipment), systems, devices and components used.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of learners' achievement of the learning aims and related assessment criteria could be collected from two assignments. These assignments could require learners to start with gaining an appreciation of the types of maintenance activities and the reasons why equipment failures occur. This could be followed by a maintenance activity that allows learners to plan and resource maintenance for a given product, which forms part, or all, of an engineering system. This planning phase should include assessing the potential risks and hazards of carrying out the activity. Finally, they could carry out the maintenance activity. Learners could follow the plan they have developed in 2B.P4 or could be supplied with a different plan.

Centres are required to select one of the engineering products or systems from the range given in the unit content. Systems should be non-complex. If a centre chooses to use a complex product such as a motorbike or car, for example, it might be appropriate for learners to look at a sub-assembly such as the braking system.
This could be considered to be a non-complex engineering system.

Due to the practical nature of this unit, evidence such as detailed and referenced teacher observation records, oral questioning and annotated photographs should supplement other forms of evidence, such as written responses, completed checklists and presentations. This direct evidence of process skills should be planned, documented and recorded appropriately and with the level of detail required to show that the full maintenance activity has been carried out appropriately. Learners should evidence, in addition, appropriate health and safety awareness, with assessments of risks completed before any practical activities are carried out.

Level 2 learners are expected to use maintenance documentation when carrying out the maintenance activity. Written evidence of the work carried out, completed documentation, adjustments made to documentation and process, parts fitted and consumables used should be provided.

When describing the causes of equipment failure, level 1 learners could provide their evidence in the form of a checklist, where given examples of failure are cross-referenced to the likely cause. Alternatively, examples that illustrate the failures could be used, combined with verbal questioning of learners, with a record of their responses being used as evidence. When producing their maintenance plan for 1B.4, level 1 learners need only indicate the frequency of maintenance and identify which elements will be checked/repaired/replaced, although they will be expected to incorporate any health and safety elements. When carrying out the maintenance activity, level 1 learners will be expected to work safely. They should demonstrate that, typically, they are able to disassemble/dismantle parts, check for wear/ alignment and adjust as necessary; lubricate parts, replace faulty or worn parts
and ensure parameters are to the required specifications.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1,	Engineering Maintenance Purposes, Procedures and Resources	You have been asked by your manager to describe and explain the reasons for a range of failures in engineering products, and to explain maintenance strategies used in order to minimise repeat failures.	Written statements outlining and explaining the causes and effects of engineering component failures in a variety of case studies. Written statements describing maintenance strategies and specific procedures that could be used to minimise these failures.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.D1	Resource and Plan Out a Maintenance Activity	Your manager has asked you to plan a specific maintenance activity, for presentation to maintenance technicians. The plan is to be used in the maintenance of a sequence of identical components, with the first in the sequence being used as a demonstration.	A portfolio of work that includes identification of the resources, health and safety requirements and the maintenance plan for the engineering product/system, with appropriate justification. A presentation, including photographic evidence showing the maintenance activity being carried out, with commentary explaining the procedure and documentation being used/ completed, and the reasoning for these choices.
1C.5, 2C.P5, 2C.M3, 2C.D2	Carry Out a Maintenance Activity	Your manager has asked you to carry out a maintenance activity and complete documentation.	Practical demonstration, with authentication and witness testimony.

Unit 5: Engineering Materials

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how large commercial aircraft take off and fly thousands of passengers and their luggage to destinations around the world? The answer lies in the ability of skilled engineers to successfully identify and use a range of materials that combine a number of factors, such as strength to weight ratio, cost and availability. Engineering technicians need to be able to identify materials that are specified on engineering drawings, production plans and servicing schedules. Some materials, such as copper and lead, have a distinctive appearance, but others are not so easy to tell apart. This is particularly true of the different grades of steel, polymers, composites, brass and aluminium alloys. Very often, an engineering technician has to select raw materials in the form of wire, bars, sheet, tube and plate and also components such as rivets, nuts and bolts from stores. It is essential for engineers to select the correct material if a product or a replaced component is to be fit for its intended purpose.

This unit will develop your knowledge of a range of common materials you may encounter in engineering, as well as their properties, uses, availability, and how they contribute to a sustainable environment.

You will be expected to identify a range of ferrous, non-ferrous and non-metallic materials and know about the form in which they are obtained. You will also need to know about the properties that make individual materials suitable for particular tasks. You will need to know about the way in which materials are colour coded when stored, as well as other material identification standards that are commonly used, such as the British and European Standard classifications. Armed with this knowledge, and using information, abbreviations and symbols supplied on engineering drawings, you will then be able to select the correct form and size of the material specified for a particular application. You will conduct some tests, to investigate properties of materials and their suitability in engineering applications. You will also be introduced to the sustainability issues that surround the use of a range of engineering materials and come to understand how this is a major consideration when developing products for the present day and in the future.

Learning aims

In this unit you will:

A know about the properties of common engineering materials and selection for engineering applications

B know about the supply and sustainable use of engineering materials and selection for an engineering product or activity.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the properties of common engineering materials and selection for engineering applications
Topic A1: Types of engineering materials ● Ferrous metals, e.g. low and medium carbon steels, high carbon steels, stainless steel and cast iron o applications include – cutting tools, e.g. drills (carbon steel), cutlery and medical instruments (stainless steel), castings and manhole covers (cast iron). ● Non-ferrous metals, e.g. aluminium, copper, zinc, brass, lead, titanium, tungsten carbide, superalloys (nickel-based and cobalt-based) and ceramics (boron carbide and cubic boron nitride) o applications include – aircraft components and kitchenware (aluminium), electrical wiring, cables and pipes (copper), anti-corrosion coatings and batteries (zinc), locks, gears, valves and door knobs (brass), building and construction, weights and radiation shielding (lead), aerospace, military, mobile phones and sporting goods (titanium), industrial machinery, tools and abrasives (tungsten carbide), aerospace and automotive components (superalloys), high performance mechanical and industrial applications, e.g. abrasive cutting tools, nuclear reactor control rods, anti-oxidant refractory mixes and tank armour (boron carbide, cubic boron nitride). ● Composite materials, e.g. plywood, glass reinforced plastic (GRP), medium density fibreboard (MDF) carbon fibre and Kevlar® o applications include – floors and roofing (plywood), boats, automobiles, hot tubs, water tanks, roofing, pipes and cladding (GRP), building material, e.g. furniture and kitchen cabinets (MDF), bicycle tyres, racing sails and body armour (Kevlar®). ● Thermoplastics, e.g. acrylic, polyvinyl chloride (PVC), polythene (PET), polystyrene, nylon and polycarbonate o applications include – aquariums, aircraft windows and motorcycle helmet visors (acrylic), sewage pipes, plumbing pipes, clothing and upholstery, electrical cable insulation and inflatable products (PVC), packaging, e.g. plastic bags, plastic films and foam insulation (PET), disposable cutlery, plastic models, CD and DVD cases, disposable foam cups, smoke detector housings and insulation for packaging (polystyrene), bristles for toothbrushes, strings for musical instruments, threads, ropes, filaments, nets, hosiery and knitted garments (nylon), electrical and telecommunication components, domelights, flat/curved glazing, sound walls, sunglass/eyeglass lenses, lightweight luggage, computer cases and food/drink containers (polycarbonate). ● Thermosetting polymers, e.g. formica, melamine, epoxy resin and polyester resin o applications include – kitchen worktops (formica), kitchen utensils and plates (melamine), moulds, laminates, casting, fixtures, coating and adhesives (epoxy resin), marine construction materials, automotive and aircraft components, luggage, furnishings, textiles and packaging (polyester resin). *continued*

What needs to be learnt

- Smart materials, e.g. shape memory alloys (SMAs), shape memory polymers, electrochromic, piezoelectric, quantum tunnelling composite (QTC)
    - o applications include – surgical equipment, dental braces, oil line pipes and eyeglass frames (SMAs), window frame seals, helmets, small scale surgical products (shape memory polymers), smart windows, information displays and eyewear (electrochromic), production and detection of sound, generation of high voltages, electronic frequency generation, ignition source for cigarette lighters and push-start propane barbecues (piezoelectric), electrically conductive clothing (QTC).

Topic A2: Properties of materials

- Mechanical, e.g. density, tensile strength, shear strength, hardness, toughness/brittleness, malleability/ductility, elasticity and plasticity.
- Electromagnetic, e.g. electrical conductivity, electrical resistance, paramagnetism/diamagnetism/ferromagnetism.
- Chemical, e.g. resistance to corrosion and environmental degradation, reactivity.
- Thermal, e.g. melting point, thermal conductivity and thermal expansion.

Topic A3: Suitability of materials in engineering applications

- Simple mechanical tests e.g. tensile/ductility test (loading a suspended wire specimen and recording the breaking load and amount of permanent extension), shear strength test (using bench shears or tin snips), hardness test (centre punch, file or saw used to assess surface hardness or a test in which a hardened steel ball bearing is dropped from a given height and its rebound measured to assess surface hardness), impact test (striking a specimen held in a vice with a hammer and noting its effect).

Topic A4: Heat treatment processes

- Processes that rely on heating to a certain temperature, time at that temperature, speed of cooling, for ferrous materials e.g. annealing, normalising, hardening, tempering, case hardening.

Learning aim B: Know about the supply and sustainable use of engineering materials and selection for an engineering product or activity

Topic B1: Selection for applications

Selection through activity, e.g. design, construction, manufacture, operations, or maintenance.

Selection through use in a product, e.g. an engineered product consisting of multiple production methods and forms of supply, such as a bicycle or office chair.

Topic B2: Sustainable use of materials

- Raw materials extraction and processing.
- Lower volatile organic compounds.
- Reducing material use.
- Reusing materials and products where applicable.
- Recycling materials or using recycled materials.
- Waste management.

What needs to be learnt
Topic B3: Forms of supply ● Symbols, abbreviations and identification coding, e.g. International Organisation for Standardisation (ISO), British Standards Institution (BSI) materials coding system, suppliers' and organisations' colour codes. ● Material selection, e.g. bright drawn mild steel bar, solid diameters, pipe/tube diameters and wire gauges. ● Metal forms, e.g. bar stock, sheet materials, pipe/tube, wire, plate, rolled steel sections, pressings, castings, ingots, forgings and extrusions. ● Polymers/composite forms, e.g. sheet, pipe/tube, mouldings, powders, granules, resins and film. ● Size, e.g. diameters, thickness and gauge. ● Surface finish, e.g. bright drawn, cold drawn, plated, painted and plastic coated.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the properties of common engineering materials and selection for engineering applications			
1A.1 Identify an example of each type of material used in given engineering applications.	2A.P1 Describe examples of each type of material and the properties of these materials in engineering applications.	2A.M1 Explain the choice of material for engineering applications.	2A.D1 Compare advantages and disadvantages of material choices for engineering applications.
1A.2 Carry out a simple mechanical test on an engineering material	2A.P2 Carry out a range of simple mechanical tests on engineering materials and interpret the results		
1A.3 Describe a heat treatment process to alter a ferrous materials property.	2A.P3 Describe two heat treatment processes that alter a ferrous materials properties.		
Learning aim B: Know about the supply and sustainable use of engineering materials and selection for an engineering product or activity			
1B.4 Outline the environmental impact of a given engineering product or activity.	2B.P4 Describe sustainable use of materials in a given engineering product or activity.	2B.M2 Assess whether materials have been used sustainably in an engineering product or activity.	2B.D2 Analyse the sustainability of an engineering product or activity, including materials used and forms of supply. *
1B.5 Identify the forms of supply for materials in an engineering product or activity. *	2B.P5 Select appropriate forms of supply for materials in a given engineering product or activity. *	2B.M3 Justify the selected forms of supply for materials in an engineering product or activity. *	

*Opportunity to assess mathematical skills #Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- a range of materials in their different forms of supply for identification and demonstration purposes
- a variety of finished components, which illustrate the application of particular materials
- standard workshop tools and equipment used for informal testing, engineering drawings, parts lists and service manuals to assist learners in the identification of materials.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of achievement of the learning aims and assessment criteria may be obtained from well-planned investigative assignments or reports of workshop activities. Alternatively, it may be accumulated by learners building a portfolio from investigations and observations in the workplace or through realistic exercises and tests. In either case, the opportunity should exist for learners to achieve Merit and Distinction grades with relevant and sufficient evidence to justify the grade awarded. It is anticipated that integrative assignments might be used to link this unit with other, more practical or project related, units in the programme. If this approach is adopted, the evidence for the specific learning outcomes and associated assessment criteria will need to be clearly and separately identified.

To achieve learning aim A at level 2, learners must consider at least two examples of each type of material and the use of each example for appropriate applications. Learners should undertake tests to determine mechanical properties. A PowerPoint presentation could be used to specify the materials and their associated properties.

Level 1 learners will identify one example of each type. Evidence of this could come from a completed checklist. Learners will carry out one test but will not relate this to the materials in the content. They should also be able to describe one heat treatment process.

To achieve learning aim B, learners should be presented with an engineering product or activity with multiple production processes and forms of supply. Learners could be asked to produce an A3 poster detailing the environmental impact of production.

Learners could create a presentation specifying the forms of supply and sustainable use of materials for a chosen engineering product or activity. Learners could prepare supporting notes for the presentation, justifying the forms of supply and sustainable methods used.

A case study for a given engineering product or activity could be studied in depth to examine the materials and methods used for construction or development. A report could be produced that evaluates the chosen materials and methods of sustainability and puts forward measures for improvement.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3 2A.P1, 2A.P2, 2A.P3 2A.M1 2A.D1	Properties of Engineering Materials and their Applications	You have been asked by your supervisor to prepare a presentation to your peers about different types of engineering materials, their properties and their applications. You will conduct some tests on the materials and interpret the results. You will be asked to describe some heat treatment processes.	PowerPoint® presentation. Materials list. Report.
1B.4, 1B.5 2B.P3, 2B.P5 2B.P4, 2B.M3 2B.D2	Identifying Engineering Materials	You are an engineer working for a local bicycle manufacturer, and are asked to investigate the production process of a bicycle. In your investigation you will identify the materials used and the possible impacts of the development on the environment. You will come up with suggestions to reduce the environmental impact. You will select the most appropriate forms of supply for the materials in a bicycle.	Table of abbreviations, codes and symbols. A3 poster. PowerPoint® presentation and notes. Report.

Unit 6: Computer-aided Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered what computer-aided engineering (CAE) is and how it is used in engineering and manufacturing? Computer-aided design (CAD) and computer-aided manufacture (CAM) are two key CAE technologies that have replaced some traditional techniques in engineering manufacture. By using computer technology in their manufacturing systems, products and service engineering industries can remain competitive in the modern global economy.

In this unit, you will be given opportunities to learn about CAE by designing and producing drawings of a simple component and circuit using CAD. You will also produce a CAE component using CAM software linked to computer-controlled machine tools.

You will use CAD software to design and create a working drawing of an engineering component. In addition, you will demonstrate the many uses of CAD software by creating a simple circuit diagram – either electrical/electronic, hydraulic or pneumatic – using standard component symbols. You will then convert the CAD data into a computer numerical control (CNC) program using appropriate techniques.

Once the CNC operating program is developed, you will use it to produce a component, setting work coordinates and tooling/work holding as required to enable production. Then, you will check the component for quality in terms of its accuracy.

Learning aims

In this unit you will:

A use a CAD system to produce engineering drawings

B use a CAM system to manufacture an engineering component.

Learning aims and unit content

What needs to be learnt
Learning aim A: Use a CAD system to produce engineering drawings
Topic A1: Use of a CAD system to produce an engineering drawing Use the basic and advanced features of a CAD system, including: ● basic drawing commands and editing commands to produce and erase lines, circles, text ● outputting to a printer/plotter device ● appropriate tools to allow accurate geometry definition ● manipulation of views, including zoom and pan options ● saving the drawing data in an appropriate format ● modification and manipulation of drawn features, including scaling, revolving/rotating, copying/duplicating and moving ● dimensioning and hatching ● drawing template, typically to include a border, title block, projection, scale, drawing number, title of drawing, material, names of drawing creator and who checks/authorises the drawing ● produce drawings to BS8888 standards ● further CAD commands, including erase, stretch, trim, scale; absolute, relative and polar co-ordinates, features, e.g. type of line, grid, snap, circle, text, hatch, zoom-in, zoom-out. **Topic A2: Use of a CAD system to produce a circuit diagram** Circuit design techniques using a CAD system, including: ● basic drawing, insertion and editing commands to produce and erase circuit components and connections ● outputting to a printer/plotter device ● appropriate tools to allow accurate geometry definition ● standard symbols used in circuit diagrams ● saving the drawing data in an appropriate format ● circuit diagrams to standard, e.g. BS EN 60617, BS 2917 ● annotation of circuit diagrams to include component name or description ● CAD commands, including copy/duplicate, move, rotate/revolve, erase, stretch, trim, scale; absolute, relative and polar co-ordinates, features, e.g. type of line, grid, snap, circle, text, hatch, zoom-in, zoom-out.

What needs to be learnt
Learning aim B: Use a CAM system to manufacture an engineering component
Topic B1: Use of a CAM system Component features of a CAM system, including: ● how CAM programs are loaded into a CNC machine, e.g. turning centres, milling machines, machining centres, fabrication machines, electrical discharge machining (EDM – die and wire machines), grinding, rapid prototyping/3D printing ● production of components ● comparison of components produced against specification, conformity with the design specification, e.g. unilateral and bilateral tolerances, direct measurement, use of measurement equipment, e.g. rulers, callipers, micrometers, slip gauges ● cutting tool data and machining information ● use of CAD drawings to produce files suitable for use by a CAM system ● tool changes, 3D co-ordinate systems, efficient cutter paths ● conversion of cutter path data into CNC code.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Use a CAD system to produce engineering drawings			
1A.1 Produce a CAD drawing of an engineering component using a CAD system.	2A.P1 Produce a fully dimensioned CAD drawing of an engineering component using basic and further CAD commands and BS conventions.		
1A.2 Produce a circuit diagram using a CAD system.	2A.P2 Produce a circuit diagram fully labelling all components using basic and further CAD commands and BS conventions.		
1A.3 Identify drawing and modification commands used to produce engineering component and circuit diagrams.	2A.P3 Describe drawing and modification commands used to produce engineering component and circuit diagrams.	2A.M1 Explain the importance of drawing and modification commands and the benefits when used to produce engineering components and circuit diagrams.	2A.D1 Justify the use of CAD in the production of engineering component drawings and circuit diagrams.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning Aim B: Use a CAM system to manufacture an engineering component			
1B.4 Load CAD data from a drawing into a CNC machine in order to produce an engineering component.	2B.P4 Produce an engineering component by converting CAD data into an appropriate CNC program and loading the program into a CNC machine.		
1B.5 Check a component, produced using a CNC machine, for conformity with the design specification. *	2B.P5 Describe how the component produced meets the design specification. *	2B.M2 Simulate component production, identify improvements in programs and suggest solutions.	2B.D2 Evaluate CAM as a means of producing different engineered components.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- Access to a computer-aided design facility, including computers loaded with appropriate CAD software. In addition, access to a printer/plotter to produce hard copies would assist in assessment.
- Computer-controlled machines. These might be CNC machines, such as lathes, milling machines, routers, and laser cutters; although other machines such as rapid prototyping/3D printers would also be beneficial. It is important that learners have access (for assessment) to at least one type of computer-controlled machine that can be programmed or accept the data developed from a CAD drawing, where they can, for example, set the offsets/tool changes and feeds/speeds. Where resources are not directly available, it may be possible to engage local industry, colleges or universities to support the delivery of this unit.

Assessment guidance

This unit is assessed internally by the centre, and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of learners' achievement of the learning aims and related assessment criteria could be collected from two assignments. These assignments could require learners to produce evidence such as a portfolio of drawings and records of activities in a workshop environment, where the use of computer-controlled machines and the use of CAM software can be shown. Due to the practical nature of this unit, evidence such as learner observation records, screenshots, oral questioning and annotated photographs could supplement other forms of evidence. This direct evidence of process skills should be planned, documented and recorded appropriately. In addition, appropriate health and safety awareness should be evidenced by learners, with risk assessments being checked, before any practical activities are undertaken.

For learning aim A, drawings should be saved, in an appropriate format, to an appropriate storage device or network system. Learners should print or plot hard copies of the final drawings to an appropriate scale, and it would be expected that, whilst not necessarily being fully dimensioned, overall sizes would be indicated on the drawing. While a printed version of the final drawing/drawings would be expected, screen shots showing drawing development could be used as supporting evidence.
A commentary should be provided, detailing the techniques that can be used.

For learning aim B, learner observations, witness testimonies, and annotated photographs could be used as evidence.

Level 2 learners should produce a drawing of an engineering component and a circuit diagram using a full range of commands as shown in the unit content and which meets British Standards. They will need to describe these commands. They should also be able to convert CAD data into an appropriate program for loading on to a CNC machine. Although many different CNC machines could be available, only one needs to be used for the manufacture of the engineering component. At this level the learner would also need to describe how the manufactured component is fit for purpose.

Level 1 learners should produce a drawing and circuit diagram using a basic range of CAD commands and would be able to identify those used. They will need to load the data into a CNC machine and check the manufactured component against the design specification (drawings etc).

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance, and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1	CAD Component Drawing	Your manager has asked you to produce a CAD drawing of a given component using basic and further CAD commands. This needs to include a supporting presentation describing the range of CAD drawing and modification tools used across a range of drawings and the use of BS conventions. You will need to justify the use of CAD in the production of these drawings.	A portfolio containing a drawing or drawings, including: ● screen grabs ● written statements ● annotations. Supporting evidence for higher grades should include teacher observations and presentation slides.
1A.2, 2A.P2	Circuit Diagram	Your work was well received and, as a result, your manager has asked you to produce a circuit diagram using basic and further CAD commands, fully labelling all components using appropriate BS conventions.	A printout or plot of a circuit constructed using CAD techniques.
1A.3, 2A.P3, 2A.M1, 2A.D1	Drawing and Modification Techniques	You have been asked to describe drawing and modification commands to a colleague.	A checklist with commands and explanations.
1B.4, 1B.5, 2B.P4, 2B.P5, 2B.M2, 2B.D2	Safe Use of Computer-aided Manufacture Techniques	To conclude, your manager has asked you to produce an engineering component using CNC techniques, including a simulation of the activity. You will also need to identify errors, and suggest solutions as well as be able to justify the use of CAM in an engineering environment. You should describe how your component is fit for purpose.	A portfolio containing a range of evidence, including teacher observations/witness testimonies, annotated photographs/screen grabs, presentation slides. This should be accompanied by evidence of component manufacture and software simulation. In addition, presentation slides outlining the key advantages to the organisation of using CAM techniques should be provided.

Unit 7: Machining Techniques

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Did you know that you can use lathes or milling machines and drills in different ways when you are machining engineered products? The machines that you will use as part of this unit are some of the most important pieces of engineering equipment. Most modern Computer Numerically Controlled (CNC) machine tools have been developed from conventional lathes, milling machines and drills.

This unit will help you to understand the engineering processes that we use to generate and form shapes through machining techniques.

You will learn how to select, investigate and use machining techniques that involve shaping or forming with loss of volume. You will also use work-holding devices and a range of tools so that you can carry out a variety of machining processes.

You will learn how to set the machines before you use them and how to monitor the machines while you are using them. You will also learn how to inspect the items you produce for compliance and accuracy.

Health and safety is vital. Therefore, you will also learn how to operate machinery safely.

Learning aims

In this unit you will:

A select and use tools and work-holding devices for drilling and for turning or milling

B make workpieces using drilling and turning or milling techniques safely.

Learning aims and unit content

What needs to be learnt
Learning aim A: Select and use tools and work-holding devices for drilling and for turning or milling
Topic A1: Tools Tools for specific drilling and turning or milling techniques: ● for drilling – simple tools, e.g. centre drill, drill bit; more complex tools, e.g. flat-bottomed drill, counterboring tool, countersinking tool, reamer, tap ● for turning – simple tools, e.g. turning tools, facing tools; more complex tools, e.g. form tools, parting off tools, single point threading, boring bar, recessing tool, centre drill, twist drill, reamer, tap, die, knurling tool ● for milling – simple tools, e.g. face mills, end mills; more complex tools, e.g. slot drills, slotting cutters, slitting saws, profile cutters, twist drills, reamer, boring tools ● tooling materials – high-speed steel, cobalt steel, tungsten carbide, diamond. **Topic A2: Work-holding devices** Work-holding devices for drilling and for turning or milling: ● for drilling – simple work-holding device, e.g. machine vice; more complex work-holding devices, e.g. clamping direct to machine table, angle plate, vee block and clamps. ● for turning – simple work-holding device, e.g. three jaw chuck with hard jaws; more complex work-holding devices, e.g. four jaw chuck with hard jaws, centres (live or dead), faceplate, fixed steady or travelling steady ● for milling – simple work-holding device, e.g. machine vice; more complex work-holding devices, e.g. clamping direct to machine table, angle plate, vee block and clamps, indexing head/device, rotary table.

What needs to be learnt
Learning aim B: Make workpieces using drilling and turning or milling techniques safely
Topic B1: Features of the workpiece Use of drilling and turning or milling techniques for producing features in a workpiece: ● for drilling – simple features, e.g. through holes, blind holes; more complex features, e.g. flat-bottomed holes, counterbored holes, countersinking, reaming, tapping ● for turning – simple features, e.g. flat faces, parallel diameters; more complex features, e.g. stepped diameters, tapered diameters, drilled holes, bored holes, reamed holes, profile forms, internal threads, external threads, parting off, chamfers, knurls, grooves, undercuts ● for milling – simple features, e.g. flat faces, square faces; more complex features, e.g. parallel faces, angular faces, steps/shoulders, open-ended slots, enclosed slots, recesses, tee slots, drilled holes, bored holes, profile forms, serrations, indexed or rotated forms. **Topic B2: Machining parameters** Parameters for drilling and turning or milling techniques: ● for drilling – positional, e.g. position of workpiece, position of tool in relationship to workpiece; dynamic, e.g. tooling revolutions per minute (speed), linear feed rate (feed), swarf clearance ● for turning – positional, e.g. position of workpiece, position of tools in relationship to workpiece; dynamic, e.g. workpiece revolutions per minute (speed), linear feed rate (feed), depth of cut for roughing and finishing, swarf clearance ● for milling – positional, e.g. position of workpiece, position of tools in relationship to workpiece; dynamic, e.g. milling cutter revs per minute (speed), linear/table feed rate (feed), depth of cut for roughing and finishing, swarf clearance. **Topic B3: Checks for compliance and accuracy** Checks for accuracy relevant to drilling and turning or milling techniques: ● for drilling – visual checks, e.g. workpiece to be free from false tool cuts, burrs and sharp edges removed; specific checks, e.g. dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface texture 1.6μm (63 μin), reamed holes within H8, screw threads BS medium fit ● for turning – visual checks, e.g. workpiece to be free from false tool cuts, burrs and sharp edges removed; specific checks, e.g. dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6μm (63 μin), reamed or bored holes within H8, screw threads BS medium fit, angles within +/- 1.0 degree ● for milling – visual checks, e.g. workpiece to be free from false tool cuts, burrs and sharp edges removed; specific checks, e.g. dimensional tolerance equivalent to BS EN 22768-1 or BS 4500, surface finish 1.6μm (63 μin), flatness and squareness within 0.125mm per 25mm, angles within +/- 1.0 degree. *continued*

What needs to be learnt
Topic B4: Working safely General safety awareness while carrying out drilling and turning or milling techniques, including: ● alertness to moving parts ● ensuring machine guards are in place ● use of emergency stop ● machine isolation ● wearing appropriate personal protective equipment (PPE) ● keeping a clean and tidy work area ● removing burrs or sharp edges ● identification of risks, associated hazards and their control. Safe working practices relevant to drilling and turning or milling techniques: ● for drilling – handling drilling tools, tool breakage procedure, swarf handling and disposal, cutting fluids ● for turning – handling turning tools, tool breakage procedure, swarf handling and disposal, backlash in machine slides, cutting fluids ● for milling – handling milling tools, tool breakage procedure, swarf handling and disposal, backlash in machine slides, cutting fluids.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Select and use tools and work-holding devices for drilling and for turning or milling			
1A.1 Outline the functions of simple tools used for drilling and turning or milling.	2A.P1 Describe the functions of simple and complex tools used for drilling and turning or milling.	2A.M1 Explain why particular tools and work-holding devices are useful for different drilling and turning or milling tasks.	2A.D1 Evaluate the effectiveness of tools and work-holding devices for different drilling and turning or milling tasks.
1A.2 Use simple tools for accurate drilling and turning or milling.	2A.P2 Select and use simple and complex tools for accurate drilling and turning or milling.		
1A.3 Use a simple work-holding device for accurate drilling and turning or milling.	2A.P3 Select and use simple and complex work-holding devices for accurate drilling and turning or milling.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Make workpieces using drilling and turning or milling techniques safely			
1B.4 Set positional parameters before machining workpieces by drilling and turning or milling techniques.	2B.P4 Set positional parameters before machining and set and monitor dynamic parameters during machining by drilling and turning or milling techniques.		
1B.5 Produce two given machined workpieces that demonstrate simple features of drilling and turning or milling techniques. *	2B.P5 Produce two machined workpieces that demonstrate simple and complex features of drilling and turning or milling techniques. *	2B.M2 Demonstrate high levels of precision and accuracy when using drilling and turning or milling techniques. *	2B.D2 Assess own levels of precision and accuracy, identifying strengths and weaknesses and safe working practices. *
1B.6 Describe and carry out visual checks made for compliance on a machined workpiece according to instructions.	2B.P6 Describe and carry out visual and specific checks carried out for compliance and accuracy when producing the machined workpieces.	2B.M3 Explain why it is important to carry out checks on the accuracy of workpiece features both during and after manufacture.	
1B.7 Demonstrate safe practice when using drilling and turning or milling techniques.	2B.P7 Demonstrate consistency in safety awareness and safe working practices when machining workpieces.	2B.M4 Explain the importance of safe working practices when using drilling and turning or milling techniques.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to centre lathes and/or vertical milling machines and pedestal drills/pillar drills/drill presses, as required by the learning aims and unit content
- auxiliary equipment (such as that listed under ‘work-holding devices’ and ‘tools’)
- a range of equipment suitable for measuring the accuracy of the workpieces to be machined.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

For this unit, learners need to provide evidence of either turning or milling, as well as drilling machining techniques. It is not necessary or appropriate for learners to cover all three machining techniques.

Learners need to provide a variety of evidence to demonstrate competence. This evidence could be in the form of witness statements, detailed learner observation records, annotated photographs or drawings of components and diaries/logs.

For 2B.P4 and 2B.P5, level 2 learners must use both drilling and turning or milling techniques to correctly set up and machine two given workpieces, in order to produce two different simple features and at least four different complex features for both the techniques covered and as defined by the workpieces.

It would be advisable to provide each learner with two working drawings – one for a turned/milled component and one for a drilled component.

For 1B.4, level 1 learners need to set the workpiece position (for example, the length of bar from a lathe chuck) and tool position (for example, the centre height on a lathe) prior to machining. To achieve 1B.5, learners need to produce two different simple features, such as through and blind holes for drilling, as defined by the unit and the two simple features for the chosen technique, such as flat faces and parallel diameters for turning or flat and square faces for milling.

A similar approach and interpretation should be taken when setting tasks for the criteria associated with learning aim A. However, there is also a need for level 2 learners to describe the functions of a range of tools and for level 1 learners to outline the functions of simple tools.

The evidence for 1B.6/2B.P6 is likely to be in the form of descriptions and a table of recordings/checks/measurements, with annotated photographs confirming that checks took place, both in-process and on the final workpieces. The tasks provided for learners should make it clear that these checks should not only take place when a given workpiece is complete, but that ongoing in-process checks are also required.

In the same way, evidence for 1B.7 and 2B.P7 is likely to be in the form of observation records or witness statements supplemented by annotated photographs of safe working.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.D1	Work-holding Devices and the Use/Types of Machining Tools	An employer has asked you to undertake some work with turning/milling and drilling machinery. In preparation, you have been asked to outline and describe the functions of tools and the selection of work-holding devices.	A written response with diagrams. Witness statements, detailed learner observation records, annotated photographs, diaries/logs, and a written response with annotated photographs. Written explanation and evaluation.
1B.4, 1B.5, 1B.6, 1B.7, 2B.P4, 2B.P5, 2B.P6, 2B.P7, 2B.M2, 2B.M3, 2B.M4, 2B.D2	Parameters, Techniques, Safe Working Practices and Accuracy Checks when Machining Workpieces	An employer wants you to start work. You need to: ● set/monitor parameters before/during machining ● describe how to carry out workpiece accuracy checks during/after machining and explain why it is important ● carry out workpiece compliance/accuracy checks ● machine two workpieces ● demonstrate safe working practices.	Witness statements, detailed learner observation records, annotated photographs, diaries/logs, and a written response with annotated photographs. A table of recordings plus annotated photographs. Observation/witness statements, detailed learner observation records, annotated photographs, diaries/logs.

Unit 8: Electronic Circuit Design and Construction

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

In our world, we are surrounded by electronic devices that make life safer, more comfortable, more entertaining and more convenient.

Have you ever wondered how something as small as a mobile phone can do so much, or how computers can retrieve information from anywhere in the world in seconds? None of the things we take for granted, such as watching television, listening to the radio, downloading music to personal devices or playing computer games, would be possible without the work of electronic engineers. Programmable domestic devices such as washing machines and microwave ovens use electronic control and on a larger scale the UK's military, financial, communication and commercial business systems rely on state-of-the-art electronics to operate successfully.

Almost all electronic circuits can be broken down into input, process and output blocks and you will learn to recognise and use some of the components that are classified in this way. You will learn about their function and application and how they can combine to make more complex electronic systems.

You will learn to design electronic circuits using input, process and output building blocks to solve problems and you will build circuits, working safely, and using permanent construction methods. You will also learn how to ensure that your construction methods are effective and are carried out using appropriate circuit boards.

In order to check the function of the circuits you have built, you will learn how to test them using appropriate test equipment.

Learning aims

In this unit you will:

A know about electronic systems design

B design and construct electronic circuits using electronic building blocks

C know how to populate circuit boards permanently and construct electronic circuits safely

D test and evaluate electronic circuits.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about electronic systems design
Topic A1: Input components Identification, function and application of input components used in electronic circuits, including: ● sensors – light dependent resistor (LDR), thermistor (negative temperature coefficient – NTC), moisture sensor, piezo electric sensor ● switches – toggle, slide, rocker, push-to-make, push-to-break, key, micro, tilt. **Topic A2: Process components** Identification, function and application of process components used in electronic circuits, including: ● transistor (NPN and PNP) ● Darlington Pair ● thyristor ● field effect transistor (FET) ● 555 timer – in monostable and astable modes ● operational amplifier (Op-Amp) ● Peripheral Interface Controllers (PICs): how to program PICs using flowcharts to switch outputs on and off from input signals, create routines to control outputs with delays, and repeat loops and counts. **Topic A3: Output components** Identification, function and application of output components used in electronic circuits, including: ● lamp/bulb ● buzzer ● light emitting diode ● loudspeaker ● motor ● 7-segment display. **Topic A4: Passive components** Identification, function and application of passive components used in electronic circuits, including: ● fixed resistor (including resistor colour code and British Standard BS 1852, EN 60062), coding method to determine resistor values and tolerance ● variable resistor ● polarised capacitors ● non-polarised capacitors ● diode – used as a protective device against back voltage from electro-magnetic components ● relay – used as an interface between primary and secondary circuits. *continued*

What needs to be learnt
Topic A5: Power Power supplies, units of measurement and calculations for electronic circuits. Identification, characteristics, application and advantages/disadvantages of power supplies used in some electronic circuits, including: ● batteries – zinc-carbon, alkaline, NiCad rechargeable, button cells ● low voltage power supply units – PSU ● solar power – when powering low current circuits. Units of measurement: ● current (amp) ● resistance (ohm) ● voltage (volt) ● power (watt). Application of the units and formulae when calculating values relating to electronic circuits, including: ● simple calculations: o Ohm’s law – V = I x R in parallel circuits consisting of two resistors o resistors in series – Rtotal = R1 + R2 + R3 etc. o time period – t = R x C o power – W = I x V ● complex calculations: o Ohm’s law – V = I x R in series circuits consisting of two resistors o resistors in parallel – Rtotal = (R1 x R2)/(R1 + R2).

What needs to be learnt
Learning aim B: Design and construct electronic circuits using electronic building blocks
Topic B1: Circuit design Design an electronic circuit using input, process and output components, for example: ● a low temperature alarm that will give a warning when the temperature falls below a pre-set level, including – o input – thermistor and fixed/variable resistor o process – single transistor/Darlington Pair/Op-amp o output – buzzer/LED/lamp ● a timing circuit that gives a flashing LED or pulsing sound output after a set time period, including – o input – capacitor and variable resistor o process – 555 timer (monostable), 555 timer (astable) o output – LEDs/loudspeaker ● a circuit to count people passing through a sports stadium barrier, including – o input – push-to-make switch and fixed resistor o process – programmed PIC o output – 7 segment display. **Topic B2: Circuit board construction** Applications, advantages/disadvantages and construction of a circuit using an appropriate circuit board, including: ● prototyping board (breadboard) ● stripboard (veroboard) ● printed circuit board (PCB) ● mass production, miniaturisation and surface mount technology (SMT). *continued*

What needs to be learnt
Learning aim C: Know how to populate circuit boards permanently and construct electronic circuits safely
Topic C1: Circuit soldering techniques Use appropriate techniques for soldering components into an electronic circuit and dealing with exposed component legs, including: ● soldering using multi-core lead-free soldering technique to avoid dry joints ● tinning component legs and multi-strand wire using heat sinks and shunts ● using IC sockets and heat shrink sleeving or insulation tape. **Topic C2: Risk assessments** Specify risks and control measures appropriate to the engineering activity (handling soldering equipment), including: ● identifying hazards ● deciding who might be at harm and how ● evaluation of the risks and appropriate control measures ● recording of findings and implementation ● full Health and Safety Executive (HSE) risk assessment.
Learning aim D: Test and evaluate electronic circuits
Topic D1: Testing electronic circuits Testing and evaluating electronic circuits to check voltage levels, continuity and current, and to identify and diagnose faults, including use of: ● a voltmeter or multimeter to measure voltage levels across components and power supplies in a circuit ● an ohmmeter or multimeter to check for continuity in circuit tracks and wires, and to detect breaks and bridges in connections ● an ammeter or multimeter to measure current levels in a circuit ● a logic probe to test digital signal levels when using PICs.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about electronic systems design			
1A.1 Describe the function and characteristics of electronic input, process, output and passive components.	2A.P1 Select and apply appropriate input, process and output, and passive components for a circuit.	2A.M1 Explain reasons for the selection of electronic input, process, output and passive components.	2A.D1 Justify the selection of appropriate input, process and output components in a circuit design to solve a given electronics problem.
1A.2 Carry out simple calculations using units of current, resistance, voltage and power.	2A.P2 Describe the characteristics of power supplies and carry out simple and complex calculations using units of current, resistance, voltage and power in electronic circuits. *		
Learning aim B: Design and construct electronic circuits using electronic building blocks			
1B.3 Identify components in a given circuit diagram.	2B.P3 Describe the design features of a simple circuit diagram that uses input, process and output components.	2B.M2 Explain the operation of the circuit in terms of its input, process and output components.	2B.D2 Explain the limits of operation of the circuit in terms of its input, process and output components.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Know how to populate circuit boards permanently and construct electronic circuits safely			
1C.4 Identify the main hazards and people at risk when using soldering equipment.	2C.P4 Describe the risks associated with identified hazards when using soldering equipment.	2C.M3 Explain, with reference to particular soldering activities, the risks involved and record appropriate control measures.	2C.D3 Using a full risk assessment, evaluate all activities in the production of electronic circuits.
1C.5 Identify the main features of a given electronic circuit.	2C.P5 Describe the main features of an electronic circuit and the construction techniques.	2C.M4 Compare the advantages and disadvantages of different circuit construction techniques.	
Learning aim D: Test and evaluate electronic circuits			
1D.6 Use a test meter to accurately measure the voltage of a power supply. *	2D.P6 Test voltage levels at specific points in an electronic circuit when in use. *	2D.M5 Use a range of measurements to test the performance of an electronic circuit. *	2D.D4 Use a range of measurements to evaluate the performance of an electronic circuit. *
1D.7 Identify basic faults in an electronic circuit.	2D.P7 Diagnose faults in an electronic circuit.		

*Opportunity to assess mathematics

Teacher guidance

Resources

The special resources required for this unit are:

- a range of electronic circuit input and passive components that can be used to form potential dividers when constructing circuits
- a range of electronic circuit processing components that can be used as amplifying devices in electronic circuits
- a range of output components
- general and specialist tools and equipment for constructing electronic circuits.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Although learners are assessed individually, it is quite acceptable for them to share equipment.

For learning aim A at level 2, learners must be able to select appropriate input, process, output and passive components, which could be used in a circuit represented by, for example, a block diagram. This diagram could include statements such as ‘cold sensing potential divider’, ‘high gain amplifier’, and ‘loud audible output’. Learners should be able to: select an appropriate sensor and series resistor to respond to falling temperature; select a processing component or components that would produce a very high amplification; or select an output component that would give a loud audible output. Evidence could be in the form of annotation written on the block diagram presented to learners. At Merit, learners must give reasons for choices, and explain them. At Distinction, learners will solve a specific problem.

For 2A.P2, learners must describe the characteristics of power supplies and show evidence of carrying out at least one of each calculation. Evidence could be in the form of worksheets or a test.

For learning aim A at level 1, learners will describe key functions and characteristics without applying these to specific circuit design. Evidence could be in the form of a completed worksheet.

For 1A.2, simple calculations as specified in the content should be carried out.

For learning aim B at level 2, learners will describe the design features of the circuit, with increasing levels of explanation of components at Merit and Distinction. Evidence could be in the form of an annotated design, a completed circuit and witness testimony authenticating the work and could also be supported by annotated photographs.

Learners will construct the circuit, with increasing levels of explanation of components at Merit and Distinction. Evidence could be in the form of an annotated design, a completed circuit and witness testimony authenticating the work and could also be supported by annotated photographs.

For learning aim B at level 1, learners will identify components in a given circuit with support. The circuit plan can be provided by the tutor. Learners must identify components on the circuit design, so the design, correctly annotated by the learner, could be evidence of assessment.

Evidence for learning aim C is likely to be in the form of a report, photographs of outcomes along with witness statements, or learner observation records supported by annotated photographs. Evidence at level 2 will include a full assessment of risks, and increased precision in the creation of the circuit.

At level 1, learners must be able to use tools and equipment to build a simple circuit that functions as intended. They must be able to place polarised components into a circuit board in the correct orientation and use effective soldering techniques that avoid ‘dry’ joints.

For learning aim D, assessment could be in the form of circuits with planned faults. Evidence will include learner observation records and witness statements, annotated diagrams of the circuits to show measurements taken, annotated photographs of the process and use of test meters etc. The level of accuracy and scope of testing increases in Merit and Distinction. The Merit requirement includes testing the overall circuit performance and an evaluation of the performance.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1, 1A.2, 2A.P2	Using Electronics to Give Warning of a Temperature Increase in a Greenhouse	You have been asked to make an electronic device for use in a greenhouse to give a warning when the temperature becomes too hot. You will be given a mixture of components (including passive components) to sort into categories. These are then to be used in conjunction to create potential dividers, time delays etc. The function and characteristics of each component are described. You need to select and apply electronic input, process and output components to match the needs of the device for the greenhouse, and explain and justify your choices. You need to find out about and report on different types of power supplies used to power low current electronic circuits. The list includes zinc carbon, alkaline, NiCad batteries, button cells transformed mains power packs and solar cells. Finally, you need to carry out calculations of resistance, voltage and current using Ohm's law and to carry out calculations of total resistance of resistors connected in series, parallel and in resistor networks.	Worksheet, investigation and written report, log. Investigation and written report.

Criteria covered	Assignment title	Scenario	Assessment evidence
1B.3, 2B.P3, 2B.M2, 2B.D2	Electronic Timer Design	A client requires an electronic timer that will accurately time up to five minutes in one-minute steps before giving an audible or visual warning that time is up. You should design and construct a circuit using discrete components or ICs and fully explain its operation.	Drawn and labelled circuit diagram with written description and explanation. Circuit drawn using circuit simulation software and tested virtually.
1C.4, 2C.P4, 2C.M3, 2C.D3, 1C.5, 2C.P5, 2C.M4	Designing a Permanent Circuit	You have been given a circuit diagram, which you need to use in conjunction with an appropriately selected type of circuit board to construct a fully functioning circuit, ensuring that safety hazards and risks are identified and control measures are in place. You should produce a report to describe, explain and evaluate safety issues.	Practical activity assessment through outcome. Photographic evidence. Written report on safety issues.
1D.6, 2D.P6, 2D.M5, 2D.D4, 1D.7, 2D.P7	Checking Circuit Function	You have been asked to look at functioning and non-functioning circuits, and have been set the task of measuring voltage levels and identifying and diagnosing faults. More complex circuits are presented that contain ICs or PICs and a range of measurements are taken to test and evaluate the performance of the circuits.	Practical demonstration with commentary. Observation record.

Unit 9: Interpreting and Using Engineering Information

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **External**

Unit introduction

Have you ever wondered how modern Formula 1 racing cars are manufactured and assembled so accurately and quickly? The rapid development of such a precise piece of engineering requires skilled engineers to read, interpret and understand engineering drawings and other types of engineering information and documentation with ease. The ability to understand and use information is one of the most critical skills required in engineering. This unit will enable you to know how to make effective use of textual, numeric, diagrammatic and graphical information when working with engineering drawings, technical manuals, reference tables etc in accordance with approved procedures. You will also consider how best to extract and interpret information from engineering drawings, work output and production documentation and other types of documentation such as production plans and schedules.

The first learning aim requires you to demonstrate that you know how to interpret engineering drawings, including symbols, associated terminology and other information relevant to manufacturing or production process operations, along with health and safety signage applied in an engineering environment. The second learning aim requires you to use engineering drawings, information and documentation, in a cared for and controlled way, relevant to, and in the context of, manufacturing or production process operations.

Learning aims

In this unit you will:

A know how to interpret drawings and other documentation

B be able to use information from drawings and related documentation.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know how to interpret drawings and other documentation
Topic A.1: Interpreting engineering drawings Characteristics, the key features, applications and the advantages/disadvantages of the following: ● working drawings – component, general assembly/sub-assembly, fabrication, welding, repair/modification, installation, exploded diagrams, wiring/circuit diagrams, orthographic projections (first and third angle drawings), isometric, oblique, drawing standards, company standardised layouts, e.g. title block, company logo, parts list ● graphical representations – sketches, schematic diagrams, flow charts, physical layout diagrams, illustrations from manufacturers' manuals. **Topic A.2: Interpreting drawing information** Characteristics, applications and reasons for use of drawing information: ● materials or components – location/orientation of parts (male/female parts), connections to be made, circuit characteristics (pressure, flow, current, voltage, speed) ● dimensional detail – physical dimensions, scale, tolerances, fixed reference points, surface texture ● manufacturing/production detail – processes or treatments, assembly sequence or installation requirements, fabrication, welding, repair/modification ● symbols and abbreviations – electronic/electrical components (resistors, switches, lamp, batteries, buzzers, motors, variable resistors, transistors, diodes, capacitors, LEDs and thermistors), mechanical components (nuts, bolts, screws, springs, pins, clips, keys, drive mechanisms), weld symbols (square butt, single v butt, single bevel butt, backing run, fillet, plug and spot), linear and geometric tolerances, hole details [radius (R or RAD), diameter (Ø or DIA), chamfer (CHAM), countersink (CSK), counterbore (CBORE), centreline (CL), internal (INT), external (EXT), pitch circle diameter (PCD)], linetypes (visible outline, hidden detail, centre lines, dimensions lines, extension lines, section cutting plane). **Topic A.3: Interpreting tasks and other information** Characteristics of tasks and use of and reasons for using information sources relevant to the task: ● relevant to a manufacturing or engineering process operation – product manufacture or modification, equipment installation or repair, system or service planning ● sources relevant to task – electronic component pin configuration specifications, standard reference charts for limits and fits, tapping drill reference charts, bend allowances required for material thickness, material specifications, manufacturers' data for the use of welding rods/bonding/finishing materials ● data sheets and books – resistor colour codes, manufacturers' data sheets for components, Zeus charts, machinery handbook. *continued*

What needs to be learnt
Topic A.4: Interpreting health and safety information Characteristics of, implications and the rules relating to health and safety signage from the following categories: ● mandatory – eye protection, ear protection, protective footwear, use of guard, protective gloves, face protection, switch off instructions ● safe condition – emergency stop, emergency exit, fire exit, first aid station, first aid, emergency eye wash, emergency telephone, assembly point ● warning signs – danger of death, caution, caution trip hazard, slippery surfaces, highly flammable, high voltage, biohazard, irritant, harmful, poison, risk of explosion.
Learning aim B: Be able to use information from drawings and related documentation
Topic B.1: Using work output and production documentation Characteristics, applications and advantages/disadvantages of information related to work output and production documentation and the implications for engineers/engineering organisations: ● manufacturing or engineering process operation – product manufacture/assembly/design, maintenance planning or procedure ● relevant to manufacturing or engineering process operation – job cards, test reports, quality control documentation. **Topic B.2: Using related documentation** Characteristics, applications and advantages/disadvantages of related documentation and the implications for engineers/engineering organisations: ● working instructions – operation sheets/job cards, test schedules, manufacturers' manuals for assembly/test/installation, weld procedure specifications ● production plan – sequence/description of operations, health and safety, materials and components, feeds and speeds, tools and equipment, quality control checks, timings ● schedule for manufacture – capacity, milestones, Gantt chart, critical path analysis ● quality control information – reference tables/charts, control charts (statistical process control and pareto). **Topic B.3: Using drawing and document care and control** Characteristics, applications and advantages/disadvantages of drawing and document care and control and the implications for engineers/engineering organisations: ● location and security – storage conditions, ICT systems, filing cabinets, access points and return procedures, reporting discrepancies in data and documents, computer systems, computer security ● physical handling – damage and effects from graffiti, cleanliness, folding methods ● document control – issue and amendment dates, part/pattern numbers, reporting of loss/damage.

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed externally using a paper-based exam that is set and marked by Pearson.

Examination format

The learner will complete a 60-minute examination worth 50 marks. The paper will consist of structured questions, each with sub-sections.

The examination consists of a variety of question types, including multiple-choice questions, short-answer questions and extended writing opportunity at the end of the examination paper.

The learner will need to demonstrate and apply their knowledge and understanding.

Unit 10: Mathematics for Engineering

Level: **1 and 2**

Unit type: **Mandatory**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered why engineers use mathematics to solve many of the problems that they encounter on a day-to-day basis? Think about a design engineer working on a new eco-friendly car that can run on batteries or diesel fuel. How far will it travel before the batteries need recharging? Should the diesel engine be used to charge the batteries or is it better to plug it in overnight? What is the weight of the car? How much steel will be needed to manufacture the body? These are all questions that can only be answered if the design engineer has the right data and is able to use mathematics to work things out.

The design engineer must be confident that the finished product will perform to specification. Before spending lots of money on setting up a production line and buying in raw materials, they create a mathematical model using numbers and computer simulation.

This unit is the starting point for you to gain the mathematical skills needed to solve many of the interesting challenges which car designers and other engineers face on a day-to-day basis. You start by looking at simple number work and then move on to consider equations and formulae, topics which engineers work with all the time – for example, Ohm's law (V = IR) and Newton's second law of motion (F = ma).

You will then investigate how to present and process engineering data relating to quantities that vary in relation to each other. For example, what happens to the current in a circuit if the voltage changes? How does the displacement of a moving object vary with time? These problems can often be visualised by first plotting a graph of the relationships and then interpreting the graph to find the solution.

Another useful technique that you need to know about is mensuration. This process involves working out the areas of regular and compound two-dimensional shapes, and also the volumes of regular and compound three-dimensional objects such as cylinders and spheres. The design engineer would use mensuration to work out the mass of a drive shaft (mass = volume × density). The final part of the unit is an introduction to trigonometry; working with triangles is useful to engineers when designing wood- or steel-framed structures. It enables them to work out the lengths of components and the angles at which they should be set.

Learning aims

In this unit you will:

A be able to use arithmetic, algebraic and graphical methods in engineering contexts

B be able to use mensuration and trigonometry in engineering contexts.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to use arithmetic, algebraic and graphical methods in engineering contexts
Topic A.1: Arithmetic methods Arithmetic methods: ● addition, subtraction, multiplication and division of whole and decimal numbers ● fractions and percentages ● use of a scientific calculator ● arithmetic precedence (BODMAS rule) – brackets, order, division, multiplication, addition, subtraction ● powers and roots of numbers ● expressing numbers using standard form and engineering notation ● substituting numerical values into simple engineering formulae and solving ● reasonable answers – approximations, significant figures, decimal places. Engineering contexts – at least two from, e.g.: ● number of products produced per hour on a machine ● cost of machining a product ● the gear ratio for a pair of spur gears ● compression ratio of an engine ● percentage error in a reading taken from an instrument being tested ● VAT to be added to an invoice ● percentage discount for a product produced in large quantities ● fuse rating of an electrical product ● tensile stress in a tie rod and expressing the answer in kPa ● spindle speeds and feed rates ● 'ballpark figure' for making a batch of components. **Topic A.2: Algebraic methods** Algebraic methods for solving engineering equations and evaluating engineering formulae: ● transposing linear equations and engineering formulae ● solving linear equations ● engineering equations, e.g.: $x + 3 = 8$, $6m + 11 = 25 - m$, $2(x+1) = 8$, $7/x = 2$, $4/t = 2/3$, $3x = 7(8 - 2x)$ ● substituting values into and evaluating engineering formulae ● simple engineering formulae: (electrical) $V = IR$, $P = VI$, $P = I^2R$; (gas) $PV = C$; (mechanical) $v = u + at$, $s = ½(u + v)t$, $\sigma = F/A$ ● complex engineering formulae: (electrical) $V = V_0 \sin 2\pi ft$, $X_c = ½ \pi fC$, $½QV = ½CV^2$, (gas) $PV^n = C$, (mechanical) $s = ut + ½at^2$, $v^2 = u^2 + 2as$, $½mv^2 = mgh$ ● chained calculations, e.g. $(\text{value } 1 + \text{value } 2)^n \times (\text{value } 3 + \text{value } 4)^{1/n}$, $(\text{value } 1 \times \text{value } 3)/(\text{value } 3 + \text{value } 4 + \text{value } 5)^n$. *continued*

What needs to be learnt
Engineering contexts – calculating at least two from: ● potential differences (pd) in an electrical circuit ● pressure when a gas is compressed ● time taken to lift and move a heavy object using an overhead gantry crane ● potential energy of an object ● kinetic energy of a moving vehicle ● the energy stored in an electrical capacitor. **Topic A.3: Graphical methods** Graphical methods: ● plotting a linear relationship from given data – axis labels, title, line of best fit ● plotting a linear relationship from given data and extracting/interpreting information – gradient, intercept and the law connecting the variables ● graph interpretation to determine engineering parameters, e.g. the stiffness of a spring, velocity of a moving body, resistance of an electrical circuit ● plotting a non-linear relationship from given data – e.g. gas law (PV = C), electrical power ($P = I^2R$), capacitor (exponential) discharge ($V = V_0e^{-t}$). Data from at least one of the following engineering contexts, e.g.: ● determining the stiffness of a spring ● determining the acceleration of a moving body ● investigating how the load carrying capacity of a beam varies in relation to its span ● investigating the charging and discharging characteristics of an electrical capacitor.
Learning aim B: Be able to use mensuration and trigonometry in engineering contexts
Topic B.1: Areas of regular and compound shapes Measurement of area: ● simple shapes – rectangle, triangle, circle ● objects with compound shapes – e.g. L-shaped bracket, I-section beam, trapezium, circular ring, rectangular plate with through hole(s). Measurement of area in at least one engineering context from given data, e.g.: ● amount of scrap produced after punching circular holes into sheet steel ● surface area of a heat sink fitted to an electronic amplifier ● surface area of a product to be chromium plated ● number of integrated circuits that can be fitted onto a breadboard given their foot print ● cross-sectional areas of I-section, L-section and T-section beams ● floor area of a workshop ● number of sheets of mild steel that are needed to make an extractor hood. *continued*

What needs to be learnt
Topic B.2: Volumes of regular and compound three-dimensional objects Measurement of volume: ● regular objects (hollow and solid) – rectangular prism, cylinder, cone, sphere ● compound objects (hollow and solid) – e.g. truncated cone, cylinder with hemispherical ends, cylinder with conical end, circular tube, I-beam. Measurement of volume in at least one engineering context from given data, e.g.: ● an oil storage tank ● a turned component ● a hot water cylinder which has a hemispherical top ● a compressed air receiver ● molten metal to be poured into a mould ● a standard section beam. **Topic B.3: Trigonometry** Using trigonometry: ● Pythagoras' theorem – side lengths of right-angled triangles ● relationships – right-angled triangle functions (sine, cosine, tangent), trigonometric relationship ($\tan\theta = \sin\theta/\cos\theta$) ● right-angled triangles – side lengths and angles ● non-right-angled triangles – side lengths and angles ● compound shapes – solve unknown dimensions and angles for a combined rectangle and triangle. At least one engineering context requiring use of trigonometry for finding the dimensions of, e.g.: ● roof trusses ● frameworks ● sheet metal panels ● cover plates and gaskets.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to use arithmetic, algebraic and graphical methods in engineering contexts			
1A.1 Using a scientific calculator, add, subtract, multiply and divide whole and decimal numbers, and calculate a percentage.*	2A.P1 With the aid of a scientific calculator, use arithmetic methods to evaluate data in two engineering contexts.*		
1A.2 Solve two linear equations and evaluate two simple formulae.*	2A.P2 Use algebraic methods to transpose and solve two linear equations and evaluate two simple formulae in engineering contexts.*	2A.M1 Transpose and evaluate complex engineering formulae in engineering contexts.*	2A.D1 Carry out chained calculations using a scientific calculator, justifying the sequence of arithmetic precedence in an engineering context.*
1A.3 Plot a linear relationship using given data.*	2A.P3 Using given engineering data, plot linear graphs and establish gradient, intercept and the law connecting the variables in an engineering context.*	2A.M2 Using engineering data, plot a non-linear graph and establish its gradient at a given point in an engineering context.*	

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Be able to use mensuration and trigonometry in engineering contexts			
1B.4 Find the areas of rectangles and triangles from given data.*	2B.P4 Find the areas of three simple and compound shapes from given data in an engineering context.*		
1B.5 Find the volumes of rectangular prisms from given data.*	2B.P5 Find the volumes of regular objects from given data in an engineering context.*	2B.M3 Find the volumes of compound objects in an engineering context.*	2B.D2 Systematically carry out area and volume calculations to a high degree of accuracy in an engineering context.*
1B.6 Find the hypotenuse lengths of right-angled triangles using Pythagoras' theorem.*	2B.P6 Use Pythagoras' theorem to find the missing lengths of right-angled triangles in an engineering context.*	2B.M4 Use trigonometry to find the dimensions and angles of right-angled triangles in an engineering context.*	2B.D3 Use trigonometry to find the dimensions and angles of complex engineering shapes and non-right angled triangles in an engineering context.*

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

There are no special resources needed for this unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Learners should be encouraged to use correct layout and accepted mathematical principles when presenting their evidence. It is important that full working out is shown so that a simple carry-through error – for example, misreading a value from given data – does not bar the learner from achieving the criterion.

For learning aim A at level 2, learners must use arithmetic methods to evaluate at least two engineering problems and ensure that the answers are reasonable. Learners are expected to use a calculator and should present their answers to a degree of accuracy specified by the assessor. Tasks set should test working with whole and decimal numbers, positive and negative numbers, fractions and percentages, bracketed values and the square/square root and cube/cube root keys of the calculator. Learners should present answers in decimal and fractional form and also be able to express numbers using standard form and engineering notation. They must transpose and evaluate formulae appropriate to an engineering context. Learners should work with numerical data sourced from experiments. Learners should also plot and present data and comment on what can be seen – for example, if the graph for an Ohm's law experiment is a straight line, then the law is proven. It is important that graphs are plotted using suitable axis scales and are fully annotated. They should be hand plotted and could be compared against spreadsheet-generated versions.

For learning aim B at level 2, learners must calculate the areas of shapes from given data. A good way to present this data would be in the form of drawings of simple engineering components to be manufactured from thin sheet metal. They must calculate the volume of three-dimensional solid or hollow objects from given data. A good way to present this data would be in the form of drawings. Dimensional units should be given, but if their calculations are correct, the learner should not be penalised if they apply the wrong units to their answer. For 2B.M3, learners must present some form of working out with their numerical answers. However, for 2B.D2 they must work in a methodical manner to a higher level of accuracy.

Learners must solve right-angled triangle problems. This should include working with Pythagoras' theorem to find the third side given two others and using the sine, cosine and tangent relationships to find side lengths and angles within triangles. It is important that the questions are set in an engineering context – for example, calculating the resultant of two forces acting at right angles.

Across the two learning aims, the higher levels of achievement (Merit and Distinction) require the learner to present evidence that demonstrates they are able to carry out more complex mathematical manipulation/calculation and can present their answers with higher levels of accuracy and presentation.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.3, 2A.P1, 2A.P3, 2A.M2	Arithmetic and Graphical Methods	You are an apprentice technician working in the test department of an engineering company. You have been asked to process a set of figures recorded during a proving test on a prototype product. Using calculations and graph plotting, you will be able to establish if the product is performing to specification.	Prepare a written report which contains solutions to a number of questions. Evidence produced under supervision.
1A.2, 2A.P2, 2A.M1, 2A.D1	Algebraic Methods	You are working on the design of a new type of hydraulically operated tail-gate lift for small delivery vans. You must calculate how big the various components must be to prevent failure under load. You must also find the flow rate of the hydraulic pump which makes the system work.	Prepare a written report which contains solutions to a number of questions. Evidence produced under supervision. For 2A.D1, an assessor observation record should support correct use of a calculator.
1B.4, 1B.5, 2B.P4, 2B.P5, 2B.M3, 2B.D2	Mensuration	An engineering business manufactures products from stamped aluminium sheet and turned components. To renegotiate their contract with the company that removes waste material for recycling, it is important to calculate the amount of off-cut(s) and swarf that will be produced over the next 12 months. Your manager asks you to calculate this figure.	Prepare a written report which contains solutions to a number of questions. Evidence produced under supervision. For 2B.D2, an assessor observation record should support correct use of a calculator.

Criteria covered	Assignment	Scenario	Assessment evidence
1B.6, 2B.P6, 2B.M4, 2B.D3	Trigonometry	You work as an estimator for a company which manufactures steel-framed structures and are preparing a quotation for a customer. Part of the calculation involves working out the total length of box section steel to be used.	Prepare a written report which contains solutions to a number of questions. Time-constrained and under supervision. For 2B.D3, an assessor observation record should support correct use of a calculator.

Unit 11: Electrical and Mechanical Science for Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered why most consumer products are so reliable and work so well? Think about a washing machine – it contains electrical and mechanical systems controlled by a programmer. Electronically operated valves regulate the flow of water into the machine; a multi-speed, multi-directional motor rotates the drum; a suspension system holds the tub in place and the whole assembly fits inside a metal casing. It is made up from components designed by electrical and mechanical engineers.

Think about what happens when a new model of washing machine comes off the assembly line; it will be put through a number of electrical and mechanical tests to see if it is safe and working as it should. The engineers who designed the new machine and the technicians who will test it must understand the principles of electrical and mechanical science. A principle is a law or rule that sets out how things work – for example, Ohm's law, which we use when calculating the current flowing in a circuit. Having done the calculation, we could set up the circuit using components and measure the current with a meter. Do the values correspond; if not, why not?

This unit is the starting point for you to learn how to solve problems in electrical and mechanical science using graphics and numbers.

You start by looking at electrical science: basic parameters such as voltage, current, power, magnetic field and magnetic flux. This then leads into electrical and magnetic circuits, the use of symbols to represent components, and ends with calculations – for example, working out the current, power and force on a conductor. This is followed by the study of static mechanical systems, investigating how forces act on objects and developing an understanding of how to keep an object in equilibrium.

You will investigate dynamic mechanical science: linear motion and the calculation of speed, velocity, acceleration and the power needed to move an object in a straight line. The final topic is an introduction to fluids and pressure measurement – for example, working out the pressure at the bottom of an oil tank or in a swimming pool.

Learning aims

In this unit you will:

A know about concepts and principles relating to electrical science

B know about concepts and principles relating to mechanical science.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about concepts and principles relating to electrical science
Topic A.1: Parameters of direct current circuits Voltage, current, resistance, power, electrical charge, electro-motive force, potential difference. **Topic A.2: Parameters of magnetic fields** Magnetic field, field around a current-carrying conductor, magnetic flux, flux density. **Topic A.3: Direct current electrical circuits** Electrical circuits and calculation of their parameters, including: ● circuit symbols – battery, fixed value resistor, switch, ammeter, voltmeter, lamp, variable resistor, fuse ● circuit diagram ● combining resistors in a series circuit, combining resistors in a parallel circuit ● Ohm's law ● current in a series circuit, current in a parallel circuit ● circuit power, potential difference, currents and potential differences in combined series/parallel circuits. **Topic A.4: Magnetic circuits** Application of magnetic circuit theory, including: ● interaction between a current-carrying conductor and magnetic field ● force on a current-carrying conductor (F = BIL) ● torque produced by the armature of a simple DC motor (T = nBILd) ● construction and operation of a product that uses electro-magnetism to make it operate, e.g. solenoid valve, relay, DC motor.

What needs to be learnt
Learning aim B: Know about concepts and principles relating to mechanical science
Topic B.1: Parameters of static and dynamic mechanical systems Mass, Earth's gravity, weight, force, pressure, density, relative density, moment of a force, displacement, velocity, acceleration/retardation, limiting coefficient of kinetic friction, work done, power. **Topic B.2: Statics** Finding forces in engineering contexts using graphical methods, including: ● concurrent coplanar forces ● parallelogram of forces ● resultant force ● space diagram ● vector diagram ● triangle of forces ● polygon of forces ● equilibrant force ● principle of moments ● static equilibrium of a body. **Topic B.3: Linear motion** Linear motion in engineering contexts, including: ● distance, time, speed, graphical representation of distance against time ● displacement, graphical representation of displacement against time, velocity ● acceleration, graphical representation of velocity against time, formulae for calculating uniform acceleration and retardation, limiting coefficient of kinetic friction, frictional resistance to motion ● work done, power. **Topic B.4: Fluids and gases** Properties and behaviour of fluids and gases, including: ● atmospheric pressure ● gauge and absolute pressure ● density ● acceleration due to gravity (g) ● pressure at depth in a fluid ● pressure measurement using a U-tube manometer.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about concepts and principles relating to electrical science			
1A.1 Identify parameters of direct current circuits.	2A.P1 Define parameters of direct current circuits.#		
1A.2 Identify parameters of magnetic fields.	2A.P2 Define parameters of magnetic fields.#		
1A.3 Draw a simple series DC circuit and calculate the total resistance, current and power.	2A.P3 Draw a series and a parallel DC circuit and determine total resistance, potential difference, current and power for each.*	2A.M1 Find total resistance, potential difference, current and power in a combined series/parallel circuit.*	
1A.4 Describe the interaction between a current-carrying conductor and a magnetic field.#	2A.P4 Find the force on a current-carrying conductor situated in a magnetic field from given data.*	2A.M2 Find the torque produced by the armature of a simple DC motor.*	2A.D1 Compare the construction and operation of two types of electro-magnetic coils in the context of engineered products.#

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Know about concepts and principles relating to mechanical science			
1B.5 Identify parameters of static and dynamic mechanical systems.	2B.P5 Define parameters of static and dynamic mechanical systems.#		
1B.6 Using a graphical method find the resultant of two concurrent coplanar forces from given data.*	2B.P6 Using a graphical method find the resultant and equilibrant of a system of concurrent coplanar forces from given data.*		
1B.7 Produce a velocity/time graph from given data.*	2B.P7 Find the uniform acceleration and retardation of a body by plotting and interpreting a velocity/time graph from given data. *	2B.M3 Describe the conditions required for the static equilibrium of a body.#	2B.D2 Calculate the work done and power dissipated in moving a body of given mass along a horizontal surface at constant velocity.*
1B.8 Describe gauge and absolute pressure.	2B.P8 Describe gauge and absolute pressure and calculate the pressure at depth in a fluid from given data.*	2B.M4 Describe how a U-tube manometer would be used to measure gas pressure.#	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are science software packages suitable for level 2 programmes, including:

- electrical circuit simulation
- electro-magnetism simulation
- forces simulation
- movement simulation
- fluids simulation.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Learners should work in a supervised environment and where appropriate be given access to a formulae sheet and data sources. It is expected that learners will use correct mathematical conventions; they must also use the correct symbols and units of measurement when presenting evidence for tasks which have numerical answers. It is important that full working out is shown so that a simple carry-through error – for example, misreading a value from given data – does not bar the learner from achieving the criterion being addressed. Some criteria are addressed through tasks involving diagrams/sketches and written text; it is acceptable to use graphics clipped from data sources (these must be acknowledged) but the writing that goes with them must be the learner's own work. Definitions cut and pasted from the web are not acceptable evidence. At level 2, it is expected that where a 'definition' is called for, the writing will be more detailed than at level 1. At level 1, a learner can just make very basic statements when asked to 'identify'.

For learning aim A at level 2, learners should present full definitions for all of the parameters in the topic lists A.1 and A.2. For each parameter the learner should give a full description and state its symbol (e.g. I for current) and its S.I. unit (e.g. V for potential difference). Use of diagrams to support the written definitions should be encouraged, but a diagram on its own would not be sufficient evidence.

At least two direct current circuits should be looked at: series and parallel. Each should have, as a minimum, three resistors, a battery and a switch. The learner should be given a list of components and be asked to draw a circuit diagram for each configuration, correctly presented with appropriate symbols and conventions. They should show on their diagrams the test points for an ammeter and a voltmeter. They then go on to calculate total resistance, potential difference(s), circuit current(s) and power. Correct units should be applied to numerical answers. Answers for total resistance and current could be checked experimentally or by using simulation software. The magnetic circuit calculation should be supported by a diagram.

For 2A.P4, the evidence presented should include a diagram, written description and calculation.

For 2A.M2, learners will apply the principle of interaction between a current carrying conductor and a magnetic field to a practical application - the torque produced by the armature of a simple permanent magnet DC motor. This includes interpreting given dimensional data about the armature of the motor so that the effective length of the conductor can be established.

The evidence for 2A.D1 should be annotated diagrams with a fully detailed written comparison. A cross-sectional view of products could be taken from a data source but the written work must be learners' own. The products chosen should be taken from the list in the unit content for topic A4, for example a solenoid valve and a DC motor. The learner will be describing the construction of the products; a relatively straightforward task. The harder part of the task is comparing how the coils operate; learners should compare how the interaction between the magnetic fields produce movement.

For learning aim A at level 1, learners should only be required to make very simple statements about the parameters listed in the unit content. They do not need to specify units or symbols.

For 1A.4 the evidence presented should be in the form of a diagram (taken from a data source or hand drawn) supported by the learner's own written description.

For learning aim B at level 2, learners should present full definitions for all of the parameters in the topic list B.1. For each parameter, the learner should give a full description and state its symbol (e.g. m for mass) and its S.I. unit (e.g. N for force). Use of diagrams to support the written definitions should be encouraged, but a diagram on its own would not be sufficient evidence.

Learners should investigate three or four concurrent forces and find the resultant and equilibrant by using a graphical technique. This will involve drawing, to a suitable scale, a space diagram and a vector diagram (polygon of forces). Once the resultant has been established, it is important that the learner marks the equilibrant onto their drawing. The magnitude, direction and angle relative to a datum should be read off and written down. The learner must use recognised techniques when preparing their drawing, i.e. specifying scale, correct use of arrow heads, vector coding, title, etc. It will add interest and relevance to the assignment if learners are able to check their answers experimentally using a force board. There must be no requirement to check answers using an analytical method because that would be a level 3 topic.

The linear motion topic should be addressed by an assignment task that requires the learner to plot a graph of velocity against time for a moving body. The graph could be in three sections: uniform increase in velocity, a period of constant velocity and then a final section where the velocity reduces. By measuring the gradients for the increasing and decreasing sections of the graph, the uniform acceleration and deceleration can be established. The plotted data could be derived experimentally.

When calculating the pressure at depth in a fluid, the learner's calculations should be supported by an annotated diagram. It is important that answers are expressed as both gauge and absolute values, with the appropriate units.

Across the unit's two learning aims, the higher levels of achievement (Merit and Distinction) require the learner to carry out tasks which build on expertise demonstrated when presenting evidence for the Pass assessment criteria.

For learning aim B at level 1, learners should only be required to make very simple statements about the parameters listed in the unit content. They do not need to specify units or symbols.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A. 2, 1A.3, 1A.4, 2A.P1, 2A.P2, 2A.P3, 2A.P4, 2A.M1, 2A.M2, 2A.D1	Electricity and Magnetism	You have been asked to help the training manager of a company that makes a range of electrical equipment such as solenoids and relays. They want you to prepare a range of documents to help them understand concepts and principles relating to electrical science, so they have asked you to investigate the parameters of direct current, electricity and magnetic fields. You need to draw DC circuit diagrams for given component data and perform circuit calculations. They have also asked you to investigate the interaction between a current-carrying conductor and a magnetic field and explain a practical application of electro-magnetism.	Preparation of a report that contains solutions to a number of tasks. Written, diagrammatic and numerical evidence. Evidence could be produced under supervision.
1B.5, 1B.6, 2B.P5, 2B.P6, 2B.M3	Static Mechanical Systems	The training manager has asked you to investigate the parameters of static and dynamic mechanical systems. You will need to use a graphical technique to determine the resultant and equilibrant of a system of forces. Afterwards you will investigate and describe the conditions required for the static equilibrium of an object, for example a car engine suspended from a lifting gantry.	Preparation of a report that contains solutions to a number of tasks. Written, diagrammatic, graphical and numerical evidence. Evidence could be produced under supervision.

Criteria covered	Assignment	Scenario	Assessment evidence
1B.7, 1B.8, 2B.P7, 2B.P8, 2B.M4, 2B.D2	Dynamic Mechanical Systems and Fluids	The training manager would also like you to investigate the work done and power dissipated when a heavy piece of equipment is slid along a horizontal surface. The final task they set is to investigate the measurement of fluid pressure and to calculate the pressure at depth in a liquid.	Preparation of a report that contains solutions to a number of tasks. Written, diagrammatic and numerical evidence. Evidence could be produced under supervision.

Unit 12: Engineering Design

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how complex products, made using a variety of technologies, can work so effectively? The answer is because of good design. Engineering design is a complex process of bringing together expertise in marketing, customer liaison, conceptual design, materials technology, manufacturing methods, finance and legislation. Designers often work in teams, with different members of the team adding their individual expertise. Large-scale engineering projects are often the result of teams working together. This is not always the case, however, and some designs can start with just one person coming up with a good idea and developing it into an innovative product – for example design entrepreneurs such as Sir Trevor Bayliss and Sir James Dyson.

In this unit you will learn about what factors influence the design of new products; you will also interpret a design brief in order to generate a product design specification (PDS). The PDS is a critical document, outlining all the key requirements that the finished product or system should meet and this will form part of the assessment for this unit. From the PDS you will use design and creativity skills to produce initial concept designs, which you will evaluate and analyse. Having decided upon the best concept, you will use appropriate presentation techniques to produce a final design, ensuring it meets the requirements of the PDS. Both the initial design ideas and the final design concept are also key components that form part of the assessment for this unit.

Learning aims

In this unit you will:

A know about the factors that influence the design of a new product

B be able to develop a product design specification (PDS) from a customer brief

C be able to prepare design proposals and design solutions that meet the requirements of a PDS.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the factors that influence the design of a new product
Topic A.1: The design process How new designs are generated, what internal/external factors drive the design process: ● internal factors: o how market research informs the design process o what creates demand for products o product lifecycle o design for manufacture – choice of materials, manufacturing and assembly techniques o ensuring designs are meeting customer needs ● external factors: o the influence of competition o changing customer requirements o technology push and innovation o environmental factors o legislation, regulations and standards.
Learning aim B: Be able to develop a product design specification (PDS) from a customer brief
Topic B.1: Interpreting the customer brief Extracting information from customer briefs including market information: ● physical requirements: o styling aesthetics – the appearance and appeal of the product o size – the approximate size in three dimensions o potential materials – the types of material that might be suitable for different parts of the product o scale of production – quantity required, use of mass or batch production ● performance requirements: o function – where and what the product will be used for o environment v expected operating conditions for the product o performance – how well the product has to perform ● market requirements: o intended markets – who might use the product o competition – with other similar products. *continued*

What needs to be learnt
Topic B.2: Requirements of a PDS Interpret and anticipate technical, economic, performance requirements: ● physical dimensions ● weight restrictions ● ergonomics ● safety and testing requirements ● product functions ● compliance, legislation, regulations and operating standards ● economic requirements ● product life and end-of-life disposal ● production quantities (custom built, modification to an existing product, small batch, large volume) ● maintenance requirements ● reliability and product support ● potential future development (additional products, services, customer requirements).
Learning aim C: Be able to prepare design proposals and design solutions that meet the requirements of a PDS
Topic C.1: Initial design proposals Methods of generating ideas and proposed design solutions: ● researching existing products ● producing design sketches ● using group and individual creative thinking techniques ● using evaluation techniques ● using decision-making strategies, e.g. flow charts, thought showers, mind mapping, decision trees, comparison matrices. **Topic C.2: Final design solution** Developing design proposals into final design solutions: ● 2D drawing techniques, e.g. general arrangement drawing, assembly drawing, detail drawings, circuit diagrams, flow diagrams, schematic diagrams, CAD drawings ● use of appropriate standards and drawing conventions, e.g. BS8888, BS7307, BS14617-1 ● selection of materials ● selection of manufacturing techniques ● producing cost estimates ● generating quality requirements ● incorporating legislation and design standards ● producing a design report including technical details, e.g. design calculations, specific manufacturing requirements, use of design models, rapid prototyping, CAD models.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the factors that influence the design of a new product			
1A.1 State the internal and external factors that contribute to the design of a new engineered product.	2A.P1 Describe the internal and external factors that contribute to the design of a new engineered product.	2A.M1 Explain how internal and external factors contribute to the design of a new engineered product.	2A.D1 Evaluate the impact of internal and external factors on the design of a new engineered product including the potential benefits and drawbacks of developing new products.
Learning aim B: Be able to develop a product design specification (PDS) from a customer brief			
1B.2 Identify physical requirements for a given customer brief.	2B.P2 Identify physical, performance and market requirements for a given customer brief.		
1B.3 Produce a PDS that meets the physical and performance requirements of a given customer brief. #	2B.P3 Produce a PDS that meets the key requirements including technical, economic and performance requirements of a given customer brief. #	2B.M2 Explain how a PDS meets a customer design brief.	2B.D2 Evaluate the PDS, suggesting possible future development and design issues.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to prepare design proposals and design solutions that meet the requirements of a PDS			
1C.4 Prepare an initial design proposal that meets the requirements of a PDS.	2C.P4 Prepare and compare three different initial design proposals that meet the requirements of a PDS.	2C.M3 Explain why the chosen initial design proposal best meets the requirements of a PDS.	2C.D3 Analyse the influences on whether the chosen initial design proposal should be developed into a final design solution, suitable for manufacture.
1C.5 Prepare a final design solution stating the materials and method of manufacture.	2C.P5 Prepare a final design solution and design report that considers legislation, standards, materials, manufacture, costs and quantities.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- access to a range of customer design requirements/briefs and a range of products to investigate design requirement features
- access to manual drawing equipment or 2D/3D commercial CAD software
- access to reference materials such as extracts and illustrations from appropriate drawing standards and conventions
- access to reference material that gives information about the physical and mechanical properties of materials, relevant legislation and design standards and material suppliers' catalogues.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Assessment of this unit could be covered through three assignments covering each complete individual learning aim. The first of these would require learners to investigate the factors that influence the design of new products. This could be facilitated by a visit to a local engineering company or an investigation of how new products are developed and could be evidenced, typically, using a written report or PowerPoint® presentation.

The second assignment should be based around a given design brief. Learners could identify the key requirements from the brief and produce a PDS that details all the requirements for the design and manufacture of the product.

A third assignment could be linked to the second. Learners should use the PDS and appropriate design and creativity skills to develop three potential solutions that meet the needs of the customer and fulfil the requirements of the PDS. These three solutions can then be compared using an appropriate analytical/evaluative approach in order to rank them in order of preference and make a decision upon the preferred option for further development. In order to complete this assignment, learners will need to demonstrate basic design methods to develop design proposals and demonstrate basic competence in 2D drawing techniques. They should be producing sketches and drawings which are broadly in line with British Standards and which use straightforward drawing conventions. The techniques used are dependent on the design solution developed (for example, if it involves an electronic system, then circuit diagrams will be needed as well as perhaps general arrangement drawings; a mechanical solution would probably require part drawings to be produced). Learners will demonstrate knowledge of the required materials and manufacturing method as well as estimating the cost of producing the products or systems. In order to do this, the designs produced should be accompanied by a written report or response that incorporates all the requirements outlined in the unit content.

For learning aim A at level 2, learners will develop their responses to describe both internal and external market factors such as staying ahead of the competition, how customer requirements change and develop, and how improving design to aid manufacture all act as catalysts to inform the design process. Knowledge of how legislation and standards can have an effect on the design process should also be indicated in the learner evidence. To access the Merit criterion learners will go beyond descriptions and explain, in some detail, the specific reasons why internal factors affect the design of an engineering product. In addition, the influence of external factors and the detailed reasons why these factors contribute to the design process should be explained. Learners who assess the impact of internal and external factors in terms of improvements, and evaluate the advantages and disadvantages of these factors in the design process will have met the distinction criterion for this learning aim.

For level 1, learners will demonstrate knowledge of the factors that drive the design process, listing both internal and external factors. Written responses should state how design is informed by these factors, with the linking of market research, demand and customer needs and how new designs are influenced by competition, customer requirements and changes in technology and innovation.

For learning aim B at level 2, learners will produce a PDS which includes not only physical and functional requirements but also operating standards requirements, product life and product disposal options, production volumes and reliability/product support requirements for a given engineered product. They will also include physical and performance requirements from the given design brief. This activity may require some research or calculations, as the requirements should not be so straightforward as to be directly copied from the brief. Learners will give a description, which at Merit and Distinction will develop into evaluation of their PDS.

For level 1, learners will produce a PDS that outlines the physical and functional requirements required in the design brief. They will use a given design brief to identify the key physical requirements of a product such as size, weight, volume, etc. This should be information that is readily accessible from the given design brief. Where possible, real customer requirements should be used to give context to this element.

For learning aim C at level 2, learners will use the previously created PDS, or a given PDS, to prepare three design proposals. These three proposals should be developed through appropriate creative techniques such as flow diagrams, thought showers, mind mapping, etc. This should be supported by research into similar products produced by competitors. Simple design sketches, specifications, etc should be used to present evidence, which will allow subsequent analysis to take place. Learners should then prepare their final design solution. Learners should then move on to present written evidence of their preferred design solution and a design report that includes the full range of requirements. To access higher grades learners will consider their three design proposals with a comparative analysis of each leading to a preferred design solution. The design solution could be a circuit diagram, engineering drawing or a CAD model for instance. This preferred design should be fully justified.

At level 1, although it is anticipated that learners will use the PDS created in order to evidence 1C.4, if assessors judge that this will restrict learners in accessing the assessment criterion, an alternative PDS could be given. A design proposal should be developed through appropriate creative techniques such as flow diagrams, thought showers, mind mapping, etc. This could be supported by research into existing and similar products produced by competitors. Simple design sketches, specifications, etc could be used to present evidence, which will allow subsequent analysis to take place. Learners should then extend this to the preparation of a final design solution.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	The Design Process	You are a trainee designer working in the design department of an engineering company. You have been asked to work with the marketing department to prepare a presentation for colleagues describing the internal and external factors that should be considered when designing a new engineered product such as a new type of computer mouse.	A PowerPoint® presentation outlining the internal and external factors that should influence the design of the new computer mouse.
1B.2, 1B.3, 2B.P2, 2B.P3, 2B.M2, 2B.D2	From Design Brief to PDS	The engineering company you work for has been asked to develop a new type of computer mouse by a client. Your manager has asked you to consider the design brief and determine the physical and performance requirements. Using this information you should then prepare, explain and evaluate a PDS for the computer mouse.	A written PDS for the product supported by a PowerPoint® presentation detailing the physical and performance requirements for the computer mouse and explaining how and why the PDS presented is fit for purpose relative to the original design brief.
1C.4, 1C.5, 2C.P4, 2C.P5, 2C.M3, 2C.D3	Developing Design Solutions	The client has accepted your PDS and you have been asked by your manager to prepare three design solutions that match the PDS and to propose a final design solution for the computer mouse.	A portfolio of design ideas supported by a PowerPoint® presentation, indicating which is your preferred design for the computer mouse.

Unit 13: Engineering Assembly

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how Formula 1 teams prepare their cars for competition? The accurate assembly of many different components before a race requires the skills of a range of experienced engineers. Many engineering activities rely on the correct arrangement of components to carry out specific functions. This unit aims to give you the skills and knowledge needed to carry out a range of relevant assembly methods and techniques on engineering equipment – for example, the assembly/sub-assembly and fitting of mechanical, electrical/electronic, fluid power and pipework components or systems in accordance with approved procedures.

You will use a range of assembly tools and equipment, and check that they are in a safe and usable condition. When assembling components, you will be required to work to given procedures and check that you have the appropriate information and tools to carry out the task. Having followed the assembly instructions, you will be expected to ensure that the components are correctly positioned and aligned. You will also need to check that moving parts have the correct working clearances, that all fasteners are tightened, that wiring or piping is correctly laid and that the assembly functions according to the specification.

The unit can be applied within a specific area such as fluid power equipment, but it is more likely that a range of disciplines will be covered in any one assembly task. For example, the fitting of a fluid pump may well require mechanical, electrical and pipework skills and knowledge. You will need to have a basic understanding of the components being assembled, their functions and expected operating parameters.

Safe working practices and good housekeeping will be a recurrent theme throughout the unit. You will be expected to demonstrate an understanding of the responsibility you have for your own safety and that of others in the workplace.

Learning aims

In this unit you will:

A be able to check and use tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment

B be able to assemble components to engineering equipment.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to check and use tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment
Topic A.1: Fitness for service Checking tools, equipment and measuring instruments are fit to use when carrying out a quality check on an assembled engineering piece of equipment: ● appropriate to assembly task – following the drawing guidance, job instructions, assembly procedures ● health and safety considerations – personal protective equipment and clothing, safe working methods, relevant regulations and guidance, e.g. use of control of substances hazardous to health (COSHH) sheets, risk assessment ● permitted operating range: e.g. safe working load, voltage/current range, torque, range and type of dimensions. **Topic A.2: Assembled engineering equipment** Working on engineering equipment, such as a vehicle sub-system like brake callipers or a domestic appliance like a washing machine, with a range of components to carry out quality checks, e.g.: ● quality checks: completeness, alignment, size, positional accuracy, component security, damage or foreign objects. Engineering equipment, such as car engines, computers or bicycles, that have a range of components e.g.: ● electrical/electronic – correct inputs/outputs, electrical continuity ● pipework – correct direction and flow, component quality (pipe free from creases or ripples) ● fluid power – function, leak and pressure testing, electrical continuity, pipework free from ripples or creases ● sub-assemblies – function, freedom of movement, orientation, operating/working clearances, bearing end float. **Topic A.3: Tools, equipment and measuring instruments** Demonstrate how to use: ● hand tools – e.g. hacksaws, files, spanners, screwdrivers, wrenches, sockets, crimping tools ● power tools – e.g. drills, soldering irons, air tools ● equipment: personal protective equipment (PPE); other e.g. for lifting and moving, jigs, fixtures, supports, wire looms ● measuring instruments – e.g. rule, tape measure, micrometers, gauges, dial test indicators, multimeters, pressure meters.

What needs to be learnt
Learning aim B: Be able to assemble components to engineering equipment
Topic B.1: Connect / fit components Be able to connect/fit components to engineering equipment, e.g.: ● pipework o control components – e.g. valves, taps, regulators o storage devices – e.g. tanks and reservoirs o monitoring equipment – e.g. sensors, meters, gauges o fluid distribution equipment – e.g. motors, pumps o use of pipe materials – e.g. steel, copper, plastic, flexible hoses o joining methods – e.g. compression joints, brazing, soldering, cementing, bonding o connectors – e.g. straight, reduction, elbows, flanges ● electrical/electronic o components – e.g. conduit, trunking, tray type table enclosures, plugs and sockets, sensors, motors, transformers, relays, solenoids, switches, electronic modular units, instrumentation units o techniques – e.g. routing cables and wires, mounting/securing components, cable fixings and fasteners, terminating and joining cables/wires using screwed/clamped/soldered/crimped connections o use of cable protection devices - sleeving, grommets ● fluid power o components – e.g. motors, pumps, compressors, intensifiers, filters, lubricators, separation units, reservoirs, accumulators, sensors, meters, gauges, indicators o pipework and connection devices – e.g. manifolds, couplings, laying pipework/ cabling/wires o control components – valves, actuators, cylinders, regulators. **Topic B.2: Assembly methods and techniques** Be able to perform a range of assembly methods and techniques on engineering equipment including: ● fitting – e.g. filing, scraping, lapping, polishing, blue bedding of components, shimming, packing, use of expansion/contraction methods ● securing – e.g. fasteners, threaded devices, bolt locking methods, riveting, soldering, brazing, sealants, adhesives ● use of tools – e.g. drilling, soldering irons, reaming, press tools, hacksaws, files, spanners, screwdrivers, wrenches, sockets, crimping tools, torque wrench, alignment tools ● use of assembly aids and equipment – e.g. work-holding devices, jigs, fixtures, supports, lifting and moving equipment, rollers, wedges ● working within specified timeframes - estimation time to complete task, working to set times ● maintaining safe working environment – appropriate and approved assembly techniques used at all times, work area housekeeping, risk assessments. *continued*

What needs to be learnt
Carrying out assembly tasks: ● Sub-assemblies or assemblies – e.g. panel, support framework, casings, fluid power, simple electrical circuit, component kits. **Topic B.3: Quality and accuracy** Checking compliance and achieving quality and accuracy through a range of standards and information including: ● quality checks – e.g. setting working clearance, torque settings, alignment, balancing ● national standards – British Standards (BS), International Organization for Standardization (ISO) ● design standards – customer standards and requirements, company standards and procedures ● specified instructions – e.g. specific system requirements, operational manuals, manufacturers' instructions.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to check and use tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment			
1A.1 Identify a range of hand and power tools, equipment and measuring instruments.	2A.P1 Check that hand and power tools, equipment and measuring instruments are fit for purposes.	2A.M1 Explain the action to be taken before use if tools, equipment and measuring instruments are found not to be fit for purpose.	2A.D1 Evaluate the use of tools, equipment and measuring instruments when checking the quality of assembled engineering equipment and suggest alternatives that could be used.
1A.2 Use tools, equipment and measuring instruments to carry out quality checks on assembled engineering equipment.	2A.P2 Select and use tools, equipment and measuring instruments to carry out quality checks on two different types of assembled engineering equipment.		
Learning aim B: Be able to assemble components to engineering equipment			
1B.3 Identify a range of components to be connected/fitted to either pipework, electronic/electrical or fluid power engineering equipment.	2B.P3 Identify, select and connect/fit components to either pipework, electronic/electrical or fluid power engineering equipment.	2B.M2 Explain the importance of using relevant standards and instructions when checking the compliance of an assembly.	2B.D2 Evaluate the assembly methods and techniques used to carry out an assembly task and make a proposal for improvement.

Level 1		Level 2 Pass		Level 2 Merit	Level 2 Distinction
1B.4	Use given tools and relevant assembly methods and techniques to carry out a given assembly task safely.	2B.P4	Select and use tools and relevant assembly methods and techniques to carry out two different assembly tasks safely.		
1B.5	Identify specific instructions associated with checking a given assembly for quality and accuracy.	2B.P5	Select and use relevant standards and instructions to check the compliance of an assembly for quality and accuracy.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a range of components and assemblies to enable learners to carry out the practical aspects of this unit as defined by the content and grading criteria (essential)
- access to a workshop environment and the range of tools, equipment and measuring instruments to support the cohort size undertaking the unit (as required).

Assessment guidance

This unit is assessed internally by the centre, and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

A large proportion of the summative assessment for this unit could take place through teacher observation and oral questioning. To support the high level of process evidence, centres will also need to consider what additional product evidence (that so often surrounds a process) could be used. For example, the use of a logbook record of the assembly task(s) carried out. The log could contain a description of the task undertaken, the instructions provided (annotated to record progress or difficulties), a list of tools provided and their condition, written tool/equipment defect reports and relevant photographs that have been annotated to explain procedures/difficulties. Such supporting product evidence would then validate the teacher or witness observation/oral questioning records and vice versa. For summative assessment group work is not appropriate unless very large assemblies are available and individuals can work on and generate their own evidence. To achieve the unit each learner must provide individual evidence of achievement for all the learning aims.

At level 2 there are three main tasks to be carried out – using tools, equipment and measuring instruments, connecting/fitting components and carrying out an assembly task safely. These three main tasks are supported by the two other ‘checking’ criteria – 2A.P1 and 2B.P5. Two assignments are suggested, and centres should determine the range of assessment opportunities.

For learning aim A at level 2, learners will need to be given two different pieces of equipment that use either pipework, electronic/electrical or fluid power components, and a range of tools, equipment and instruments to select from before carrying out their quality checks. Learners will need to check that the tools, equipment and measuring instruments are appropriate to the task of checking the equipment including health and safety considerations, and that they are in a safe and serviceable condition. They should also be given an opportunity to explain the action to be taken with any tools, equipment or measuring instruments that are defective or inappropriate and evaluate their use including suggesting alternatives to use. Centres may need to arrange such situations for the purpose of this criterion, by issuing learners with some defective or inappropriate tools in the tool kit provided for the task(s). If it did happen naturally then, of course, this evidence can be captured for the individual learner’s summative assessment records but this should not be left to chance.

Level 1 learners will identify a range of hand and power tools, equipment and measuring instruments and carry out quality checks on one piece of engineering equipment.

For learning aim B at level 2 learners will need to connect or fit components to a piece of engineering equipment and carry out two assembly tasks in a safe manner, then one of the completed assemblies must be checked for quality and accuracy. Learners should also be given an opportunity to explain the importance of using standards and instructions and evaluate the methods and techniques used and make a proposal for improvement. When carrying out the assembly tasks, situations where assembly problems occur may need to be arranged. For example, the learner could be provided with incorrect parts (such as bolts that are too short) but for which they then must requisition correct replacements from the workshop stores under their own authority.

Level 1 learners will identify a range of components depending on the type of engineering equipment. They will also use given tools to carry out an assembly task. When checking the assembly for quality and accuracy they should be given the opportunity to identify specific instructions that relate to the task.

As mentioned, there are many ways to collate the evidence gathered by learners. These will include learner observation records, annotated photographs, extracts from engineering logbooks, lists of tools, equipment etc used, annotated drawings or instructions sheets, and written responses to meet the higher grading criteria.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Checking Assembled Engineering Equipment	You have been asked by a local company to carry out quality checks on two pieces of engineering equipment. You will need to check that the tools, equipment and measuring instruments to be used are fit for service.	Completed logbook. Annotated photographs/drawings/ illustrations/instruction sheets. Teacher observation.
1B.3, 1B.4, 1B.5, 2B.P3, 2B.P4, 2B.P5, 2B.M2, 2B.D2	Using Assembly Methods and Techniques	You have been asked by a local company to carry out two different assembly tasks to include connecting/fitting components, using tools and relevant methods and techniques, and using standards and instructions to check quality.	Completed logbook. Annotated photographs/drawings/ illustrations/instruction sheets. Teacher observation.

Unit 14: Vehicle Engines and Other Systems

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

This unit aims to give you knowledge of the vital components and principles of vehicle engines and related fuel, exhaust and ignition systems.

Did you know that the internal combustion engine produces the power and torque to propel go-karts, motorbikes, cars and lorries, and that it has to comply with various functional and legal requirements?

The output characteristics produced depend on design factors and principles – it is these characteristics that allow motorbikes to travel through mud, help cars to accelerate quickly and enable lorries to pull heavy loads. Advances in materials, fuel, lubrication and design technology, together with enhancements in the control and monitoring systems that are integrated into today's vehicles, mean that the modern engine (for a given size) outperforms its predecessors in every way. These advances bring a greater need for understanding both the complexities of these power units and their fundamental operating principles.

In this unit you will gain a crucial understanding of the constructional detail, components and principles of operation associated with the internal combustion engine and some of its sub-systems. You will also be equipped with the generic skills that are transferable between different engines and sub-systems, regardless of the manufacturer.

Learning aims

In this unit you will:

A know about the fundamental operating principles of petrol and diesel internal combustion engines

B know about the function and operation of vehicle engine fuel, exhaust and ignition systems.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the fundamental operating principles of petrol and diesel internal combustion engines
Topic A.1: Engine components/assemblies Identify and describe the function and interaction of the following engine components/assemblies: ● cylinder block ● cylinder head ● sump ● piston ● connecting rod ● crankshaft and bearings ● flywheel ● camshaft ● inlet and exhaust valves ● valve operating mechanisms – overhead valve (OHV), single overhead cam (OHC), multiple OHC arrangements, inlet and exhaust manifolds. **Topic A.2: Engine configuration, orientation and cylinder layout** Identify and describe current vehicle applications of engine configurations, orientations and layouts, including: ● cylinder configuration – in-line, vee, horizontally opposed arrangements ● engine orientation and position – longitudinally mounted, transverse, front, mid and rear engines ● cylinder arrangements – single cylinder, twin cylinder, four cylinder, six cylinder, eight cylinder. **Topic A.3: Operating cycles and engine parameters** Identify and describe the following for petrol spark ignition (SI) and diesel compression ignition (CI): ● cycles of operation – two-stroke, four-stroke ● engine parameters – swept and clearance volume, compression ratio, valve timing/port timing.

What needs to be learnt
Learning aim B: Know about the function and operation of vehicle engine fuel, exhaust and ignition systems
Topic B.1: Engine fuel and exhaust system Identify and describe the function and operation of the following engine fuel and exhaust systems for petrol spark ignition (SI) and diesel compression ignition (CI): ● fuel systems – carburettor, single-point petrol fuel injection, multi-point petrol fuel injection, diesel pump and injector, common rail diesel injection ● exhaust systems – silencer, catalytic converter, particulate filter ● alternative fuels – electric, gas, hydrogen, biodiesel. **Topic B.2: Ignition systems** Identify and describe the following ignition system and combustion processes for petrol spark ignition (SI) and diesel compression ignition (CI): ● spark ignitions – coil, distributor, spark plug, ignition timing, firing order, electronic ignition, distributorless ignition ● combustion process – air/fuel mixing and phases of combustion ● ignition control systems – ignition timing, knock sensing, advantages, e.g. increased fuel efficiency, performance, fail-safe systems, fault diagnosis.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the fundamental operating principles of petrol and diesel internal combustion engines			
1A.1 Identify the main components/assemblies of petrol and diesel internal combustion engines.	2A.P1 Describe the function of the main components/ assemblies of petrol and diesel internal combustion engines.		
1A.2 Identify the current engine configuration, orientation and cylinder layout of two given vehicles, one petrol and one diesel.	2A.P2 Describe the current engine configuration, orientation and cylinder layout of two given vehicles, one petrol and one diesel.	2A.M1 Compare the advantages and disadvantages of engine configuration, orientation and cylinder layout of petrol and diesel vehicles.	2A.D1 Justify an engine operating cycle, configuration, orientation and cylinder layout for a given vehicle.
1A.3 Identify the operating cycles of a petrol and a diesel internal combustion engine.	2A.P3 Describe the operating cycles of a petrol and a diesel internal combustion engine.		
1A.4 Identify the engine parameters of a petrol and a diesel internal combustion engine	2A.P4 Describe the engine parameters of a petrol and a diesel internal combustion engine.		

Level 1	**Level 2 Pass**	**Level 2 Merit**	**Level 2 Distinction**
Learning aim B: Know about the function and operation of vehicle engine fuel, exhaust and ignition systems			
1B.5 Identify engine fuel and exhaust system components.	2B.P5 Describe the function and operation of an engine fuel and exhaust system.		
1B.6 Identify spark ignition and control system components.	2B.P6 Describe how spark ignition control systems are aligned to the combustion process in operation.		
1B.7 Identify compression ignition combustion processes.	2B.P7 Describe compression ignition combustion processes.	2B.M2 Compare the combustion processes of petrol and diesel engines.	
1B.8 Identify different types of alternative fuels.	2B.P8 Describe different types of alternative fuels.	2B.M3 Compare the advantages and disadvantages of different fuels.	2B.D2 Evaluate the performance of a vehicle using two different fuels.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- a range of two-stroke and four-stroke SI and CI power units of varying configurations
- a range of engine components (e.g. pistons, connecting rods, valves, crankshafts and camshafts) and assemblies (e.g. cylinder blocks, cylinder heads and rigs)
- fuel system components or rigs.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Although the criteria require descriptive evidence, it is not expected that centres will only use reports to achieve this. The unit lends itself to an investigative approach and this should also be reflected in the assessment strategy wherever possible.

Access to a vehicle workshop equipped with appropriate vehicles would be beneficial, and working with rigs or components would ensure experiential learning is vocationally appropriate. Direct work experience in a workshop would dramatically enhance the delivery and assessment process, and enable learners to consider what they like about vehicle workshop activities. Learners' interest can be stimulated by references to current engine applications in areas they may be aware of, such as motor sport. Centres can also combine references to wider engine applications – for example, from large diggers to small combustion engine models. It is good practice for learners to make references to current applications in their assessments.

For learning aim A at level 2, learners will be able to describe the function of each component to include the multiple valve operating mechanisms. The evidence for this may be in the form of a write-up.

Learners will be able to describe the application of engine configuration, orientation and layout in two current vehicles (one petrol and one diesel). Describing current vehicle application is crucial to make the jump between level 1 and level 2. Learners' descriptions should include reasons for using the different arrangements.

Learners will be able to describe the operating cycles of a petrol and a diesel internal combustion engine. Their description must include a two- and four-stroke cycle of operation, as well as the following – swept and clearance volume, compression ratio and valve timing/port timing.

At level 1, learners will be able to identify components and sub-assemblies of petrol and diesel combustion engines. Evidence for this could be in the form of an observation test, whereby learners are asked to study a selection of numbered components before compiling a list of what each component is. Alternatively, learners could be verbally tested on the components with an observation record/witness statement submitted as evidence.

Learners will also be able to look at two different vehicles and identify the configuration, orientation and layout of their engines. This could be evidenced by walking learners round vehicles – for example, in a car showroom – and asking them to identify the engine configuration, orientation and layout of two vehicles (one petrol and one diesel). If large groups are involved, these vehicles will need to be varied to aid authenticity.

Learners should also be able to identify the operating cycles of a petrol and a diesel internal combustion engine. This will include a two- and a four-stroke cycle of operation. This is more complex and may require learners to provide a write-up and handouts to show that they can identify the operating cycles.

For learning aim B at level 2, learners will be able to describe the function and operation of one fuel and exhaust system. Learners should be able to show clearly each component of the identified system and describe, verbally or in writing, the functions of each component in the system's operation. Evidence of this at level 2 will be more substantive than at level 1. Learners are also required to describe a spark ignition system in operation. They should use previously gained knowledge to describe how the components operate and how the air and fuel are mixed in the system, along with what happens next in the process. Following on from this, learners will similarly describe the compression ignition process to include the phases of combustion. This may be helped by investment in pre-prepared pictures which are incomplete, such as a 'set' of tasks with given information or a software package containing similar tasks to complete. Learners will also need to describe different types of alternative fuels. This covers an area that is constantly changing. Therefore, the fuels being described can be varied. The description should, however, clearly present how the fuels are used in a current vehicle application.

At level 1, learners should be able to identify the components of given or sourced fuel, exhaust and spark ignition systems and their functions. There are many different types of systems available to engage learners, but it is imperative that the chosen system gives learners fundamental knowledge that can be used as a basis for development through the unit. At this level, learners will also be able to identify the processes of combustion. This should include the phases of diesel combustion and the air/fuel mixing process in spark ignition engines. The identification process could be achieved using gapped handouts or working models. Learners will also be able to identify different types of alternative fuels.

The evidence at this level could be direct observation of identification activities aided by the use of interactive assessment methods, such as component identification games. These could include the use of real components.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1	Introduction to Engines – Components and Sub-assemblies	Your employer wants you to investigate components of SI and CI for a small car engine and a large lorry engine, in order to show DIY mechanics the different components found in an engine and their function(s).	Visual – the matching of components from engines to pictures and labels (1A.1). A short written/verbal report based on practical investigations (2A.P1). Witness/observation records can be used to validate the evidence given.
1A.2, 2A.P2, 2A.M1	Engine Configuration, Orientation and Layout	You are asked to carry out an exploration of the engine configuration with multiple arrangements of different vehicles in a vehicle showroom/car workshop/staff car park and are asked to present your findings to new apprentices.	A table presenting the vehicles and their engine configuration, orientation and layout. A short written report based on the practical investigations clearly indicating the advantages/disadvantages of the arrangements (to include SI/CI engines).
1A.3, 1A.4, 2A.P3, 2A.P4, 2A.D1	Engine Cycles	Before deciding on a new engine for two vehicles, a farmer asks you to identify and describe the differences between two- and four-stroke SI/CI operating cycles. The farmer then wants you to select and justify an engine operating cycle, configuration, orientation and layout for a quad bike and tractor.	A written report/verbal presentation based on investigations/research including logical justification for the selection made or a verbal structured task aligned to a multimedia presentation.

Criteria covered	Assignment	Scenario	Assessment evidence
1B.5, 2B.P5	Fuel Systems	You have an opportunity to undertake a work experience placement at a fuel system specialist. You are requested to present information on a diesel system, one other different system and one exhaust system. You will identify and describe the components in the systems and their function.	This is a good opportunity to stretch and challenge learners by using a variety of assessment methods, such as presentation to peers, articles for a magazine or a group discussion or role play. A written formal assessment should be used for learners wishing to progress to higher levels.
1B.6, 1B.7, 2B.P6, 2B.P7, 2B.M2	Spark and Control Systems and Combustion	A motor sport racing team is looking for an apprentice. Part of the application requires you to look at spark ignition systems, associated control systems and the process of combustion for different fuels. You must identify and describe spark ignition system components, and the process of combustion. Then, you must do the same for a compression ignition process and compare the two processes.	The format of the evidence should be tailored to the resources available, but guidance should be given to ensure the phases of fuel burning and flame spread are included along with system components.
1B.8, 2B.P8, 2B.M3, 2B.D2	Alternative Fuels	Your local newspaper is hoping to raise awareness of alternative fuels. You are challenged to identify, describe and evaluate the performance of different fuels in an article and poster designed to promote the campaign. You should include a description of the advantages and disadvantages of different alternative fuels.	The evidence could be in a variety of formats – for example, posters, a written report and a final article. Care must be taken to ensure the authenticity of the evidence as a lot of material is available, particularly on the internet. Level 2 Distinction learners must include a logical conclusion in their evaluation of the types and performance described.

Unit 15: Operating an Efficient Workplace

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how fast food restaurants can produce your food so quickly? One of the reasons is workplace organisation and the use of standard operating procedures (SOP). These are both examples of operating an efficient workplace. These same techniques are also widely used in engineering manufacture to improve efficiency and the quality of products being made.

In this unit, you will learn about these techniques and the use of workplace organisation methods, including the application of 5S (Sort/Set/Shine/Standardise/Sustain) or 5C (Clear out/Configure/Clean and Check/Conformity/Custom and Practice) principles, in order to organise a workplace. You will also learn about visual display techniques and how these can be used to communicate important information. In addition to this, you will come to recognise the importance of using visual control methods in order to improve safety and efficiency.

In order to apply the principles, you will undertake practical activities including a 5S or a 5C activity in a safe engineering workplace. Assessment of this unit is based on these practical activities and an understanding of the importance of visual management.

Learning aims

In this unit you will:

A know about the principles of the 5S or 5C process

B plan and carry out a 5S or 5C activity

C know about how methods of visual control are used and prepare a visual management display

D be able to produce a standard operating procedure (SOP).

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the principles of the 5S or 5C process
Topic A.1: 5S or 5C The principles of 5S (Sort/Set/Shine/Standardise/Sustain) or 5C (Clear out/Configure/Clean and Check/Conformity/Custom and Practice), including: ● principles of workplace organisation ● business efficiency. **Topic A.2: Benefits of 5S or 5C** These include: ● promotion of teamwork ● promotion of a safer working environment ● more efficient workplace ● improvement of quality ● foundation for continuous improvement.
Learning aim B: Plan and carry out a 5S or 5C activity
Topic B.1: Planning and carrying out a 5S or 5C activity Planning and carrying out a 5S or 5C activity in a safe manner. Planning a 5S or 5C activity, including: ● health and safety ● isolation of machine/area ● waste disposal procedures ● personal protective equipment (PPE) requirements ● identification of 'clear-out' area ● red tag requirements. Carrying out a 5S or 5C activity, including: ● sorting/clearing out the work area ● setting/configuring the work area ● shine/clean all parts of the workplace and check all equipment is functioning correctly ● ensure work practice is standardised/conforms to the set standard ● identify how improved workplace custom and practice can be sustained ● effect of activity on workplace/production activities.

What needs to be learnt
Learning aim C: Know about how methods of visual control are used and prepare a visual management display
Topic C.1: Principles of visual management Why is visual management used and what are the requirements: ● problems with traditional reporting systems, e.g. lack of ownership, complexity, inaccuracy, corrupted reports, poor circulation, currency and validity of information ● inputs/process/outputs ● information required to develop a local visual management system, e.g. machine status, production targets, defect rates, customer requirements ● benefits of visual management. **Topic C.2: Visual display:** Planning methods, types of visual display techniques: ● where to apply visual display ● good practice, e.g. accurate and relevant, eye-catching, simple ● use of different media, e.g. electronic boards, notice boards, whiteboards, poster display ● team boards ● storyboards ● plan, do, check, act (PDCA) worksheets ● business and local key performance indicators (KPIs), e.g. quality, cost, delivery (QCD) measures, skills matrices, health and safety, 5S or 5C scores, autonomous maintenance worksheets, standard operating procedures, defect rates, orders shipped on time, efficiency of different lines/processes/machines, mission statements. **Topic C.3: Visual control:** ● where to apply visual control ● good practice, e.g. accurate and relevant, eye-catching, simple ● location ● shadow boards ● colour-coding equipment ● floor footprints ● Kanban card systems, Just-in-Time (JIT) ● electronic line status systems ● Andon lights, traffic light system.

What needs to be learnt
Learning aim D: Be able to produce a standard operating procedure (SOP)
Topic D.1: The principle of standardised work Including the significance of standardised operations, the rules of the standardised job, line balancing, aid to training. **Topic D.2: SOP documentation:** ● standard operating procedures (SOPs) ● standard combination sheets ● standard work charts ● functions, e.g. sequence of operations, key quality and safety points, work elements, element times, manual, walking, machine, cycle times, equipment and machine layouts. **Topic D.3: Producing and / or updating SOPs:** ● the application of standard operations using the PDCA philosophy ● issues of implementing standardised work ● priority of improvement ● responsibilities. **Topic D.4: Benefits of SOPs:** ● predictable output in terms of cost, quality and delivery ● safer working practices ● foundations for training and continuous improvement.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the principles of the 5S or 5C process			
1A.1 Identify the benefits of a 5S or 5C activity.	2A.P1 Describe the benefits to an engineering workplace of a 5S or 5C activity.	2A.M1 Explain the benefits and limitations of a 5S or 5C activity.	2A.D1 Evaluate a 5S or 5C activity as a means of improving efficiency.
Learning aim B: Plan and carry out a 5S or 5C activity			
1B.2 Carry out a 5S or 5C activity describing the effect of the activity on the workplace.	2B.P2 Plan and carry out a 5S or 5C activity describing each of the five steps and the effect of the activity on the workplace.		
Learning aim C: Know about how methods of visual control are used and prepare a visual management display			
1C.3 Identify two examples of visual control found in an engineering manufacturing environment.	2C.P3 Describe two examples of visual control found in an engineering manufacturing environment.		
1C.4 Prepare a visual management display identifying two key features.	2C.P4 Using information and inputs/process/outputs prepare a visual management display that addresses at least two problems associated with traditional reporting systems.	2C.M2 Explain how the display demonstrates the principles of visual management.	2C.D2 Evaluate how the display demonstrates the principles of visual management, including the fitness for purpose of the display.

Level 1	**Level 2 Pass**	**Level 2 Merit**	**Level 2 Distinction**
Learning aim D: Be able to produce a standard operating procedure (SOP)			
1D.5 Produce a standard operating procedure for an engineering workplace.	2D.P5 Produce a standard operating procedure for an engineering workplace using relevant documentation and PDCA philosophy. #	2D.M3 Produce a standard operating procedure that includes an accurately completed standard operations sheet and work chart and indicates priority of improvement and those responsible. #	2D.D3 Evaluate the standard operating procedure, assessing the potential benefits to the manufacturing workplace.
1D.6 Outline the key benefits of a standard operating procedure.	2D.P6 Describe the benefits of a standard operating procedure (SOP) to an engineering workplace.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a workshop environment and appropriate equipment, systems, devices and components required to carry out 5S/5C activities
- appropriate measuring instruments and documentation in order to carry out a data collection activity.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of learners' achievement of the learning aims and related assessment criteria could be collected from two assignments covering complete learning aims. These assignments could be linked to the same workplace and activity, or could be separate activities. The workplace activity should, ideally, be a production/ assembly operation. This evidence might be generated from a workplace visit or could be a simulated activity, the key requirement being the opportunity to observe the process before and after the activity and measure the time saving or labour saving that changing the process achieves.

Due to the practical nature of this unit, evidence such as teacher observation records, oral questioning and annotated photographs could supplement other forms of evidence. Where presentations are used, video footage can often be used to record what happened against a variety of learning aims and/or assessment criteria. This direct evidence of process skills should be planned, then documented and recorded appropriately for assessment requirements. In addition, learners should evidence appropriate health and safety awareness, before and during any practical activities that are carried out.

Although the expression '5S or 5C' is used throughout, centres need not use both as they are acronyms for, essentially, the same process.

In carrying out activities, it is likely that centres will use group work with learners working in teams. It is therefore important to plan a strategy for recording the contributions by individual learners in order to ensure authenticity and record individual evidence to support the assessment criteria.

For level 2, learners should be identifying, describing and planning a 5S or a 5C activity. They should be able to describe the five steps in order to consider the outcomes of the initial activity and indicate the actions that normally follow. In addition, the impact on the workplace of carrying out the activity should be considered. Learners should be applying the principles of visual management and visual control. In each case, at least two examples of traditional problems should be given from the appropriate range outlined in the unit content. These examples should demonstrate how the problems associated with traditional non-visual techniques are overcome. They should also produce an SOP using appropriate visual tools and techniques, and should describe the benefits of this procedure.

For level 1, learners should identify the benefits of carrying out a 5S or 5C activity and should carry out a practical 5S or 5C activity, although they may not necessarily plan this activity.

Learners will produce a simple visual management display and this is best evidenced using examples from an appropriate manufacturing environment. A similar approach can be taken for the identification of examples of visual control. They should also produce an SOP that, whilst being fit for purpose, need not demonstrate the PDCA technique or have supporting documentation.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1B.2, 1C.3, 1C.4, 2A.P1, 2B.P2, 2C.P3, 2C.P4, 2A.M1, 2C.M2, 2A.D1, 2C.D2	Workplace Audit	The engineering manufacturing company you work for is reorganising its production cells and wants your ideas on how to make things more efficient. You decide to plan and carry out a 5S or 5C activity and investigate methods of visual control to help you to develop a visual management display.	Preparation of a visual management display. A witness testimony of a 5S or 5C activity being carried out. A written report giving examples of the use of visual control in industry and outlining the benefits of the visual management display prepared and the 5S/C activity undertaken.
1D.5, 1D.6, 2D.P5, 2D.P6, 2D.M3, 2D.D3	New Standard Operating Procedures	The engineering manufacturing company you work for wants to standardise its operations to further improve efficiency in its manufacturing cells. You have been asked to develop a presentation to operators on a typical standard operating procedure and the benefits of its use.	A standard operating procedure plus supporting documentation. A PowerPoint® presentation showing an example of a SOP in a step-by-step format indicating the benefits to a manufacturing workplace.

Unit 16: Vehicle Electrical Systems

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

There are many different types of motor vehicle, ranging from sophisticated luxury cars and high-performance sports cars to very basic battery-powered ‘buggies’. Despite their differences they all contain electrical systems within them. This unit will introduce you to some of the main electrical principles, components and systems found in modern vehicles, and enable you to identify and confirm the function and operation of these systems.

This unit specifically considers the function and correct operation of lighting systems and their auxiliary components. You will consider the role of a vehicle’s battery, alternator and starter systems. In the first part of the unit you will learn about the function of vehicle lighting and auxiliary systems. This will enable you to check they are working and understand what’s wrong if they are not.

The second part of the unit deals with the function and operation of the charging and starting system, including the lead acid battery and a vehicle’s alternator and starter systems. Without these systems, the engine will not start and the vehicle cannot perform. Understanding these systems is vital if you want to develop your career in the automotive and other related sectors.

Working closely with these systems will enable you to further develop your ability to use test equipment. As a result, you will be able to measure various electrical values and use test results to determine if each system is working correctly.

Learning aims

In this unit you will:

A be able to identify, describe and check the performance of vehicle lighting and auxiliary electrical systems and components

B be able to confirm the correct function and operating principles of a vehicle’s lead acid battery, alternator and starter motor safely.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to identify, describe and check the performance of vehicle lighting and auxiliary electrical systems and components
Topic A.1: Lighting systems and components Describe given test circuits of lighting systems and components, including: ● statutory requirements, function and operating procedures – side and rear, main and dip beam, rear fog lamp, stop lamp, indicators, hazard warning ● non statutory – interior, front fog lamps, reverse lamp, information panel lighting. ● Check performance of test circuits of lighting systems and components, including testing of circuits and complete calculations – amperes, volts, watts and ohms. **Topic A.2: Auxiliary electrical systems and components** Describe the function of auxiliary electrical systems and components, including: ● general systems, e.g. windscreen wipers, horn, window opening/closure, bonnet/boot releases, heated screens/seats/mirrors ● components to include loads/motors, relays, switches, wiring, circuit protection ● air-conditioning/climate systems, e.g. interior cabin ● security systems, e.g. central locking, vehicle alarm systems, proximity sensors ● information systems, e.g. entertainment, on-board monitoring. Check performance of test circuits of auxiliary electrical systems and components including testing of circuits and complete calculations to include Ohm's law and the use of power formulae to relate actual results to theoretical findings.
Learning aim B: Be able to confirm the correct function and operating principles of a vehicle's lead acid battery, alternator and starter motor safely
Topic B.1: Lead acid battery function and operation Identify components, operating principles and check performance of a lead acid battery, including: ● how electricity works – atoms, electrons, protons, neutrons ● units of measurement, simple formulae ● process of a simple lead acid cell ● connecting simple cells/batteries in series and parallel ● identification and naming of component parts – materials used for case, terminal types, cell arrangements ● low maintenance and no maintenance batteries. Check performance of a lead acid battery including: ● battery performance – use of battery test meters, battery state of charge indicators, battery acid relative density values and capacity ● interpretation of test results – e.g. fit for use or in need of charge or replacement. *continued*

What needs to be learnt
Topic B.2: Safe handling and testing Identify and describe safe working practices involving charging and starting systems, including: ● procedures for battery handling – physical removal and replacement from a vehicle, storage, personal protective clothing ● disconnecting from and reconnecting to a vehicle's electrical circuit ● connecting and removing from charge ● safe use of chargers and jump-start procedures ● measurements of charge and specific gravity values ● interpretation of test results, data comparison (manufacturers' data where possible, preset if not available). **Topic B.3: Alternator function and operation** Identify and describe the function, principles and operation of components of an alternator, including component parts of the alternator – rotor, stator, diode, brushes, windings, regulator, rectifier, casing, bearings. Check performance of an alternator, including: ● maintenance and service adjustments – drive belt tension, checking drive belt condition, measure output voltage and current ● application of magnetic principles to alternator operation – increase of electro-motive force (emf) by increasing rotor current and speed, use of diodes to convert alternating current (AC) to direct current (DC) for battery charging, need for output voltage control ● factors affecting current output. Data referenced to include voltage output, inductive amperage output, loaded and unloaded, e.g. fit for use or in need of repair or replacement. **Topic B.4: Starter motor function and operation** Identify and describe the function and operation of components of a starter motor, including: ● component parts and interaction within the starter motor and circuitry, armature, commentator, field coils, brushes, solenoid, starter circuit, pinion and protection devices (roller clutch, armature brake) ● the application of magnetic principles to starter and solenoid operation – how rotary motion is generated within the starter motor, e.g. fit for use or in need of repair or replacement. Check performance of a starter motor, including starter performance measurements (current drawn by starter motor, battery voltage under load, circuit voltage drop tests).

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to identify, describe and check the performance of vehicle lighting and auxiliary electrical systems and components			
1A.1 Identify the components within vehicle lighting and auxiliary electrical systems.	2A.P1 Describe the operation of a vehicle's lighting system and components, and auxiliary electrical system and components.		
1A.2 Check the on/off operation of the components of a vehicle's lighting system.	2A.P2 Check the performance of a vehicle's lighting system and components meets statutory requirements.		
1A.3 Identify the components and check the basic operation of a vehicle's auxiliary electrical systems.	2A.P3 Carry out tests to check the performance of a vehicle's auxiliary electrical systems and components.	2A.M1 Carry out tests and calculations of a vehicle's lighting and auxiliary systems and components, comparing actual results to manufacturers' specifications. *	2A.D1 Evaluate the performance of a vehicle's lighting and auxiliary systems and components, drawing on test data and manufacturers' specifications. *#

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Be able to confirm the correct function and operating principles of a vehicle's lead acid battery, alternator and starter motor safely			
1B.4 Identify the components of a vehicle's lead acid battery, identify units of measurement and outline the operating principles.	2B.P4 Describe the function and operating principles of a lead acid battery.		
1B.5 Identify procedures for safe working and handling of a lead acid battery.	2B.P5 Describe procedures for safe working and handling of a lead acid battery.		
1B.6 Identify the components, principles and service adjustments of an alternator.	2B.P6 Describe the function and operation of an alternator.	2B.M2 Explain the need for voltage control on an alternator and the consequence of a faulty rectification process.	
1B.7 Identify the components of a starter motor.	2B.P7 Describe the components, their function and the operation of a starter motor.		
1B.8 Identify the equipment and tests to check a battery, alternator and starter motor.	2B.P8 Use test equipment to confirm the functioning of a battery, alternator and starter motor.	2B.M3 Carry out performance tests and interpret results to identify faulty components or circuits for an alternator, battery and starter motor. *	2B.D2 Evaluate test data from an alternator or starter motor and make recommendations for repair or replacement. *

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are access to small tools, test meters, a range of vehicles/working rigs, components and manufacturers' data and information.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence for this unit could be collated from a mixture of written and practical assessments. The use of working systems is imperative to enable the learner to check the performance of components and systems against their specifications. The assessment should authenticate the practical work through assessor or witness observation records. These should give details of what has been seen, any oral questioning that has taken place and the context within which the work was undertaken (e.g. on the job, college repair workshop, simulated activity). If learners work in pairs (or groups), then there must be a clear strategy to ensure that each learner produces relevant and individual evidence to satisfy the criteria.

For learning aim A at level 2, learners should be able to describe lighting components and circuits, either in writing or verbally with the aid of images. They should be able to demonstrate their ability to make a decision regarding the correct performance of a range of lighting circuits to both operational and legal expectations. If a number of learners are using the same vehicle, then simulated faults in the system should be changed to retain the validity of the task. Similarly for the auxiliary systems, learners should describe the systems and check the performance against manufacturer specifications and any statutory requirements as researched or given. They must include at least one system from each of the identified bullet points – general, air, security and information – within the unit specification. At Merit and Distinction level, learners will be carrying out calculations and evaluating their data where the data from testing is compared to the theoretical results from completing calculations.

At level 1, learners should be able to identify components to outline the circuits for a variety of both lighting and auxiliary electrical systems. It is expected this will be of actual systems and involve diagrammatic representation. Once the learner has developed this knowledge, they should be able to check the operation of the systems as fitted to vehicles in a practical exercise. This could be generated from witness/assessor documentation if the learner has a work placement.

For learning aim B at level 2, learners should show that they are able to describe the lead acid battery. Learners should make it clear to the assessor that they understand the process of energy conversion and storage. This will include how electricity works and direct reference to battery performance and ratings. Assessors could use practical exercises to demonstrate energy conversion and storage and give verbal feedback to simplify the assessment process. Assessors should also ensure that the tests are completed safely and ensure learners generate performance feedback on the battery. Alternatively, the demonstrations could be given by a specialist who then allows learners to complete the tests, giving an opportunity for assessment. The relationship stated in Ohm's law will be demonstrated by using calculations to reinforce learning.

Learners should describe the technical detail and operation of the alternator and starter motor, including operating principles such as Fleming's rules aligned to reference of specific components and their function. This must include direct reference to the application of magnetic principles and rectification in the alternator of AC to DC voltage. Learners will be able to use a multimeter and other test equipment in a safe manner and follow operational guidelines to test the performance of batteries, starter motors and alternators. At Merit level, learners will fully complete the tests to ascertain which components or circuits are faulty. Where there are no faulty components or circuits it is up to centres to create simulation by the generation of faults. Learners should show that they are able to explain the need for voltage control and the consequences of a faulty rectification process. The evaluative process at Distinction level will include recommendations made on the cost-effectiveness of repair or replacement to include any warranty and longevity decisions.

At level 1, learners should be able to identify the components within the lead acid battery. They should also be able to outline the operating principles of storing electricity in a chemical state, with direct reference to electrolyte, sulphuric acid and deionised water. The learner will recognise the units associated with working with electricity, volts, amps, ohms and watts, and have an awareness of the formula used, such as Ohm's law. The safe engagement of learners when working with high-risk materials such as acid needs careful planning but will have a major impact. Where possible, a practical experience would be very beneficial and would increase the learners' knowledge of the safe working and handling of this type of material. At this level, they will have knowledge of the operating principles of both a starter motor and an alternator, the components, different types of alternator and starter motors, along with any service adjustments and testing procedures.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1	Vehicle Lighting and Auxiliary Electrical System and Components Understanding	Your employer wants you to prepare for some future testing of vehicle lighting and auxiliary electrical system and component testing. They have asked you to investigate systems and components.	A portfolio or presentation of systems and components.
1A.2, 2A.P2, 1A.3, 2A.P3, 2A.M1, 2A.D1	Vehicle Lighting and Auxiliary Electrical System and Components Testing	Your employer is going on holiday and requested that you check the electrical lighting and auxiliary systems on their car. You will need to ensure that the vehicle conforms to legal requirements. Carry out testing that ensures the vehicle would pass examination to the Ministry of Transport's (MOT) expectations.	A practical task should be set to complete the performance checks and tests. This should be supported by written records, records of teacher observation and oral questioning.
1B.4, 1B.5, 2B.P4, 2B.P5	Vehicle Charge and Start Systems – Batteries and Starter Motors	A technician needs to explain the function and operation of lead acid batteries to a new apprentice. You are to prepare a short guide along with a safe handling guidance sheet.	Visual and verbal prepared materials. Teacher assessments which include observations of safe handling processes by demonstration.
1B.6, 2B.P6, 2B.M2	Vehicle Charge and Start Systems – Alternators	Some learners studying science at a centre near you are struggling to understand alternators. Your employer suggests you offer to help them out. You have been asked to create a presentation on the function and operation of alternators.	A visual presentation with notes.

Criteria covered	Assignment	Scenario	Assessment evidence
1B.7, 2B.P7	Vehicle Charge and Start Systems – Starter Motors	Some learners studying science at a centre near you are struggling to understand starter motors. Your employer suggests you offer to help them out. You have been asked to create a presentation on the function and operation of starter motors.	A visual presentation with notes. A handout for components or specific diagrams could be provided.
1B.8, 2B.P8, 2B.M3, 2B.D2	Vehicle Charge and Start Systems – Testing Vehicle Batteries, Alternators and Starter Systems	Your employer is considering taking on new apprentices. You are required to carry out the testing of the systems identified.	The evidence from the practical tasks should be supported by written records and records of teacher observation.

Unit 17: Welding

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how oil and gas platforms withstand the harsh conditions encountered in places such as the North Sea? Continuous buffeting by heavy winds, sea currents and salt spray usually does not cause a problem. Rigs are made up from lots of components, such as tubes and plates that are joined in a way which prevents them from coming apart. Nuts and bolts are not suitable because they might work loose due to the vibrations caused by the buffeting of the wind. The components are joined together by fusion welding, a method which involves heat and melted metal. Can you think of a problem that might occur when someone joins two pieces of metal together by welding? Once the parts are joined you cannot take them apart, so it is important to ensure that they are in the correct position before making the weld.

In this unit you will start by investigating the different types of welding processes used in the engineering industry. Welding is done in two ways: either by burning gases or by an electric arc. There are hazards involved when welding metals and you will think about ways of reducing and controlling the risk to yourself and other people. After finding out about welding processes and the tools, equipment and consumables to be used when making a welded joint, you will put theory into practice by having a go at making some simple welds.

You will learn how to select and set up the equipment, as well as how to prepare the materials to be joined before going on to produce some fusion welds. The welders who work on the construction of oil and gas rigs are trained to a very high standard and must produce welds which meet British/European/International quality standard BS EN ISO 5817. You will be expected to use visual inspection and test procedures to check if your welds are accurate, properly made and defect-free. On completion of welding you will be expected to close down equipment safely and leave the working area in a tidy condition.

Learning aims

In this unit you will:

A be able to prepare for work in a welding environment

B be able to safely produce welded joints to quality standards

C be able to safely perform non-destructive and destructive tests on welded joints.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to prepare for work in a welding environment
Topic A.1: Welding processes Types of process used when welding metallic materials, including: ● gas welding: oxy-acetylene ● electric welding: manual metal arc (MMA). **Topic A.2: Consumables** Consumables relevant to the welding process, including: ● gas welding: oxygen, acetylene, filler rods ● electric welding: welding rods, filler wire. **Topic A.3: Tools, equipment and information sources** Selecting welding equipment, including: ● tools: basic hand tools, chipping hammer, clamps, fixtures ● equipment: o cables, hoses, torch, electrode holders, gas bottles, regulators, power supply o assembling welding equipment – cables, weld return lead and clamp, electrode holders, gas supplies, safety devices o setting and adjusting welding conditions – gas pressures/flow rates, voltage, amperage ● information sources: o safety instructions, job instructions, engineering drawings o weld procedure specification, record/reporting sheet. **Topic A.4: Working safely** Safety awareness while carrying out welding processes, including: ● hazards and risks ● people at risk ● control measures.

What needs to be learnt
Learning aim B: Be able to safely produce welded joints to quality standards
Topic B.1: Safety Keeping safe in a welding environment, including: ● fire and accident prevention and reporting ● manual handling – materials, equipment, gas cylinders ● checking conditions – pipes, torches, voltage and amperage, leads ● keeping a clean and tidy work area ● personal protective equipment (PPE), ventilation and extraction ● closing down equipment safely. **Topic B.2: Making welded joints** Preparation of materials to be joined: ● check materials are free from excessive contamination – rust, oil, grease, dirt ● edge preparation – flat, square, bevel, chamfer, groove ● set up and restrain materials – position, alignment, gapping, clamps, fixtures. Making joints: ● material – steel ● form – plate, section, pipe/tube ● tack, butt, fillet welds ● starting the weld – striking, initiating, torch lighting, adjusting/controlling the arc/flame. Welding positions: ● flat/horizontal, vertical downwards, vertical upwards ● welding technique – torch and filler angles for various positions. Quality standards: ● British, European and International standard BS EN ISO 5817 ● dimensional checks, e.g. positional accuracy, size, profile of weld, distortion ● visual checks, e.g. uniformity, alignment, correct fusion, fillet of appropriate size, porosity, slag inclusions, parent metal substantially free from arcing or chipping marks.

What needs to be learnt
Learning aim C: Be able to safely perform non-destructive and destructive tests on welded joints
Topic C.1: Weld testing **Non-destructive tests** Carry out visual inspection (for surface defects macroscopic examination) and tests on a welded joint to assess any defects or irregularities and record/report the outcome: Tests, e.g.: ● dye penetrant ● fluorescent particle ● magnetic particle. **Destructive tests** Carry out visual inspection (for surface defects macroscopic examination) and tests on a welded joint to assess any defects or irregularities and record/report the outcome: Preparation, e.g.: ● cutting a specimen – e.g. hand saw, power saw, abrasive disc ● specimen preparation – e.g. removing slag/spatter/surface irregularities, cleaning, degreasing, polishing, making saw cuts in welds. Tests, e.g.: ● nick break (fracture) test ● bend test. **Topic C.2: Safety** Safety awareness when testing welded joints: ● hazards and risks, e.g. hand/powered cutting equipment, cleaning/degreasing chemicals ● people at risk ● personal protective equipment (PPE), e.g. eye protection, face protection, hand protection ● agreed testing procedures.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to prepare for work in a welding environment			
1A.1 Identify the main hazards and people at risk when welding metals.	2A.P1 Identify specific risks and suggest control measures when welding metals.		
1A.2 Identify key aspects of how to set up a gas and an electric welding process safely for a given welding application.	2A.P2 Describe how to set up a gas and an electric welding process safely for a given welding application.	2A.M1 For a given welding application, select the most suitable welding process, including tools, equipment information and consumables, giving reasons.	2A.D1 Explain the choice of tools, equipment, information and consumables for given welding processes. #
1A.3 Identify the categories of consumables that are needed for a given welding process.	2A.P3 Prepare a list of the consumables that are needed for a gas and an electric welding process.		
1A.4 Identify six tools/pieces of equipment to be used when making a welded joint safely.	2A.P4 Select the tools, equipment and information needed for a gas and an electric welding process.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Be able to safely produce welded joints to quality standards			
1B.5 Safely prepare two pieces of material that are to be welded together.	2B.P5 Safely set up equipment and prepare materials for welding.		
1B.6 Safely make a butt weld to a required quality standard.	2B.P6 Safely make two butt welds to a required quality standard using different weld positions, one with plate and one with section/tube.	2B.M2 Review the success of the welding techniques used and suggest ways of improving them.	
1B.7 Safely make a fillet weld to a required quality standard.	2B.P7 Safely make two fillet welds safely to a required quality standard using different weld positions.	2B.M3 Identify by visual examination the features that affect the quality of the two welded joints.	2B.D2 Analyse the quality of the welding, suggesting remedies for defects.
Learning aim C: Be able to safely perform non-destructive and destructive tests on welded joints			
1C.8 Make a visual inspection of a welded joint to assess any surface defects.	2C.P8 Perform a non-destructive test on a welded joint, make a visual inspection and record/report the outcome.	2C.M4 Describe the procedure used during this non-destructive test.	2C.D3 Draw on outcomes of tests conducted to explain the function of destructive and non-destructive tests.
1C.9 Make a visual inspection of a welded joint that has undergone a destructive test.	2C.P9 Perform a destructive test on a welded joint and make a visual inspection and record/report the outcome.	2C.M5 Describe the procedure used during this destructive test.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- appropriate welding equipment, consumables and materials as outlined in the unit
- access to appropriate destructive and non-destructive test equipment
- HSE risk assessment template – www.hse.gov.uk/risk/guidance.htm.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

The practical activities specified in this unit involve the use of procedures that are hazardous and must be carefully monitored by the assessor. It is important that when designing assignment briefs, the assessor makes it quite clear to learners that they must follow specified safety procedures so that risk to themselves and others is minimised. Some criteria are addressed through tasks involving diagrams/sketches and written text; it is acceptable to use graphics clipped from data sources (these must be acknowledged) but the writing that goes with them must be the learners' own work. Descriptive text cut and pasted from the web is not acceptable evidence. At level 1, a learner can provide more basic statements when asked to 'identify'.

For learning aim A at level 2, learners are required to give full descriptions of oxy-acetylene welding and one type of electric arc welding. Written notes should be supported by diagrams/images. Learners should be given scenarios to work from, for example, drawings and job instructions for two products that are to be welded. They should consider safety issues and select the tools, equipment and information that a third party would need if they were to go ahead and make the welded joints safely. Information sources should include safety instructions and weld procedure specifications.

For learning aim A at level 1, learners must be able to identify the key steps involved with setting up gas and electric welding equipment. Learners should identify the two main categories of consumable: gases and welding/filler rods. It is recommended that learners be given a sketch or drawing of a simple product that is to be welded from mild steel. They should be told which welding process is to be used and asked to make a list of the tools and equipment needed. They should also identify the hazards that are present in a welding environment.

For learning aim B at level 2, learners should set up the equipment and prepare the materials to be used when making a range of welded joints. They should present evidence of checking that the materials are free from excessive contamination, taking corrective action if required, carrying out edge preparation and setting up the equipment. They must be able to confirm that they worked safely. Evidence should be presented as annotated photographs, brief notes and a teacher-signed observation record.

Learners must produce butt and fillet joints to a given quality standard using different welding positions. The components to be joined will have been previously edge prepared by the learner. Photographs supported by brief notes and teacher observation records are the required forms of evidence.

For learning aim B at level 1, learners should be given two pieces of mild steel which are to be either butt or fillet welded. They should give evidence of checking that the materials are free from excessive contamination, taking corrective action if required and carrying out edge preparation. They must be able to confirm that they worked safely. Evidence should be presented as annotated photographs, brief notes and a teacher-signed observation record.

For learning aim C at level 2, learners must perform a non-destructive test and a destructive test on different welded joints. These can be the ones that they made previously or they could be given welds with specific faults. Having carried out the inspection, they then record the result as notes and annotated diagrams/images. An observation record would support this evidence.

For learning aim C at level 1, learners have to carry out visual inspections of two welded joints. These could be prepared by the centre or, if appropriate, the welds that learners produced previously. It may make the task more controlled if they are given joints which have easy-to-spot surface or internal defects 'designed' into them. Images with annotation are acceptable evidence but should be supported by an observation record.

Across the unit's three learning aims, the higher levels of achievement, Merit and Distinction, require learners to carry out tasks which build on the expertise demonstrated when presenting evidence for the pass assessment criteria.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 1A.4, 2A.P1, 2A.P2, 2A.P3, 2A.P4, 2A.M1, 2A.D1	Welding Processes	You have recently started work as an apprentice with a company which manufactures pre-fabricated steel framed industrial buildings. The training manager thinks it a good idea if you familiarise yourself with the welding processes carried out on site. They ask you to investigate processes, materials, consumables, tools, equipment and safe working practices; your findings are to be presented in a portfolio.	Prepare a written report which includes diagrams and images. These can be taken from reference sources, as long as they are supported by learners' 'own writing'.
1B.5, 1B.6, 1B.7, 2B.P5, 2B.P6, 2B.P7, 2B.M2, 2B.M3, 2B.D2	Positional Welding and Visual Examination of Welds	Your employer wishes to review your progress with the company by checking out how much you have learnt at college and in the training workshop. They ask you to set up welding equipment, prepare materials for welding, produce welded joints and visually inspect them. They also ask you to review the success of the welding techniques carried out and to suggest ways of improving them.	The assessment should be in two parts: 1. A practical activity with evidence presented in a logbook and/or portfolio. Annotated photographic evidence and assessor observation records must be included. 2. A review presented as a written report.
1C.8, 1C.9, 2C.P8, 2C.P9, 2C.M4, 2C.M5, 2C.D3	Testing Welded Joints	You supervisor is happy with your work and now wants you to test welded joints using non-destructive and destructive test methods. They ask that you prepare a record of what you did, including descriptions of the procedures used. Finally they require you to compare and contrast non-destructive and destructive test methods.	A report which includes descriptions of the procedures used, test results, photographs and/or diagrams; an assessor observation record.

Unit 18: Computer Numerical Control Programming

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how complex machined components, from small gear mechanisms for bicycles to large jet engines for aeroplanes, are manufactured to such a high degree of accuracy? The answer is with the help of computers and specifically CNC, which stands for computer numerical control.

CNC is used extensively throughout the engineering industry as a means of producing precisely controlled movements. Its main application in engineering/manufacturing is in the production of components, using machine tools for material removal. Typical examples of these machines and processes include CNC turning and milling centres, routers and CNC lathes.

In addition to manufacturing processes, CNC is used to aid the quality control process by providing the movement of probes (for in-line inspection) and on co-ordinate measuring machines (CMM). CNC has revolutionised the engineering/manufacturing environment in many ways. In particular, it has helped to improve productivity, speed of design, flexibility and quality.

This unit will provide you with an introduction to CNC part programming. It will enable you to use a CNC machine to plan for the manufacture of a product from its design specification. You will learn how to write a part program for safe use on a CNC machine. You will also learn how CNC machines use these programs and how, by running part programs on CNC machines, components can be accurately and consistently produced, complying with all relevant health and safety regulations. An important part of this process is the development of an accurate program and you will gain experience of proofreading CNC programs and checking products are being correctly made and they are running as expected.

Learning aims

In this unit you will:

A know about the types of CNC machines and their uses

B be able to create a production plan for a CNC machine using a product specification

C be able to write a part program and safely demonstrate its use for the manufacture of a product or component on a CNC machine

D be able to carry out a proofreading procedure for a CNC program and check conformity of a manufactured product or component to its specification.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the types of CNC machines and their uses
Topic A.1: Types of CNC machines and their uses Types of CNC machines used to manufacture a specific product or component, including: ● 2-axis CNC lathes ● turnmill centres ● milling machines ● routers ● machining centres. Comparison with traditional machining techniques, including: ● turning ● milling ● routing.
Learning aim B: Be able to create a production plan for a CNC machine using a product specification
Topic B.1: Product specification and production plans Using a product specification to create a production plan for the manufacture of a product or component on a CNC machine. Using a product specification, including: ● production drawings ● production quantities and delivery rates ● quality specifications ● parts and materials to be used ● processing methods specified in the design. Create a production plan, including: ● types of CNC machine required ● materials required ● cutting tools required ● speeds and feeds appropriate to given materials ● suitable sequences of machining operations ● avoidance of wasted tool/cutter movements and tool changes.

What needs to be learnt
Learning aim C: Be able to write a part program and safely demonstrate its use for the manufacture of a product or component on a CNC machine
Topic C.1: Part programs Writing straightforward and complex part programs for a CNC machine. Writing a straightforward program, including: ● reference (datum) points ● absolute co-ordinates ● machine axes ● positional information using absolute systems of measurement ● tool change positions ● tool lengths ● safe use. Additional features of a part program which increase its complexity: ● incremental co-ordinates ● positional information using incremental systems of measurement ● cutter path change points ● tool offsets and radius compensation ● codes for preparatory and miscellaneous functions ● effective sequencing of operations. **Topic C.2: Working safely** General safety awareness while carrying out CNC processes: ● use of personal protective equipment (PPE) ● keeping a clean and tidy work area ● identifying hazards ● deciding who might be at harm and how ● identifying risks and appropriate control measures e.g. evaluation, recording of findings and implementation, Health and Safety Executive (HSE) risk assessment, use of appropriate guarding ● recording of findings and implementation, e.g. sharing results of risk assessments carried out, making improvements, identifying long-term solutions, regular checks. **Topic C.3: Load, store, retrieve, transfer and run part programs on CNC machines** Running programming procedures, including: ● manual data input (MDI) ● storing and retrieving programs using portable media or networks ● downloading via computer interface ● program edit facilities.

What needs to be learnt
Learning aim D: Be able to carry out a proofreading procedure for a CNC program and check conformity of a manufactured product or component to its specification
Topic D.1: Proofreading Proofreading methods to check a program, including: ● simulation/graphing software ● single block program run ● dry run ● over-ride controls ● adjustments for tool or probe compensation. **Topic D.2: Conformity of a manufactured product or component to its specification** Checking conformity of a manufactured product or component to its specification, including: ● direct measurement using rulers and callipers ● unilateral and bilateral tolerances ● use of further measurement equipment to check conformity, e.g. micrometers, slip gauges.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the types of CNC machines and their uses			
1A.1 Identify two different CNC machines used to produce given products or components.	2A.P1 Outline the use of two different CNC machines used to produce given products or components.	2A.M1 Compare and contrast the use of CNC machines with traditional machining techniques.	
Learning aim B: Be able to create a production plan for a CNC machine using a product specification			
1B.2 Use a given product specification to identify the required material, cutting tools and CNC machine required to produce a given component.	2B.P2 Use a given product specification to produce a complete production plan for the manufacture of a given component using a CNC machine.	2B.M2 Explain how the production plan meets all of the criteria in the specification.	2B.D1 Justify how the production plan meets all of the criteria in the specification by comparing the plan with alternative methods of producing the given component.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to write a part program and safely demonstrate its use for the manufacture of a product or component on a CNC machine			
1C.3 Write a straightforward part program for safe use on a CNC machine.	2C.P3 Write a complex part program, which is based on a straightforward part program and incorporates three additional features, for safe use on a CNC machine.		
1C.4 Safely load, store, retrieve, transfer and run a straightforward part program on a CNC machine.	2C.P4 Safely load, store, retrieve, transfer and run a complex part program on a CNC machine including downloading techniques.	2C.M3 Explain the methods used to store, retrieve, transfer, load and run a CNC program.	2C.D2 Justify the chosen method used to store, retrieve, transfer, load and run a CNC program.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning Aim D: Be able to carry out a proofreading procedure for a CNC program and check conformity of a manufactured product or component to its specification			
1D.5 Use simulation/graphing software to check a straightforward CNC part program.	2D.P5 Use simulation/graphing software and other proofreading techniques to check a complex CNC part program.	2D.M4 Explain the proofreading methods used to check the program conforms to specification.	2D.D3 Justify the use of proofreading methods and use simulation/graphing software to check the program conforms to specification.
1D.6 Use rulers and callipers to take direct measurements to check the conformity of a given manufactured product to its specification.	2D.P6 Use rulers, callipers and further measuring equipment to take direct measurements to check the conformity of a given manufactured product to its specification.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to CNC machines - these may be lathes, milling machines, routers etc. It is important that learners have access (for assessment) to two types of CNC machine identified in the content. Centres do not need to cover all the CNC machine types that are commercially available. Where resources are not directly available, it may be possible to engage local industry, colleges or universities to support the delivery of this unit
- access to relevant software will be needed to design, transfer, prove and run a part program on the intended machine type. Proofreading needs to be carried out using simulation/graphing software together with dry run facilities for the program. Planning templates would also be useful for learners to follow when preparing their part programs. A full range of tooling and work-holding devices should also be available
- access to traditional machining techniques, including turning, milling and routing techniques, to support the knowledge based requirement.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of learners' achievement of the learning aims and related assessment criteria could be collected from three assignments which reflect the overall planning and production of a given product/component. These assignments should require learners to prepare reports of their activities in the workshop with CNC machines and related equipment, and where necessary collect the evidence in the form of a portfolio. Due to the practical nature of the unit, teacher observation and possibly oral questioning will play an important part in the final assessment of the learners' achievement. This direct evidence of process skills should be planned, documented and recorded appropriately. In order to reflect the difference between achievement at level 1 and level 2 the part program that learners write, proof and run is described as either 'straightforward' or 'complex'. In addition a complex program should have all the elements of the straightforward program included.

As much of the evidence for these activities is likely to be in the form of a portfolio of evidence it would be advisable to link the three suggested assignments, reflecting each stage of a part programming activity as it is carried out. Photographic records may also be helpful to capture the steps and processes carried out by learners (for example, machine layout and set-ups, tooling, safety equipment used etc). Such photographic evidence must be suitably annotated by learners to indicate its relevance with respect to unit content/criteria and verified by the teacher (e.g. comments added, signed and dated as a true record).

Throughout the assessment of this unit it is important that learners can demonstrate the appropriate use of personal protective equipment (PPE) required and identify potential hazards along with safe working practices, such as the use of guards and screens.

At level 2, learners will need to go beyond simple identification and produce a complete production plan for the production of a part or component using a specific CNC machine. This plan should consider the given product specification in some detail and consider the parts and materials to be used and specific processing methods that are specified within the production drawing. The product specification could be a drawing that learners extract information from in order to decide the type of machining process required.

Learners should produce an outline of the use of two different CNC machines to produce given components or products. The two given products/components should require the use of two different CNC machines and it would be anticipated that learners would have access to these machines or sufficient information to produce written responses that outline how the machines are used and the reasoning for the machine selection. Learners will also need access to traditional techniques, allowing comparison to the use of CNC machines.

Following on from this, when writing the part program learners are required to add the full range of more complex elements outlined in the unit content. The complex program will be based on a straightforward program and should, ideally, be for the product or component identified in the previously developed production plan. This could be evidenced with learners highlighting the complex features with specific annotations, or additional commentary, within a report. Alternatively, witness testimonies will need to highlight these elements.

Learners should be able to evidence that they have edited the program and used an appropriate computer interface to download the program. Evidence could include a record of the part programs annotated to show where editing has taken place. This additional evidence is likely to be incorporated within the portfolio of evidence as further teacher observations or witness testimonies/screenshots etc.

As part of editing the program learners will proofread their part programs. This will include the use of simulation/graphing software; in addition, learners will demonstrate the wider range of proofreading techniques outlined in the unit content. Again, the evidence for this is likely to be in the form of teacher observations, witness statements, annotated photographs and screen grabs that should be collated into the portfolio of evidence.

Finally, learners will consolidate their use of direct measurement techniques and consider tolerances and the use of further measurement equipment such as micrometers and slip gauges. The one-off part/component previously produced should be used in conjunction with the appropriate specification, which should provide sufficient scope to allow the use of more complex measurement techniques. Teacher observations and annotated photographs could be used to evidence the safe use of these techniques.

At level 1, learners will use a given product specification to identify the required material, cutting tools and CNC machine required to produce a given component. This list should be generated, predominantly, from production drawings; although production quantities, delivery rates and quality specifications will also contribute to this identification.

As part of this activity learners will identify two different CNC machines used to produce given products or components provided the given product or component requires the use of at least two of the types of CNC machine listed in the unit content.

Learners will write a straightforward part program for safe use on a CNC machine. This program should be for a given component or part and the assessment activity could be a continuation of the previous activity, normally using the same product/component. Straightforward programs are defined from the range given in the unit content. The evidence could be presented as a report, clearly showing the stages of planning and preparation of the part program; alternatively, a witness testimony could be used as evidence. This testimony could take the form of a checklist indicating that the unit content has been satisfactorily evidenced.

Learners should be able to safely run a part program in order to produce a given part/component. In order to complete this exercise they should be able to locate the part program indicating how it is created and stored. They should retrieve it and use appropriate techniques to transfer it to the CNC machine(s) in order to enable production. This process should include the use of appropriate portable media and manual data input. It is likely that this evidence will be a continuation of the activities used to evidence learning aims A and B. It is likely to be in the form of a portfolio of evidence of each stage as it is carried out; once again the use of annotated photographs, including photographs of the part produced, and teacher observations is likely to be a key part of the portfolio evidence collated by the learners.

Learners should present evidence of the use of simulation/graphing software to check a CNC part program. It would be expected that the part program developed previously would be used and teacher observation and annotated printouts/screen grabs from the software would be appropriate sources of evidence, which could be presented as part of a portfolio.

Learners will use rulers and callipers to take direct measurements to check conformity to specification. Learners should have run a part program and produced a one-off part or component. By referencing the specification for the part/component learners can take direct measurements to ensure sizes are as specified. Teacher observations and annotated photographs could be used to evidence the correct and safe use of the measuring equipment and to ensure appropriate checks are being made.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1B.2, 1C.3, 2A.P1, 2B.P2, 2C.P3, 2A.M1, 2B.M2, 2B.D1	Using product specifications to write part programs	You are working as an apprentice in a engineering manufacturing company. You have been asked to consider two CNC machines and, using a product specification, to plan the manufacture of an engineering component, using one of the machines. You are then required to write a part program to facilitate its production.	A report containing written responses concerning the range of CNC machines used for given manufacturing processes along with a program print out/screen shot and production list/plan.
1C.4, 2C.P4, 2C.M3, 2C.D2	Safely running part programs on a CNC machine	An engineering manufacturing company uses part programs to manufacture batches of a range of products. You have been asked to produce an initial engineering component using one of these part programs. You will need to load, store, retrieve, transfer and run the part program safely for your employer to evaluate the component.	A portfolio of evidence including teacher observation records of practical tasks, printout records, photographic records of processes descriptions/justification of CNC methods used. Identification of main hazards and detailed risk assessment measures.
1D.5, 1D.6, 2D.P5, 2D.P6, 2D.M4, 2D.D3	Checking conformity and proofreading CNC programs	Working as an apprentice in an engineering manufacturing company you have been asked to produce an initial component, in preparation for batch production, using a part program. Your employer has asked you to proofread and carefully check the first product produced to ensure it conforms to the specification.	A portfolio of evidence including annotated and amended part program, screenshots, records of test runs, photographs/records of equipment used and results of tests, teacher observation records, written explanation/comparison of proofreading methods.

Unit 19: Bicycle Servicing and Maintenance

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Why has there been such a surge in the popularity of cycling in recent years? Perhaps it's the many benefits it can bring, including improved health and fitness, reduction in travel costs and the fact that it is environmentally friendly. With its popularity set to continue to rise, many more people will take up cycling or cycle more often. This has resulted in an increasing need for service and maintenance of the many types of bicycles currently available on the market.

This unit gives you the opportunity to carry out practical servicing and maintenance, both of which form the building blocks of the role of a professional bicycle mechanic.

You will need to know the wide range of bicycles currently available and their purpose, as well as the features of their main component parts. Specific tools are required for bicycle servicing and maintenance, so you will also learn to be able to use the correct tools for the job.

Safety is a very important issue, and bicycles need to be checked over thoroughly. Therefore, you will need to be able to carry out rigorous safety checks in order to find any potential faults. The professional bicycle mechanic needs to be able to assemble and set up different bicycles for customers, as well as fault-find to determine why a system is not operating correctly. You will have the opportunity to perform a number of servicing and maintenance procedures throughout this unit.

A bicycle workshop is no different from any other engineering workshop. Mechanics need to work safely and minimise the risks from servicing and maintenance procedures. You will use the Health and Safety Executive (HSE) guidelines on risk assessment to ensure that all necessary control measures are in place to minimise those risks.

Learning aims

In this unit you will:

A know about different types, component parts and key features of bicycles

B be able to carry out checking, servicing and maintenance procedures on bicycles safely.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about different types, component parts and key features of bicycles
General classification and purpose of different types of bicycles, including: ● road bicycles, e.g. racing, triathlon/time trial (TT), touring, cyclocross ● off-road/mountain bicycles (MTB), e.g. full suspension, hardtail, downhill ● freestyle bicycles, e.g. BMX, trials, dirt jump ● city bicycles, e.g. hybrid/urban, folding, Dutch/classic, singlespeed/fixed gear. Components parts: ● frame set, e.g. top tube, seat tube, seat stay, head tube, down tube, bottom bracket, dropouts, chainstay ● drivetrain, e.g. front/rear derailleur, shifters, cassette, crankset, bottom bracket, crank arms, pedals, chain rings, chain ● steering, e.g. handlebars, stem, headset, forks ● wheelset, e.g. rims, spokes, hubs, tyres, tubes ● brakes, e.g. front/rear brakes, brake levers ● saddle and seatpost ● front and rear suspension (MTB). Key features: ● cost, e.g. low cost (available from high street shops), high cost (top of range groupsets from specialist suppliers) ● weight, e.g. low weight (titanium components), mid-weight (aluminium frame and components) ● make-up materials, e.g. carbon fibre frame and forks for high stiffness and low weight ● durability, e.g. materials and components that can perform in poor weather conditions and on badly maintained road surfaces/off-road terrain.

What needs to be learnt
Learning aim B: Be able to carry out checking, servicing and maintenance procedures on bicycles safely
Pre-ride bicycle 'M-check': ● wheels – wheel quick release/wheel nuts, tyre wear, tyre pressure, hub bearings, rims and spokes ● brakes – levers, blocks, cables ● saddle – 'minimum insertion' marker, post securely gripped in frame, saddle fitted securely, saddle straight and level ● handlebars – stem alignment, handlebar alignment, stem height, headset bearings ● gears and transmission – chain, derailleur position. Full bicycle safety check: ● handlebars/stem – tight, no distortion, protected ends, comfortable height ● headset/steering – no wobble, correctly adjusted, turns smoothly ● brake levers – comfortable position, fixed firmly, no frayed cables, working hydraulics ● gear shifters/levers – comfortable position, fixed firmly, no frayed cables ● front forks – undamaged, appear true, suspension safe (MTB) ● front hub – no wobble, turns smoothly, securely fixed wheel ● brakes (blocks/disc) – correctly fitted and aligned, sufficient wear ● wheels (rims and spokes) – reasonably true, no broken/missing spokes, good rim condition ● tyres – good tread, no splits, cracks or holes, sufficient inflation, valve straight ● frame – undamaged, appears true, rear suspension safe (MTB) ● saddle – fixed safely, straight, comfortable height (unless BMX) ● bottom bracket – no wobble, turns smoothly, securely fixed wheel ● pedal cranks – straight ● pedals – fixed firmly, complete, turning freely, not bent ● chain wheel – not bent, teeth not worn ● chain – not too worn, slack or rusty, lightly oiled ● front derailleur – properly adjusted, sufficiently lubricated, not bent ● rear derailleur – properly adjusted, sufficiently lubricated, not bent ● rear cassette – properly adjusted, sufficiently lubricated, not bent ● rear hub – no wobble, turns smoothly, securely fixed wheel ● peripherals, e.g. lights, mudguards, racks, additional items and brackets firmly secured. *continued*

What needs to be learnt
Basic bicycle servicing and maintenance procedures: ● tyre and tube removal and installation – removing tyre and tube from rim, inspecting inner tube, inspecting tyre, inspecting rim strip and rim cavity, repairing inner tube when necessary, installing tyre and tube on wheel, installing wheel on bicycle ● chain installation (derailleur bicycles) – removal of chain rivet, removing/installing chain through derailleurs, reinstall special connecting rivet ● brake servicing, for example: o sidepull brake service – pad and caliper adjustment, pad wear, caliper arm adjustment o V-brake service – calipers and pads (vertical height alignment, tangent alignment, vertical face alignment and pad toe), setting pads, pad wear o cantilever brake service – pad alignment (vertical height alignment, tangent alignment, vertical face alignment and pad toe), cantilever adjustment, pad wear o Hydraulic Brake Service (MTB) – pad wear, brake pad removal and replacement. Intermediate servicing and maintenance procedures, including: ● front derailleur adjustment – height, rotational angle, limit screw settings (L-screw and H-screw), indexing ● rear derailleur adjustment – limit screw settings (H-screw, L-screw and B-screw), indexing ● cassette and freewheel removal – cassette cog lockring/threaded freewheel removal and installation, installing cassette cogs/freewheel. Advanced servicing and maintenance procedures, including: ● chainline and shifting issues – effective chainline from rear cogs to front rings, front chainring position and bottom bracket length, chainline from rear hub ● troubleshooting a creaky or noisy drivetrain – loose crank/chainrings/pedals/ chainring cassette to crankarm/bottom bracket, dry chain/derailleur pulley (idler) wheels, creaking wheels and spokes/housing end caps/frame/saddle/headset/stem and handlebars/rear cogs/seatpost ● threadless headset service – headset removal, installing headset bearing races, pressing headtube cups, pressing fork crown race, installing the star fangled nut, headset assembly. Main tools: ● general tools, e.g. repair stand, sockets and bit set, torque wrenches, hex wrench set, combination wrenches, adjustable wrench, screwdriver set (e.g. straight blade) ● brake tools, e.g. fourth hand tool, cable cutters ● wheel and tyre tools, e.g. tyre levers, patch kit, floor pump, spoke key ● miscellaneous supplies and parts, e.g. bearing grease, bicycle cleaning kit, chain lubrication. *continued*

What needs to be learnt
Specialist tools: ● specialist bottom bracket tools, e.g. lockring wrench, adjustable/fixed cup tools, cartridge BB tool, external bottom bracket cup wrench, bottom bracket lockring tool, crankset and BB tool ● specialist headset tools, e.g. headset locknut wrench, headset lower race wrench ● specialist drivetrain tools, e.g. pedal wrench, crankarm pullers, cassette/freewheel removers, sprocket removal tool-chain whip, chain rivet extractor, chain wear checker, drivetrain cleaning kit, derailleur alignment gauge. General safety awareness while carrying out bicycle servicing and maintenance procedures, including: ● use of personal protective equipment (PPE) ● keeping a clean and tidy work area ● identifying hazards ● deciding who might be at harm and how ● identifying risks and appropriate control measures, e.g. evaluation, recording of findings and implementation, Health and Safety Executive (HSE) risk assessment ● recording of findings and implementation, e.g. sharing results of risk assessment, making improvements, identifying long-term solutions, regular checks.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about different types, component parts and key features of bicycles			
1A.1 Describe the main component parts of one type of bicycle.	2A.P1 Describe key features of the component parts of two types of bicycle.	2A.M1 Explain key features of the component parts of two different types of bicycle.	2A.D1 Evaluate how the key features of the component parts of two different types of bicycle are fit for purpose.
Learning aim B: Be able to carry out checking, servicing and maintenance procedures on bicycles safely			
1B.2 Safely perform a pre-ride bicycle ‘M-check’.	2B.P2 Safely perform a pre-ride bicycle ‘M-check’ and a full bicycle safety check.		
1B.3 With guidance, safely carry out two basic servicing and maintenance procedures on bicycles, using the main tools.	2B.P3 Independently and safely carry out two basic servicing and maintenance procedures on bicycles, making any adjustments required, using the main tools.	2B.M2 Independently and safely carry out intermediate servicing and maintenance procedures on bicycles, making any adjustments required, using specialist tools.	2B.D2 Independently and safely carry out advanced servicing and maintenance procedures on bicycles, making any adjustments required, using specialist tools.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- general and specialist tools for performing bicycle checking, servicing and maintenance activities (including a bicycle repair stand)
- a range of bicycles (including at least one road bicycle and one mountain bicycle) that can be used for checking, servicing and maintenance activities.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

This unit should be delivered in a practical manner by a competent 'home mechanic' or a professional bicycle mechanic from one of the local bicycle shops in the area. This gives the added benefit of invaluable vocational experience and the possibility of work experience placements. Learners do not have to fulfil all the assessment criteria using the same selected types of bicycle throughout. The unit assessment criteria give learners the flexibility to explore different types of bicycle should they wish to do so. Alternatively, learners may decide to select the same two types of bicycle throughout as evidence to meet the assessment criteria.

The assessment criteria have been developed to enable learners to submit evidence to meet each assessment criterion without the need to produce written evidence if so desired. For example, when giving the purpose of four different types of bicycle, learners could present evidence verbally to the assessor. This verbal evidence should be recorded, and detailed observation records/witness statements completed and retained for the purposes of summative assessment.

For learning aim A, when describing the main component parts of one type of bicycle, learners should be encouraged to have a bicycle or its component parts in front of them.

For learning aim B, it is important that assessors understand the differences between levels 1 and 2 when assessing the demonstration of skills and procedures.

It is expected that learners will perform the checks and carry out at least two adjustments safely. Faults should be introduced for the learners to adjust – for example, loose handlebars.

Learners need to carry out servicing and maintenance procedures on a bicycle and carry out at least two adjustments safely within a realistic situation. A realistic situation is one where learners are given the opportunity to demonstrate a specific skill under some pressure in a similar environment to a workshop situation. For example, learners could carry out servicing and maintenance procedures and at least two adjustments on a bicycle while the customer waits.

Learners may demonstrate their practical participation through a variety of different situations, but it is important that each assessment criterion is only awarded for full coverage of the assessment requirements.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Introduction to Bicycles	You have been employed as a school 'Bikeability' instructor and need to plan a short presentation on the different types of bicycles and main components of a bicycle for the introduction of a cycling proficiency session.	A short five-minute verbal presentation covering bicycle component parts of two different types of bicycle, evaluating the key features of these component parts. Learner observation records/witness statements must be included with the learner's own presentation notes.
1B.2, 1B.3, 2B.P2, 2B.P3, 2B.M2, 2B.D2	Bicycle Safety Checking, Servicing and Maintenance	You are to perform safety checks and a wide range of servicing and maintenance activities on a range of different types of bicycle on a day-to-day basis as part of your job as a bicycle mechanic. Risk assessments need to be carried out for all practical activities in the bicycle workshop to ensure safety.	Practical checking, servicing and maintenance activities, including learner observation records/witness statements. Alternatively, activities could be tested under controlled conditions with set tasks. Risk assessments for a range of procedures.

Unit 20: Sustainable Vehicle Power and Structure Design

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Greater awareness of our impact on the environment has led to increased interest in more sustainable approaches to travel. The environmental damage caused by petrol and diesel cars and increased fuel costs have encouraged consumers to look towards more environmentally sustainable modes of transport, such as hybrid electric vehicles and zero-emission alternatives, which use the electric motor as a source of power. Vehicle safety and economy continue to improve due to the use of lightweight modern alloys, polymers and composites within vehicle structures in place of steel, which has traditionally been the material of choice for the chassis and shell.

This unit gives you the opportunity to research and investigate these topics and to apply what you have learnt in practical situations. You will consider low-emission vehicles, focusing on the use of the fuel cells, batteries and electric motors instead of the traditional petrol/diesel engine to understand alternative approaches to environmentally sustainable vehicle design. You will also investigate methods of controlling motor speed and direction.

The focus will be on the design of vehicle structures, identification of appropriate materials and their properties, and the selection of appropriate manufacturing techniques. You will also explore alternative approaches to vehicle chassis and shell design, working safely and accurately with a range of materials, modelling tools and machines to prototype your own vehicle structures.

You will learn the importance of rigorous testing by investigating how vehicle safety has improved. You will identify the forces that act on a vehicle in different impact situations and how the vehicle structure can be designed to withstand these forces and protect its occupants. You will also learn about the standard tests used in the European New Car Assessment Programme (Euro NCAP).

Learning aims

In this unit you will:

A know about sustainable vehicle power supply and systems aligned to their benefits and environmental impact

B know about the principles of vehicle structure design

C be able to design and manufacture a model chassis and body structure

D know about vehicle safety testing.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about sustainable vehicle power supply and systems aligned to their benefits and environmental impact
Topic A.1: Sustainable vehicle power supply Types, basic operation and benefits of modern vehicle sustainable power supply and systems, including: ● operation overview, to include source of power to move the vehicle ● plug-in electric ● hybrid electric ● fuel cell powered ● modified conventional cars, including biofuel, compressed natural gas and clean diesel. **Topic A.2: Electric motors and motor control** Traditional methods, alternative methods and advantages/disadvantages of controlling motor speed and direction, including: ● traditional methods, such as mechanical switches and controllers ● alternative methods such as transistors and field effect transistors (FETs), Pulse Width Modulation (PWM) speed control and direction ● advantages/disadvantages to include the use of computer control and software development. **Topic A.3: Electrical energy as a power source** Characteristics, applications and advantages/disadvantages of generating and storing electrical energy for vehicles, including: ● storage such as in batteries (alkaline, lithium ion, lithium polymer) ● generation such as from hydrogen, fuel cell, solar and wind power ● advantages/disadvantages to include health and safety, impact on carbon footprint, range of travel and economy.
Learning aim B: Know about the principles of vehicle structure design
Topic B.1: Vehicle structures Characteristics, applications and construction of vehicle structures, including: ● chassis (separate body and chassis) ● monocoque (combination of chassis and body in 3D structures) ● space frame (internal tubular cage or frame with non-structural body). **Topic B.2: Materials and manufacturing processes** Identification and properties of appropriate materials and characteristics of manufacturing processes based on their appropriateness for vehicle structures, including: ● materials, e.g. metals, polymers and composites ● material properties, e.g. mechanical, chemical and thermal ● manufacturing processes, e.g. press forming, welding, mechanical fixings, laying-up glass/carbon fibre, casting and injection moulding.

What needs to be learnt
Learning aim C: Be able to design and manufacture a model chassis and body structure
Topic C.1: Designing and making vehicle chassis and body structures Design and make a model vehicle chassis and body, including the following tasks: ● Generation of a range of ideas for appropriate chassis and body structures. ● Design of a suitable chassis and body through modelling and development. ● Planning for the manufacture of the chassis and body structure, to include set measurement and tolerances, e.g. set out in a drawing, including wheelbase and tracking. ● Identification of risks and associated hazards, and possible control measures, to include any environmental impact. ● Use of tools, materials and manufacturing processes safely and accurately to construct the prototype vehicle chassis and body or an alternative prototype design. ● Combination of a range of materials and components using different manufacturing processes, aligned to the sustanability of supply. ● Evaluation of the effectiveness of the model and processes used, giving suggestions for improvements and cost implications.
Learning aim D: Know about vehicle safety testing
Topic D.1: Impact forces Definition and effects of the following forces that act on a vehicle structure in a collision, and safe vehicle structure/design to withstand them: ● compression force ● tension force ● torsion force ● shear force ● vehicle design and structure such as crumple zone, roll cage, collapsible steering columns and side impact bars. **Topic D.2: Impact testing vehicles** Characteristics of the European New Car Assessment Programme (Euro NCAP) methods for impact testing vehicles, including the use of 'crash test dummies' and the data collected, in the following situations: ● frontal impact ● car-to-car side impact ● pole side impact ● rear impact ● proposing modifications and adapting designs.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about sustainable vehicle design power supply and systems aligned to their benefits and environmental impact			
1A.1 Identify the different types of sustainable vehicle.	2A.P1 Describe the operation of alternative sustainable vehicle systems.	2A.M1 Compare the performance and environmental impact of two different types of sustainable vehicle systems. *	2A.D1 Evaluate design, motor control methods and power sources of two different types of sustainable vehicles in terms of their impact on the environment. *
1A.2 Identify traditional methods of controlling motor speed and direction.	2A.P2 Describe how motor speed and direction can be controlled using traditional and alternative methods and components.	2A.M2 Compare Pulse Width Modulation (PWM) with traditional methods of controlling motor speed and direction. *	
1A.3 Describe one zero-emission method of generating electricity for vehicles and describe one method used to store electrical energy.	2A.P3 Describe the advantages and disadvantages of zero-rated electrical energy generation and storage methods for vehicles.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Know about the principles of vehicle structure design			
1B.4 Identify the characteristics of chassis, monocoque and space frame vehicle structures.	2B.P4 Describe the applications and characteristics of the construction of the different types of vehicle structures.		
1B.5 Identify the materials and manufacturing processes used in the production of vehicle structures.	2B.P5 Describe the properties of the materials and the characteristics of manufacturing processes used to produce vehicle structures.	2B.M3 Compare two different types of vehicle structure design in relation to the materials and manufacturing processes used and their performance and cost. *	2B.D2 Justify the use of the different materials and manufacturing processes used for different types of vehicle design. *
Learning aim C: Be able to design and manufacture a model chassis and body structure			
1C.6 Work safely with tools, materials and processes to make a vehicle chassis.	2C.P6 Make a chassis and body by using materials, tools and processes safely and accurately.	2C.M4 Test the effectiveness of the chassis and body structures.	2C.D3 Evaluate the processes used to make the chassis and body structures and suggest improvements.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim D: Know about vehicle safety testing			
1D.7 Identify and describe the forces that act on vehicle structures in collisions.	2D.P7 Describe the forces that act on vehicle structures when vehicles are in collisions, and how those structures are designed to withstand forces.	2D.M5 Explain the effectiveness of one vehicle structure against different impacts in four types of impact/collision.	2D.D4 Compare two different vehicle structures in terms of their safety and effectiveness against forces in a collision.*
1D.8 Identify the types of situations and data to be collected as part of the European New Car Assessment Programme (Euro NCAP).	2D.P8 Describe each of the methods used to impact test cars as part of the European New Car Assessment Programme (Euro NCAP).	2D.M6 Explain how 'crash test dummies' are used to assess vehicle safety and identify the types of data collected.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit including:

- standard high-speed electric vehicle kit of components
- self-assembly vehicle test track
- basic chassis templates
- wide range of materials, components and equipment for vehicle development.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Before attempting the assessment tasks, practical investigations and design-and-make activities for the individual learning aims, it is important that learners are taught the essential elements of theory for each of the topics identified in the unit content. They should gather research and present their findings in a written report before applying what they have learnt in practical situations where they will test their outcomes and evaluate their performance to identify how their outcomes could be improved.

Suitable evidence could include video and photographic evidence supported by signed witness statements and artefacts (e.g. vehicle chassis).

For learning aim A, it is anticipated that learners will generate evidence initially on identifying, describing and comparing different types of alternative fuel system, and this could be within the range of different types being covered by the cohort. For the vehicle operation, it is expected that learners describe how the power source or energy supply is then converted into the movement of the vehicle – such as how energy stored in a chemical format in a charged battery is transferred through switching or control arrangements to activate motors for mechanical movement.

For the second part of the learning aim the evidence generated needs to focus on both the control of speed and direction. This could be through practical investigation and research, depending on the resources available. The third part of learning aim A involves the research, including advantages/disadvantages, of energy generation and storage for vehicles. Similarly the cohort could be challenged to cover the areas in the content.

The challenge set for learning aim B could use practical research to stimulate interest by the use of motorsport or high-performance structures. The range of different types needs to be identified, described and compared, along with the characteristics of the structures. This would be best served with similar research into the materials and production methods used for the identified content.

For learning aim C, a project based around the design and manufacture of the model with suitable evidence could include video and photographic evidence supported by signed witness statements and artefacts (e.g. vehicle chassis). The records need to show the planning process, risks and preventive measures along with the different materials to be used. The manufacturing of the model needs to include different manufacturing processes and different materials yet be able to be completed in a minimal timescale. A suitable selection could include welding, mechanical fixings and laying-up glass/carbon fibre. This could also include a combination of partially completed elements that are modified in manufacturing to meet the planning set up.

The testing at Merit level should set out simple methods, such as driving the model at a set speed for a frontal or rear impact, then measuring deviation, defects or observations to compare effectiveness against the original specification. This could be recorded in a video to enable further use.

Within learning aim D, learners will need to be assessed in describing how vehicle structures are manufactured to withstand forces and how they are tested. There are many videos and websites to research the material aligned to the content and assessment criteria. Should the resources be available the learners could impact test some of the models manufactured and evaluate the results.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.M2, 2A.D1	The Green Car Guide	You have been asked to write an article for a car magazine, *New Car Buyer*, reviewing the latest environmentally sustainable vehicles. The report must give a basic overview of the different types of 'green car' and compare their performance and environmental impact.	A written report.
1B.5, 1D.7, 1D.8, 2B.P5, 2D.P7, 2D.P8, 2B.M3, 2D.M5, 2D.M6, 2B.D2, 2D.D4	Why Do We 'Crash Test' Vehicles?	A car manufacturer has asked you and your research and development team to produce a report on the tests its vehicles will have to pass in the European New Car Assessment Programme (Euro NCAP).	Research and produce a written report that identifies the standard tests used in the European New Car Assessment Programme (Euro NCAP) and describes how each test is performed. A description and justification of structural design features used to protect vehicle occupants. A written comparison of the performance of two vehicle structures.
1B.4, 1C.6, 2B.P4, 2C.P6, 2C.M4, 2C.D3	Drag Racer Toy Design Challenge	A toy manufacturer has asked you and your design team to develop a vehicle that will run on its newly designed racetrack. They require the vehicle to undergo extensive safety testing to ensure it is fit for purpose and have asked you to find out about procedures.	Presentation of research notes on chassis and shell structures, including details on vehicle safety testing and materials and manufacturing processes to be used.

Unit 21: Introduction to Communications for Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

When designing, how early do engineers consider their initial thoughts and concepts? Engineers often discuss design ideas or problem-solving methods. They show and share ideas and solutions through sketches and verbal discussions.

Have you ever wondered whether people feel happy or not when you tell them something over the telephone? If they don't tell you or noticeably change their speech pattern you may not know. If you could see them and their body language, you would have a much better idea of whether they were happy or not. What about trying to remember what was discussed? A solution here is to make some notes, which can take the form of a diary/logbook in engineering for recording ideas.

This unit will help you to develop a range of sketching skills to be used in engineering. You will learn about the use of a diary/logbook to help plan and record what happens.

Have you ever been concerned or worried about sharing information with people or discussing or presenting in detail your ideas to them? In this unit you will also learn about information sources and how methods can be used effectively to outline engineering information and solve problems.

In today's world you will need to be confident in selecting and using a range of ICT software and hardware to present a range of information or ideas. You will have an opportunity to practise these skills and requirements, which will help you to communicate better in an engineering environment.

Learning aims

In this unit you will:

A be able to sketch simple shapes to represent engineering components

B be able to use communication methods in engineering contexts

C be able to select and use engineering information to solve engineering problems

D be able to select and use information and communication technology (ICT) to present information in engineering contexts.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to sketch simple shapes to represent engineering components
Topic A.1: Sketches Knowing about the benefits and limitations of using sketches, including: ● isometric pictorial views ● multiple view orthographic. Creating sketches of simple shapes: ● regular solids, e.g. cube, rectangular block ● hollow objects, e.g. circular tube, square section tube ● standard engineering components, e.g. nuts, bolts, screws. Creating sketches of complex shapes: ● irregular solids, e.g. casting, pattern, moulding, welded branch structure. **Topic A.2: Sketching techniques and equipment** Using sketching techniques and equipment, including: ● stationery, e.g. paper (plain, squared, isometric), pencil, eraser ● sketching in good proportion ● dimensions, e.g. overall sizes, detail. **Topic A.3: Pictorial sketches** Knowing about the importance, benefits and limitations, and the use of pictorial sketches when representing a standard engineering component an irregular solid, including: ● benefits, e.g. speed of production, visual impact ● limitations, e.g. lengths and shapes not true, not produced to a recognised standard, dimensions difficult to read.
Learning aim B: Be able to use communication methods in engineering contexts
Topic B.1: Communication methods Presenting communications about a simple engineering activity, knowing the advantages/disadvantages/improvements/alternatives when using: ● note taking, e.g. lists, mind mapping/flow diagrams ● graphical representation, e.g. use of graphs, charts and diagrams ● a diary/logbook for recording actions/thoughts and planning and prioritising work schedules. Outlining information about a simple engineering activity, knowing the advantages/disadvantages/improvements/alternatives when using: ● speaking, e.g. with peers, supervisors, use of appropriate technical language ● listening, e.g. asking other questions to clarify meaning, removing distractions, being patient, empathising ● body language in verbal communication. *continued*

What needs to be learnt
Topic B.2: Engineering contexts Relative to engineering: ● a simple activity, e.g. design activity, manufacture of a product or component, maintenance or service activity, planning operation, identifying and controlling hazards.
Learning aim C: Be able to select and use engineering information to solve engineering problems
Topic C.1: Information sources Selecting, using, explaining and justifying appropriate information sources, including: ● non-computer-based sources, e.g. technical reports, institute and trade journals, data sheets and test/experimental results data, manufacturers' catalogues ● computer-based sources, e.g. internet/intranet, CD ROM-based information (manuals, data, analytical software, manufacturers' catalogues), spreadsheets, databases. **Topic C.2: Use of information to solve an engineering problem** Solving an engineering problem: ● the solution of engineering problems, e.g. for product/service/design research, gathering data or material to support own work ● checking validity of own solution/work/findings.
Learning aim D: Be able to select and use information and communication technology (ICT) to present information in engineering contexts
Topic D.1: Software packages Selecting, using and evaluating software packages, including: ● word processing ● other processing packages, e.g. spreadsheets, simulation package for electrical/electronic circuits or plant/process systems ● presentations, e.g. PowerPoint®. **Topic D.2: Hardware devices** Selecting and using hardware devices, including: ● computer system, e.g. personal computer, network, plant/process control system, tablet computers, smart phones ● input/output devices, e.g. keyboard, scanner, optical/speech recognition device, printer, plotter. **Topic D.3: Preparing to present information** Presenting information, including: ● documents that include written and technical details, e.g. letters, tabulated test data, graphical dat ● visual presentation, e.g. overhead transparencies, charts, computer-based presentations (PowerPoint®), interactive white boards , visualisers. Using effective communication to convey key messages to a target audience, using the most appropriate features of technology. *continued*

What needs to be learnt
Topic D.4: Presenting information Relative to engineering: ● a simple activity, e.g. design activity, manufacture of a product or component, maintenance or service activity, planning operation, identifying and controlling hazards ● audience, e.g. familiar, unfamiliar, group or individual.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to sketch simple shapes to represent engineering components			
1A.1 Create sketches of a regular solid and a hollow object using a limited range of techniques.	2A.P1 Create sketches of regular solids, hollow objects and an engineering component using a range of techniques.	2A.M1 Create sketches of regular solids, hollow objects, an engineering component and an irregular solid using a range of techniques.	2A.D1 Justify the choice and use of a sketch, sketching techniques and equipment when representing a standard engineering component an irregular solid.
1A.2 Identify the benefits and limitations of using pictorial sketches when representing a standard engineering component.	2A.P2 Describe the benefits and limitations of using pictorial and orthographic sketches when representing a standard engineering component.	2A.M2 Explain the importance of achieving the benefits and overcoming the limitations of using pictorial and multi-view orthographic sketches when presenting a standard engineering component to a third party.	

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Be able to use communication methods in engineering contexts			
1B.3 Use a diary/logbook to represent an account of a simple engineering activity. #	2B.P3 Use a diary/logbook and graphical representation to produce an account of a simple engineering activity, including planning or prioritising. * #		
1B.4 Communicate information about a simple engineering activity.	2B.P4 Explain information about a simple engineering activity using different communication methods.	2B.M3 Discuss the advantages and disadvantages of different communication methods, stating how any disadvantages can be addressed in a given situation.	2B.D2 Justify why a specific communication method was used and the reasons for not using a possible alternative.
Learning aim C: Be able to select and use engineering information to solve engineering problems			
1C.5 Use information sources to solve an engineering problem.	2C.P5 Select and use appropriate information sources to solve an engineering problem.	2C.M4 Explain appropriate information sources to solve an engineering problem, checking the validity of the solution.	2C.D3 Justify the use of appropriate information sources to solve an engineering problem, checking the validity of the solution.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim D: Be able to select and use information and communication technology (ICT) to present information in engineering contexts			
1D.6 Use an ICT software package and hardware device to prepare information for a presentation.	2D.P6 Select and use appropriate ICT software packages and hardware devices to prepare information for a presentation.	2D.M5 Explain the use of an ICT presentation method, identifying an alternative approach.	2D.D4 Compare and contrast the use of an ICT presentation method with the use of an alternative approach.
1D.7 Carry out a presentation about a simple activity to a familiar audience or individual.	2D.P7 Carry out an effective presentation about a simple activity to an unfamiliar audience or individual.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- a variety of solids, objects and components for sketching
- normal sketching equipment
- a range of non-computer and computer-based sources of information associated with engineering activities
- computers and software packages.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of achievement of the learning aims and assessment criteria may be obtained from well-planned investigative assignments or reports of workplace visits or practical activities. It is anticipated that integrative assignments might be used to link this unit with other, more practical or project-related units in the programme. If this approach is adopted, the evidence for the specific learning outcomes and associated assessment criteria will need to be clearly and separately identified.

For 2A.P1 and 2A.P2, learners' evidence could consist of a small portfolio of sketches and written explanations addressing each criterion respectively. Items sketched must include regular solids, hollow objects and standard engineering components. The techniques used must involve sketching equipment, pictorial and orthographic representation and sketching in good proportion with the addition of some dimensions (all as specified in the unit content). The benefits and limitations described should be in relation to representing a standard engineering component such as a nut, bolt or screw. A description of the benefits and the limitations of using both isometric pictorial views and multiple-view orthographic sketches is required for 2A.P2.

For 2A.M1, learners will need to show sketching skills to produce more complicated shapes, a casting or moulding of a simple nature could be given. Castings and mouldings can be very complex so care should be taken in selecting the item to sketch. The level of complexity should be that seen if some of the simple shapes ranged in the content were combined to give more 'component-like' features rather than a simple abstract shape. For 2A.M2, learners must explain the importance of both achieving the benefits and overcoming the limitations of using both isometric pictorial views and multiple-view orthographic sketches. The explanation will build on the descriptions required for the pass criterion and will reflect on the learner's experience of creating sketches. An extension to this requirement for 2A.D1 should include the need to justify the choice of sketch, sketching technique and equipment to use when representing a standard engineering component and an irregular solid. This could be achieved by the inclusion of a range of benefits and limitations but would need to be more than an explanation, stating why some are most appropriate and why others are not.

For 1A.1, learners need to create sketches but do not need to use all techniques listed; a limited range may include the use of sketching equipment but the sketches do not need to be in good proportion or have many dimensions. For 1A.2, learners only need to identify, rather than describe, the benefits and limitations, although they must identify both.

For learning aim B at level 2, learners should carry out an engineering activity. They should complete a diary/logbook for 2B.P3 and then use communication methods to explain the information about the activity to a third party for 2B.P4. The work in the diary/logbook must include evidence of note-taking, planning or scheduling and the use of graphical presentation techniques. The use of other communication methods will require learners to demonstrate speaking and listening skills and appropriate body language. This could be a meeting with either peers and/or a supervisor, or could come from a presentation delivered by the learner to a group or individual. It would be important to ensure that the learner had to take questions from the group or individual to enable the assessor or witness to capture evidence of their ability to listen.

Evidence for 2B.P4 is likely to be a report, a teacher observation record or witness statement. Evidence for 2B.P3 will be the completed diary/logbook.

For 2B.M3, learners must discuss the advantages and disadvantages of different communication methods, stating how any disadvantages can be addressed for a given situation. For 2B.D2 they also need to justify why a specific communication method was used rather than a possible alternative. Evidence for these two criteria could be in the form of a written description, explanation or report.

For 1B.3, learners are required to use a diary/logbook with notes, not including graphical representation or any planning or prioritising. It is likely to be a list of what happened after the activity took place. For 1B.4, learners must communicate information about a simple engineering activity.

2C.P5 requires learners to select and use appropriate information sources to solve an engineering problem. It is essential that there is an opportunity to check the validity of the solution and that the information comes from both computer-based and non-computer-based sources. The evidence for this criterion could include suitably referenced and annotated work (a bibliography would not be sufficient). However, it would be preferable to have a record of the original source and an annotated hard copy to show the information identified and used to solve the problem.

To achieve 2C.M4, learners will need to explain the use of the information sources to check that a solution is valid. To achieve 2C.D3, learners will need to justify why they used the information sources they did when solving an engineering problem and checking the solution.

For 1C.5, learners will only be expected to use appropriate information sources to solve an engineering problem, so the sources of information could be given. The evidence must show that the learner was given the sources as they were unable to select them for themselves.

For 2D.P6, learners should be assessed preparing relevant and appropriate ICT software packages and hardware devices to present information. It is essential that they are given opportunities to select and use appropriate software to cover all the ICT applications listed in the unit content, i.e. there must be evidence of learners' use of ICT for word processing software, other processing software and presentation software. The requirement for hardware devices is limited to the choice and use of a computer system and relevant input/output devices that would be needed for the task carried out. It is expected that the presented information from the use of ICT will be a range of documents, to include written and technical details and visual presentation materials, that focus on a simple engineering activity. Having prepared the presentation for 2D.P7, the learner should present it to an unfamiliar group of people or an unfamiliar individual. This would be a good opportunity to have the learner present information to a potential employer. Practical elements of this learning aim are best captured using observation records.

For 2D.M5, learners are required to explain the use of an ICT presentation method and identify an alternative that could be used. This criterion is about the method of presentation and not the method of communication. For 2D.D4, learners should consider the overall approach taken. For example, could a word-processed technical report have been presented using a computer-based presentation package, such as PowerPoint®, including automated routines and animated graphics or video clips? The evidence for this is likely to be a written comparison. A rough outline illustrating the learner's identified alternative approach and advantages and disadvantages of both could be used to support the written response.

For 1D.6 and 1D.7, learners will only be expected to prepare and use an appropriate ICT software package from the list in the unit content and appropriate hardware devices to present information. The software and hardware to use could be given, but the evidence must show that learners were unable to select them for themselves. Learners working at this level are unlikely to be confident to present to a person or people they do not know but are likely to be able to present to someone familiar like their peers or member of staff.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	The Use, Benefits and Limitations of Sketching in Engineering	You have just started work in an engineering design office and the office manager wants to see that you are able to use sketches appropriately and understand the importance of their use.	A small portfolio of sketches complete with written responses about the importance of achieving the benefits and overcoming the limitations of using isometric pictorial views and multiple-view orthographic methods, and the justification of using particular sketches, techniques and equipment.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M3, 2B.D2	Communicating Well in Engineering	Your manager is impressed with your portfolio and asks you to gather information, investigate and report back on the possibility of introducing a new design required by one of the company's clients.	A completed diary/logbook, including a description and an explanation of the advantages and disadvantages of your use of a particular communication method. Plus, either a discussion with your manager or a presentation to others in the design office. An observation record will be required to show what happened during the discussion or presentation.
1C.5, 2C.P5, 2C.M4, 2C.D3	Finding and Using Information	Your manager is considering taking the new design forward and needs a range of information to help his decision-making. She needs you to find this information.	A written report explaining, justifying and recording the original information sources, including an annotated hard copy showing the information identified and used to solve the problem and check the validity of the solution.

Criteria covered	Assignment	Scenario	Assessment evidence
1D.6, 1D.7, 2D.P6, 2D.P7, 2D.M5, 2D.D4	Using ICT to Present Information	Your manager is comfortable with the new design and the information you have supplied. She wants you to use a range of ICT resources to present the design and information used. She also wants an alternative presentation approach to take and has asked you for information about this. She will need this presenting to people you have not met before.	A record to show what happened during your preparation for the presentation, including the use of the software and hardware. A range of presentation documents. An observation record about the presentation carried out and the people involved. A written report about alternative approaches.

Unit 22: Continuous Improvement and Problem-Solving

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered why certain manufacturers are often regarded as ‘world class’? The answer is often down to their desire to continually improve their manufacturing processes in order to increase their manufacturing efficiencies. World-class manufacturers are always looking for ways to make the production processes better as well as ensuring that they maintain or improve the quality of their products and services.

This unit will introduce you to some of the key developments in manufacturing. You will learn about ‘quality gurus’ and how their ideas have influenced the way we manufacture products. You will also learn about continuous improvement techniques and how to solve problems in an engineering manufacture environment. You will develop an understanding of the tools used in engineering to address these problems and how to use them.

This knowledge, experience and understanding will equip you to undertake a teamwork exercise to identify a problem within a work-based setting and provide and implement a solution to improve the productivity and efficiency of that work area.

Learning aims

In this unit you will:

A know about quality gurus’ philosophies and continuous improvement principles

B be able to use quality tools to solve a manufacturing problem

C be able to use continuous improvement techniques.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about quality gurus' philosophies and continuous improvement principles
Topic A.1: Quality gurus The quality gurus and their philosophies, e.g.: ● Crosby – four absolutes, 14-point improvement plan, zero defects ● Deming – 14-point quality management plan; Plan, Do, Check, Act (PDCA) cycle ● Juran – breakthrough, customer–supplier chains, quality trilogy ● Ishikawa – company-wide quality, quality circles, quality tools ● Feigenbaum – total quality control ● Taguchi – product and process optimisation ● Boothroyd and Dewhurst – design for manufacture and assembly (DFMA) ● Shingo Shingo – Single minute exchange of die (SMED), Just in time (JIT), Poka Yoke ● Peters – Management by walking about (MBWA), 'go look see' ● Rother and Shook – value stream mapping. **Topic A.2: Continuous improvement principles** Principles of continuous improvement: ● 7 wastes – overproduction, transportation, waiting time, operator motion, over processing, inventory, defects ● 8th waste – not recognising employee creativity and knowledge ● Lean manufacturing – increasing value-adding activities and reducing non-value-adding activities, meeting customer requirements ● Kaizen – small incremental stages of continuous improvement.
Learning aim B: Be able to use quality tools to solve a manufacturing problem
Topic B.1: Quality tools The use of quality tools to measure, identify and solve a manufacturing problem: ● use of quality tools, e.g. process flow charts, tally charts, bar charts, histograms, Pareto charts, scatter diagrams, Ishikawa diagrams, root cause paths, value stream maps, 5 whys, brainstorming, statistical process control (SPC), Gantt charts, TAKT time analysis ● manufacturing problem, e.g. overproduction, unnecessary transportation, operator waiting time, excessive operator motion, overprocessing of products, unnecessary inventory, poor quality, poor use of parts, poor use of resources, breakdowns and excessive maintenance requirements, quality issues during process startup, machines not running at full capacity/speed. *continued*

What needs to be learnt
Learning aim C: Be able to use continuous improvement techniques
Topic C.1: Selection Selection of a work area requiring improvement: ● selection based on key performance indicators (KPIs), e.g. right first time, overall equipment effectiveness (OEE), people productivity, stock turns, delivery schedule, value added per person, floor space utilisation and product cost reduction ● objectives and targets ● health and safety requirements of the work area. **Topic C.2: Applying problem-solving techniques** The use of a team approach to problem-solving, including: ● team selection ● team roles and responsibilities ● planning ● data collection ● identifying the appropriate quality tool ● identifying the root cause of the problem ● determining corrective actions ● determining risks and alternative solutions. **Topic C.3: Implementation** Implementing improvement plans developed from problem-solving activities, including: ● implementation planning ● contingency planning ● process monitoring ● making changes in order to improve standard operating procedures (SOPs) ● use of visual management techniques ● time constraints ● cost and resource issues ● training and education ● change management.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about quality gurus' philosophies and continuous improvement principles			
1A.1 Outline the philosophies of three quality gurus.	2A.P1 Describe and give an example of three of the quality gurus' philosophies.	2A.M1 Explain three quality gurus' philosophies and how they apply to continuous improvement.	2A.D1 Compare three quality gurus' philosophies when used in continuous improvement.
1A.2 Outline the principles of continuous improvement.	2A.P2 Describe and give an example of the principles of continuous improvement.		
Learning aim B: Be able to use quality tools to solve a manufacturing problem			
1B.3 Use three quality tools to identify the cause of a given manufacturing problem. *	2B.P3 Select and use three quality tools to measure, describe the cause of and solve a given manufacturing problem. *	2B.M2 Explain the benefits of using quality tools in measuring, identifying the cause of and solving a given manufacturing problem.	2B.D2 Evaluate the effectiveness of the quality tools used to measure, identify the cause of and solve a given manufacturing problem. *

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to use continuous improvement techniques			
1C.4 Identify a work area for a continuous improvement activity.	2C.P4 Identify a work area for a continuous improvement activity and describe the reasons for its selection.	2C.M3 Assess the effectiveness of the chosen problem-solving techniques.	2C.D3 Evaluate the issues faced when using problem-solving techniques and implementing continuous improvement activities.
1C.5 Contribute to a problem-solving activity for the identified work area.	2C.P5 Contribute to a problem-solving activity using team-based problem-solving techniques for the identified work area.		
1C.6 Identify the actions that should be included in a continuous improvement plan developed from a continuous improvement activity. #	2C.P6 Prepare a continuous improvement plan developed from a continuous improvement activity. #	2C.M4 Explain the use of the chosen techniques used in the continuous improvement plan.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a given manufacturing environment in order to complete practical problem-solving activities.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of achievement of the learning aims and assessment criteria may be obtained from well-planned investigative assignments and/or reviews of workplace visits/activities or practical activities. It is anticipated that integrative assignments might be used to link this unit with other more practical or project-related units in the programme. If this approach is adopted, the evidence for the specific learning outcomes and associated assessment criteria will need to be clearly and separately identified.

For 2A.P1, learners could use an investigative approach in their work, reviewing the approaches and giving examples of three different quality gurus. The philosophies of these gurus should be explained in more detail for 2A.M1 and compared for 2A.D1. Further investigation into the principles of continuous improvement would allow learners to present evidence for 2A.P2.

For 1A.1, learners must outline the philosophies of three quality gurus whilst 1A.2 requires an outline of continuous improvement techniques.

To achieve 2B.P3, learners should select three quality tools from the list outlined in the unit specification. They should demonstrate use of these tools to measure, describe the cause of a problem and select an appropriate solution to a given case study or scenario provided by the teacher. Explaining the use of these tools will allow learners to achieve 2B.M2 and an evaluation of the techniques would provide sufficient evidence for 2B.D2.

For 1B.3, learners are required to use three quality tools from the list outlined in the unit specification without necessarily demonstrating evidence of fully measuring parameters, identifying issues or selecting the most appropriate solution.

For 2C.P4, learners should base their selection on a given workshop/manufacturing scenario and select a work area within the chosen setting that requires a continuous improvement activity. They should describe the reasons for selecting their chosen area. Learners should then develop an appropriate team-based approach to the identification and proposed solution required for 2C.P5, drawing conclusions and preparing a plan indicating the steps required to implement the proposed solution for 2C.P6.

To achieve 2C.M3, learners should reflect on the selection of their chosen problem-solving techniques and assess how effective each technique was. For 2C.M4, an explanation of the chosen continuous improvement activities is required. This should lead on to 2C.D3, where learners should evaluate the problems and issues associated with problem-solving techniques and continuous improvement activities.

For 1C.4, learners are asked to identify an appropriate work area for a continuous improvement activity from their chosen setting, whilst 1C.5 requires them to contribute to a team activity of continuous improvement. This contribution should be sufficient to allow them to identify the actions that should be included in a continuous improvement plan for 1C.6.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Quality Gurus	You have just started work in an engineering manufacture workplace. The workplace is in the process of changing its working practices and your team leader has asked you to investigate the philosophy of three different quality gurus and continuous improvement techniques.	A presentation describing the principles of continuous improvement techniques and the philosophies of three key quality gurus, with an explanation and comparison of these philosophies.
1B.3, 2B.P3, 2B.M2, 2B.D2	Using Quality Improvement Tools	Your team leader is impressed with your investigation and would like you to demonstrate the use of continuous improvement for a given scenario within your engineering manufacture workplace.	A presentation demonstrating the use of three of the quality improvement tools to solve the given problem. An explanation of the use of the tools while comparing and evaluating their effectiveness. Observation/witness statements, detailed learner observation records, annotated photographs, diaries/logs.
1C.4, 1C.5, 1C.6, 2C.P4, 2C.P5, 2C.P6, 2C.M3, 2C.M4, 2C.D3	Continuous Improvement Activity	Your team leader is keen to improve the efficiency of at least one element of the engineering manufacture workplace. You have been asked to complete a team improvement activity on an individual work area.	A written log demonstrating the selection of a work area, the teamwork required to carry out the continuous improvement activity and the preparation/implementation of an improvement plan. The log should also feature an explanation of the reasons for choosing the selected quality improvement technique, with an evaluation of the challenges and issues when implementing the continuous improvement plan. Observation/witness statements, detailed learner observation records, annotated photographs.

Unit 23: Electronic Devices and Communication Applications

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how systems like mobile phones, washing machines, microwaves and computers work? They all perform their tasks because they have electronic devices working inside them. A mobile phone, for example, contains thousands of components. Electronic devices and communications have brought about a revolution in computers, global positioning systems, Formula 1 telemetry and games stations.

This unit will open the door on this fascinating subject and enable you to construct and test electronic circuits so you can understand how they work.

The first learning aim looks at the basics of signals and the units of measurement used in electronic engineering. This will give you the underpinning knowledge to understand how electronics in the home and within industry operate.

Learning aim B concentrates on giving you the knowledge to be able to select electronic components and devices that are commonly used in systems engineering. You will look at different types of components and devices and learn to identify the circuit symbols as well as describe the function of electronic components and devices.

For learning aim C, you will use components and devices to build a range of electronic circuits, using a range of techniques. You will test their operation using equipment such as multimeters and oscilloscopes.

The final learning aim covers communications and data transfer. This effectively means you will learn how electronic systems talk to each other.

Learning aims

In this unit you will:

A know the types of signals and units of measurement used in electronic systems

B know the function of electronic components and devices

C be able to construct simple passive circuits and construct and test analogue and digital electronic circuits

D understand electronic communication systems and data transmission.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know the types of signals and units of measurement used in electronic systems
Topic A.1: Signals Types, application and measurement of various signals: ● digital and analogue signals, e.g. light intensity, temperature, voltage, frequency ● DC and alternating signals, e.g. sinusoidal, pulse, square/rectangular, triangular, sawtooth ● waveform measurements, e.g. amplitude, peak to peak, pulse duration, mark/space ratio, repetition rate, cycle, periodic time, frequency, phase and speech waveforms. **Topic A.2: Units of measurement** The characteristics and applications of using the correct units of measurement: ● Units of measurement o voltage (V, mV, μV, kV) o current (A, mA, μA) o frequency (Hz, kHz, MHz) o bits per second (bps, kbps, Mbps).
Learning aim B: Know the function of electronic components and devices
Topic B.1: Components The characteristics, applications, physical forms and British Standard (BS) symbols, advantages/disadvantages of using the following components: ● cells ● batteries ● power supplies ● connectors ● resistors ● variable resistors ● capacitors ● inductors/chokes ● diodes ● transistors (bipolar and unipolar). *continued*

What needs to be learnt
Topic B.2: Devices The characteristics, applications, physical forms and British Standard (BS) symbols, advantages/disadvantages of using the following devices: ● switches, e.g. normally open (NO), normally closed (NC), change over (CO), single pole single throw (SPST), single pole double throw (SPDT), double pole double throw (DPDT), push button, rocker, toggle, rotary, microswitch, tilt, pressure ● transducers, e.g. light dependent resistor (LDR), photodiode, thermistor, thermocouple, microphone, strain gauge ● indicators and output devices, e.g. lamp, LED, buzzer, speaker, relay, motor, solenoid, heater ● operational amplifiers, e.g. inverting and non-inverting amplifiers, comparators ● timers and multivibrators, e.g. astable, bistable and monostable ● two input logic gates, e.g. AND, OR, NOT, NAND, NOR, XOR.

What needs to be learnt
Learning aim C: Be able to construct simple passive circuits and construct and test analogue and digital electronic circuits
Topic C.1: Simple passive circuits Using various construction techniques to construct circuits, including: ● simple passive circuits: o combinations of series and parallel resistor components, e.g. potential divider circuits o series and parallel combinations of two capacitors o time-delay effect of capacitor, e.g. time constant T = CR, charge and energy storing. **Topic C.2: Analogue circuits** Understanding the operation and function of analogue circuits and using various construction techniques to construct circuits, including: ● analogue circuits, e.g.: o diode as a one-way device, e.g. use of diode for device protection, circuits comprising diode-resistor combinations, turn on voltage, zener diode stabiliser o bipolar and unipolar transistor circuits, e.g. transistor operation as an amplifier and as a switch o linear integrated circuit/operational amplifier, e.g. acting in inverting or non-inverting mode or as a comparator, 555 timer circuits in astable and monostable mode. **Topic C.3: Digital circuits** Understanding the operation and function of digital circuits and using various construction techniques to construct circuits, including: ● digital circuits: o simple combinational logic circuits and truth tables, e.g. 74 Series and/or CMOS 4000B series integrated circuits implementation, or teaching laboratory modules, D type and T type flip flop circuits, cascaded flip flops and effect on input waveform, counting pulses. **Topic C.4: Construction** Using various construction techniques to construct circuits, including: ● construction: o protoboard o veroboard o PCB. **Topic C.5: Testing** Using various testing techniques on constructed circuits from the following: ● test equipment, e.g. multimeter, logic probe, oscilloscope, signal and pulse generators.

What needs to be learnt
Learning aim D: Understand electronic communication systems and data transmission
Topic D.1: Electronic communication systems Features, principles, applications and advantages of electronic communication systems, including: ● transmitter sub-systems, e.g. audio source, radio carrier for radio transmission or light emitting diode for optical communication ● channel/link, e.g. copper wire twisted or untwisted and shielded or unshielded, co-axial cable, radiowave carrier, optical fibre ● receiver, e.g. radio or photodiode/phototransistor ● duplex – e.g. telephone, cell phone, CB radio ● the requirement for and function of repeaters and regenerators for communication over longer distances. **Topic D.2: Data transmission** Characteristics, principles and applications of electronic data transmission, including: ● representation of digital signals and data, e.g. digital logic levels, binary numbers, coding methods, binary, BCD, ASCII, audio tones ● protocols, e.g. handshaking, flow control, error checking ● simplex, half and full duplex working.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know the types of signals and units of measurement used in electronic systems			
1A.1 Using a multimeter, measure a range of DC and AC voltages produced by electronic devices, using the correct units of measurement.*	2A.P1 Using a multimeter, measure a range of DC and AC voltages and currents produced by electronic devices, using the correct units of measurement.*	2A.M1 Using an oscilloscope carry out measurements on a given sine wave and record your results for amplitude, periodic time, and frequency using the correct units of measurement.*	2A.D1 Using an oscilloscope carry out measurements on a given square wave and record your results for amplitude, mark/ space ratio and repetition rate using the correct units of measurement.*
Learning aim B: Know the function of electronic components and devices			
1B.2 Outline the function of at least five given electronic components.	2B.P2 Describe the function of at least five given electronic components and five devices.		
1B.3 Identify BS symbols of at least five given electronic components.	2B.P3 Identify BS symbols and the physical forms of at least eight electronic components and devices.	2B.M2 Using BS symbols produce a circuit diagram from a given physical circuit containing any combination of at least eight electronic component and devices.	2B.D2 Justify, in terms of advantages and disadvantage, each component in a given physical circuit containing any combination of at least eight electronic components and devices.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to construct simple passive circuits and construct and test analogue and digital electronic circuits			
1C.4 Construct a passive circuit using any method of construction.	2C.P4 Construct a passive circuit using at least two different methods of construction.		
1C.5 Construct an analogue electronic circuit.	2C.P5 Construct and test the operation of an analogue electronic circuit.	2C.M3 Explain the operation of an analogue electronic circuit.	
1C.6 Construct a digital electronic circuit.	2C.P6 Construct and test the operation of a digital electronic circuit.	2C.M4 Explain the operation of a digital electronic circuit.	2C.D3 Justify the choice of components and devices to ensure correct functionality of an electronic circuit.
Learning aim D: Understand electronic communication systems and data transmission			
1D.7 Describe the features of at least two electronic communication systems.	2D.P7 Explain how electronic communication is achieved.	2D.M5 Explain the function of repeaters and regenerators for communication over longer distances and how they are used.	2D.D4 Analyse the advantages of two given electronic communication systems.
1D.8 Describe how electronic communication systems can be used to successfully transfer data.	2D.P8 Explain how electronic communication systems can be used to successfully transfer data.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- fully equipped electronics laboratory
- test equipment, including oscilloscopes, signal generators, pulse generators, low voltage power supplies and multimeters
- electronic circuit construction equipment
- computer access for internet-based research.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

The focus of this unit is on selecting electronic components and using them to construct and test simple electronic circuits.

For 2A.P1, learners need to measure the types of signals, such as digital and analogue signals and Direct Current (DC) and alternating signals, used in electronic systems and use the correct units of measurement. This should be achieved by using a multimeter to measure particular electronic voltages for 1A.1, and practical work to measure DC and AC voltages and currents in given electronic circuits for 2A.P1. For 2A.M1 and 2A.D1 learners should be given a sine wave and a square wave to measure using an oscilloscope and record their results for amplitude, periodic time, frequency, mark/space ratio and repetition rate respectively.

For 1A.1, learners need to list the types of signals produced by electronic devices and the correct units of measurement.

For learning aim B, learners must describe the function of a range of electronic components and devices as well as identify their physical forms and British Standard (BS) symbols. As highlighted within the assessment criteria, learners should be able to describe the function of at least five components and devices at level 2 and outline the function of at least five given components at level 1. The components and devices could be chosen from those listed in the unit content. The components and devices could be supplied in the form of real samples, good quality illustrations, schematic symbols, or a selection of all three. For 2B.M2, learners can use their knowledge of components and symbols to produce a circuit diagram from a given physical circuit containing a range of at least eight different components. This circuit can then be used to allow learners to justify selection, in terms of their advantages and disadvantages, of each component for 2B.D2.

For learning aim C at level 2, learners must construct a passive circuit using two different methods, and construct and test an analogue and digital electronic circuit. Following these practical assessments learners could be given further tasks to achieve 2C.M3, 2C.M4 and 2C.D3, by providing given analogue and digital circuits to research operation and component choice.

For 1C.4, learners may focus on one method when constructing the passive circuit, and for 1C.5 and 1C.6 they can concentrate on construction without testing the relevant circuits.

2D.P7 and 2D.P8 are likely to involve case study and research activities to explain how electronic communication and data transfer are achieved respectively. Further work from learners will address 2D.M5 and 2D.D4 by looking at repeaters and regenerators, and the advantages of two given electronic communication systems such as transmitters and receivers.

To achieve 1D.7, learners need to describe the features of at least two electronic communication systems listed in the unit content.

To achieve 1D.8, learners must describe how electronic communication systems can be used to successfully transfer data.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1	Signals and Units of Measurement	You have recently started work as an apprentice. The company you work for installs and tests communications equipment. You have been asked to familiarise yourself with the electronic signals and units of measurement used within communications. They require you to produce a report of your findings.	A written report, which includes diagrams and images. These can be taken from reference sources, as long as they are supported by learner's 'own writing' and sources are referenced.
1B.2, 1B.3, 2B.P2, 2B.P3, 2B.M2, 2B.D2	Function of Electronic Components and Devices	Your employer has asked you to rearrange and re-stock the parts store and provide descriptions of the parts contained within each box. They expect you to use your knowledge of the components and devices in the store room and provide circuit symbols.	A table, which includes a description and a BS symbol for each component and device.
1C.4, 1C.5, 1C.6, 2C.P4, 2C.P5, 2C.P6, 2C.M3, 2C.M4, 2C.D3	Construct and Test Electronic Circuits	Your employer has asked you to join a team producing various electronic circuits for their communications equipment. You have been given circuit diagrams for passive, analogue and digital circuits. You have been asked to build and test these circuits.	Completed operational circuit and a test report. The report should contain an explanation of the operation and a justification of the components and devices used.
1D.7, 1D.8, 2D.P7, 2D.P8, 2D.M5, 2D.D4	Communications and Data Transmission	As part of your ongoing training within the company your training manager has asked you to research how electronic communications and data transfer work and make a presentation to a group of year 10 pupils from a local school.	A presentation, which includes an explanation of how electronic communication and data transfer is achieved.

Unit 24: Operation and Maintenance of Mechanical Systems and Components

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever thought about the consequences of the mechanical drive system on a factory machine tool developing a fault or breaking down completely? As well as the inconvenience of having the machine out of action, the resulting loss of production will affect company profits and possibly jobs.

The first step when inspecting a mechanical system is to see if the power input has been cut off, for example a motor failure. This is comparable to checking whether the fuel supply to an engine has been lost. If the fuel is coming through, then the fault must be with one or more of the components within the engine. How do you or a service technician identify and rectify the fault?

In this unit, you will start by investigating the operation of simple mechanical systems and the components within them. Knowing how a system works puts someone in a much better position to carry out fault finding, particularly if there is a set routine to follow.

You will then go on to identify faults in mechanical systems and correct them by replacing components. Referring to manufacturers' data sheets and spares lists will help you with this. Any type of maintenance must be carried out in a safe manner. It is very important that machinery is locked out so that it cannot be started up by mistake.

It is important to keep written records of repair work, particularly if the same fault keeps reappearing as it may indicate a design flaw. These records will also hold details of post-rectification tests performed on the system. Is it now working to specification? Speed and torque readings might be taken and checked against figures in the system specification. In the final part of the unit, you will carry out routine maintenance procedures and investigate their significance in helping to prevent faults and breakdowns.

Learning aims

In this unit you will:

A know about the operation of mechanical systems and the function and operation of components used in them

B be able to select components used in mechanical systems when carrying out maintenance procedures

C be able to prepare for and safely carry out fault-finding techniques and fault-rectification on mechanical systems and their components

D be able to prepare for and safely carry out maintenance procedures on mechanical systems and their components.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the operation of mechanical systems and the function and operation of components used in them
Topic A.1: Mechanical systems Function and operation of a system, e.g.: ● power transmission – belt and chain drives, gearbox, transmission shaft ● lifting and handling – crane, hoist, jack, roller and belt conveyor, robot arm, weighing equipment ● rotary – pump, compressor, mixer, portable power tool, pillar drill, centre lathe ● fluid – pneumatic actuator, position sensor, control valve ● control – mechanical governor, servo-system. Diagrammatic representation of the system, e.g.: ● block diagram ● flow chart. **Topic A.2: System components** Function and operation of components, e.g.: ● bearings – plain journal, thrust, ball, roller, needle ● circular oil seal ● gasket ● shim ● hose ● lubricating devices – grease nipples and cups, capillary action, gravity-fed, pressure-fed ● fastenings – nuts and bolts, screws, self-tapping screws, studs, rivets, locking devices, key ● other components – spring, coupling, circlip, dowel, lever, pulley, belt, sprocket, chain, gear, cam, shaft, guard.

What needs to be learnt
Learning aim B: Be able to select components used in mechanical systems when carrying out maintenance procedures
Topic B.1: System data Sources of system information, including: ● flow chart ● assembly drawing ● parts schedule ● block diagram ● maintenance procedure. **Topic B.2: Component data** Sources of component data, including: ● manufacturers' catalogues ● data sheet ● repair manual ● parts list. **Topic B.3: Component selection** Select components to be used in a maintenance procedure.
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification on mechanical systems and their components
Topic C.1: Identification of faults in a mechanical system Types of fault, e.g.: ● intermittent operation ● partial failure/out-of-specification output ● complete breakdown. Aids to determining faults, e.g.: ● system specification ● system diagram, component data sheets ● operation and maintenance manual ● fault codes ● previous fault/repair reports ● functional and troubleshooting charts ● final test and handover procedures ● software based records and data ● instruments – measuring equipment. Fault-finding techniques, e.g.: ● six point (collect evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system) ● half split ● unit substitution ● visual examination. *continued*

What needs to be learnt

Topic C.2: Fault rectification

Equipment, including:

- taps, dies, easy-outs, drills
- torque wrench
- circlip pliers
- soft-faced mallet
- drifts
- puller
- screwdrivers, hex keys, spanners
- other assorted hand tools
- cleaning materials
- jointing compound.

Remove and replace faulty components, e.g.:

- components – remove, test, repair, source replacement, re-fit
- procedures – remove mechanical fixings, unclip electrical connectors, dismantle, align
- post-rectification tests and checks.
- Record actions, e.g.:
- job card
- checklist.

Learning aim D: Be able to prepare for and safely carry out maintenance procedures on mechanical systems and their components

Topic D.1: Routine maintenance

Inspection checks and tests, e.g.:

- visual examination – leak detection, wear, chafing, fouling, corrosion
- overheating
- security of attachment/fixings
- noise
- lubricant levels
- pressures.

Maintenance procedures, e.g.:

- adjustments
- replace components
- replace/change consumables
- test against specification.

Record actions, e.g.:

- job card
- checklist
- routine maintenance report
- sign-off documentation.

continued

What needs to be learnt
Topic D.2: Safety Safety awareness while carrying out maintenance on mechanical systems, including: ● hazards and risk ● people at risk ● control measures and their effectiveness ● risk assessment documentation. Workplace hazards, including: ● pressurised systems ● unfenced machinery ● incorrect isolation of prime movers ● non-lockout of moving parts ● toxic substances ● badly maintained tools and equipment. Keeping safe in a mechanical maintenance environment, including: ● personal protective equipment (PPE) ● safe working practices – permit to work, danger tags, warning notices, safety barriers, isolation, treatment for eye injury (fluid and particle penetration) and other procedures in case of injury, accident reporting ● approved working procedures.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the operation of mechanical systems and the function and operation of components used in them			
1A.1 Describe the function of a given mechanical system.	2A.P1 Describe, with the aid of a diagram or chart, the function and operation of a mechanical system.		
1A.2 Describe the function of two different components used in a given mechanical system.	2A.P2 Describe the function and operation of four different components used in a mechanical system.	2A.M1 Explain the relationship between component faults and the malfunction of a mechanical system.	2A.D1 Evaluate the impact that individual components have on the reliability of a mechanical system.
Learning aim B: Be able to select components used in mechanical systems when carrying out maintenance procedures			
1B.3 Identify, from a given source, the components to be used in a maintenance procedure for a mechanical system.	2B.P3 Select components to be used in a maintenance procedure for a mechanical system, using system and component data sources.	2B.M2 Justify the selection of components to be used in a maintenance procedure for a mechanical system.	2B.D2 Analyse a given mechanical system for ease of maintenance.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification procedures on mechanical systems and their components			
1C.4 Identify faults in a mechanical system using a given fault-finding technique.	2C.P4 Identify faults in a mechanical system using two different fault-finding techniques.	2C.M3 Compare two fault-finding techniques used when carrying out rectification work on mechanical systems.	2C.D3 Justify the use of two fault-finding techniques when carrying out rectification work on mechanical systems.
1C.5 Safely replace specified components in a mechanical system.	2C.P5 Safely replace the identified faulty components in a mechanical system, checking for serviceability.	2C.M4 Explain the reasons for carrying out correct procedures and post-rectification tests and checks when undertaking fault-rectification on mechanical systems.	
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on mechanical systems and their components			
1D.6 Safely carry out a routine maintenance procedure on a mechanical system.	2D.P6 Safely carry out a routine maintenance procedure on a mechanical system and record actions.	2D.M5 Risk assess a maintenance procedure for a mechanical system.	2D.D4 Risk assess a maintenance procedure for a mechanical system and explain the effectiveness of the control measures found within it.
1D.7 Identify the main hazards and people at risk when carrying out maintenance on mechanical systems.	2D.P7 Describe the hazards and risks when carrying out maintenance on mechanical systems and suggest control measures.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- access to a workshop environment suitable for carrying out maintenance activities
- mechanical systems, which have faults that are straightforward to identify and can be rectified by substitution of components
- test equipment, tools and safety equipment
- relevant manufacturers' service manuals, data sheets, components lists, drawings and diagrams
- HSE risk assessment guidance – www.hse.gov.uk/risk/guidance.htm

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with Section 8 Internal assessment.

The assessor must carefully monitor the practical activities specified in this unit. It is important that when designing assignment briefs, the assessor makes it quite clear to learners that they must follow specified safety procedures to minimise risks to themselves and others. Some criteria are addressed through tasks involving diagrams/sketches and written text; it is acceptable to use graphics clipped from data sources (these must be acknowledged), but the writing that goes with them must be the learner's own work. Descriptive text cut and pasted from the web is not acceptable evidence. At level 1, a learner can make very basic statements when asked to 'identify' and 'describe'.

Criteria 2A.P1 and 2A.P2 should be linked so that learners only have to investigate a single mechanical system taken from the list in the unit content. It is expected that they will investigate at least four different components found within the system. These should be of different type, for example not just four pulleys or gears of varying sizes. It is important that learners know the difference between 'function' and 'operation'. Function is about purpose, operation is about how that purpose is achieved. For example, the function of a gearbox is to change rotational speed; its operation relies on the meshing of gears with different numbers of teeth. Learners should be encouraged to make their own selection of components from the system. The description of the system operation should be supported with a block diagram or flow chart and references made to inputs and outputs.

For 2A.M1 and 2A.D1, learners are expected to consider in more generic terms the effects of component faults on the operating performance of a mechanical system. They should consider full and partial system malfunction and the consequences if a system is not reliable.

For 1A.1 and 1A.2, learners are only required to provide very basic descriptions of the function of the system and its components; the components can be identified for them.

For 2B.P3, learners should be given a mechanical system block diagram or an assembly drawing, and a suitable maintenance procedure. For this criterion they should select appropriate components to be replaced during a maintenance procedure. Having selected the relevant components, learners should access published data so that they can specify part numbers on a parts schedule. To help generate appropriate evidence, the assignment task can be made more meaningful if learners are asked to cost the replacement components and to fill out a dummy online order form.

For 2B.M2, learners must present a detailed justification for selecting particular components; for example, given the selection of an original equipment manufacturer (OEM) component or one from a much cheaper third-party supplier, which is the more cost effective option? For 2B.D2, learners should present a detailed written analysis based on a given mechanical system. This could be the one used for 2B.P3, but it may be more appropriate to work with a more complex one. Learners could include a consideration of the economic issues relating to the maintenance of a system – e.g. cost of labour, consumables, replacement components and system downtime.

For 1B.3, learners are only required to identify components. They can do this by marking up a hard copy of the system diagram with single word identifiers.

Centres should select one of the mechanical systems from the range given in the unit content. The system should be non-complex and have a small number of faults that are straightforward to identify for a learner working at level 2.

For 2C.P4, learners should apply at least two of the fault-finding techniques listed in the unit content. This criterion can be linked to 2C.P5 and for both, it is important that written evidence is supported by assessor-signed observation records. After replacing faulty components learners must run post-rectification tests to ensure that the system is operating to specification. Identifying and replacing two or three faulty components would be a suitable number. To achieve 2C.M3, learners should reflect on the procedures carried out for 2C.P4. This will include comparing how straightforward the techniques were to follow, ease of identification of fault/s, equipment requirements, reliability of findings and how they documented their actions. For 2C.M4, the explanation of the reasons for carrying out correct procedures should include references to maintaining system integrity and efficiency of operation, health and safety and completing the procedure within a designated timeframe. Learners should also consider the significance of carrying out follow-up checks after a procedure has been completed, for example road testing a car after it has been serviced. For 2C.D3, learners will have extended their comparison for the merit activity and show a justification for each of the two fault-finding techniques used or others.

For 1C.4, just a single fault-finding technique need be used, for example substitution.

1C.5 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that have easily identifiable faults, for example a visual inspection to find a broken drive belt. Learners should replace two components.

To achieve 2D.P6, learners should follow a given maintenance procedure. There is no requirement in the unit content for learners to write their own procedure. There must be a proper written record of the actions carried out, i.e. inspection and tests done, consumables used, parts replaced, identification of parts which are wearing out and may need future replacement etc.

For 2D.P7 learners must present evidence about hazards and risks specific to maintenance procedures carried out on mechanical systems. The more generic aspects of health and safety are fully covered in *Unit 3: Health and Safety in Engineering*. Before a learner embarks on the practical aspects of this learning aim, they must present evidence to the assessor that shows they know how to keep safe when working with mechanical systems. To achieve 2D.M5, learners should present their risk assessment in a template, which follows the recommendations of the HSE. For 2D.D4, learners must reflect on what they have learnt about routine maintenance but may wish to also draw on experience gained when carrying out fault finding when explaining the effectiveness of the control measures suggested in their risk assessment. The risk assessment carried out for 2D.M5 will only need to show the control measures but to achieve the distinction criterion learners must explain their effectiveness when applied to the maintenance procedure.

Again, 1D.6 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that require relatively simple routine procedures, for example a visual examination or inspecting a fluid level.

For 1D.7, learners are only required to identify main hazards and people at risk; this can be recorded using a simple checklist. Learners could be placed in a maintenance workshop or be given photographs of one and then asked to match hazards against a given list.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Mechanical Systems and Components	You have recently started work as an apprentice. Your company manufactures and installs automated assembly machines. The training manager asks you to familiarise yourself with the mechanical systems that are fitted to the machines. They require you to produce a PowerPoint® presentation of your findings.	A PowerPoint® slide show with notes or speech cards to deliver a presentation that includes diagrams and images. These can be taken from reference sources, as long as they are supported by learners' 'own writing' and sources are referenced. There is no need to carry out the presentation.
1B.3, 2B.P3, 2B.M2, 2B.D2	Selecting Components used in Mechanical Systems	Your training manager decides to team you up with a service engineer. They visit manufacturing businesses to service and repair the machinery supplied by your company. They expect you to investigate any components that need replacing due to wear and tear or breakdown.	A written report, which includes a system diagram, flow chart or assembly diagram, a given maintenance procedure and evidence of where data about components was found. This evidence could be screenshots and marked-up photocopies of pages taken from manufacturers' catalogues.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.4, 1C.5, 2C.P4, 2C.P5, 2C.M3, 2C.M4, 2C.D3	System Fault-finding and Rectification	A new design of assembly machine is being put through a pre-production test. You are helping the technician who is running the test. A number of fault codes show up on the control panel and they ask you to investigate.	A portfolio, which includes: 1. a written report covering the fault-finding techniques used relating to the rectification work of a mechanical system (for level 1, a transcript of oral questioning is acceptable) 2. a written record of the fault-finding steps followed, and subsequent actions on a job card or checklist, supported by an observation record and annotated photographs.
1D.6, 1D.7, 2D.P6, 2D.P7, 2D.M5, 2D.D4	Routine Maintenance	Your manager asks you to carry out routine maintenance on the mechanical drive system of a workshop machine.	A portfolio, which includes a written record of the maintenance procedure followed and the risk assessment for that maintenance procedure, plus an observation record and annotated photographs.

Unit 25: Operation and Maintenance of Electronic Systems and Components

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered what happens when electronic equipment in a manufacturing factory breaks down? Or who fixes the faulty equipment? An electronics maintenance engineer is responsible for the repair, modification and maintenance of a variety of electrical and electronic engineering equipment within a factory. The maintenance engineer is required to perform tasks like wiring circuits, replacing components and repairing electronic devices.

In this unit you will learn about workplace hazards and health and safety requirements, such as personal protection, safe working practices and the safe handling of electronic equipment. This is an essential part of maintenance engineers' knowledge as it allows them to work safely without endangering themselves or others.

You will be introduced to the function and operation of a variety of electronic systems and circuits, refer to manufacturers' databases to select components and use fault-finding techniques to identify faults. In particular, you will carry out work on systems, such as power supplies, transmitters, receivers, signal processors, transmission lines, display systems and many more circuits associated with electronic maintenance operations.

You will be expected to understand how to select system components, how they function and how they operate in an electronic circuit. In particular, you will work with components such as cables and connectors, batteries, transformers, rectifiers, capacitors, resistors, thermistors, integrated circuits, sensors and many more.

Learning aims

In this unit you will:

A know about the operation of electronic systems and the function and operation of components used in them

B be able to select components used in electronic systems when carrying out maintenance procedures

C be able to prepare for and safely carry out fault-finding techniques and fault-rectification on electronic systems and their components

D be able to prepare for and safely carry out maintenance procedures on electronic systems and their components.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the operation of electronic systems and the function and operation of components used in them
Topic A.1: Electronic systems Function and operation of a system, e.g.: ● power supplies ● motor control systems ● transmitters ● transceivers ● receivers ● analogue signal processing ● digital signal processing ● aerial systems ● transmission lines ● display systems ● electro-optical systems ● cryptographic systems ● data network systems. Diagrammatic representation of the system, e.g.: ● block diagrams ● circuit diagrams. **Topic A.2: System components** Function and operation of components, e.g.: ● cables and connectors ● batteries ● transformers ● rectifiers ● contactors ● capacitors ● fixed resistors ● variable resistors ● thermistors ● transistors ● diodes ● overload protection device ● integrated circuits ● heat sinks ● inverter and servo controllers ● decoders *continued*

What needs to be learnt
● sensors ● encoders ● resolvers.
Learning aim B: Be able to select components used in electronic systems when carrying out maintenance procedures
Topic B.1: System data Sources of system information, including: ● circuit diagram ● assembly drawing ● parts schedule ● block diagram ● maintenance procedure. **Topic B.2: Component data** Sources of component data, including: ● manufacturer's catalogue ● data sheet ● repair manual ● parts list. **Topic B.3: Component selection** Selecting components to be used in a maintenance procedure.
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification on electronic systems and their components
Topic C.1: Identification of faults in an electronic system Types of fault, e.g.: ● intermittent operation ● partial failure/out-of-specification output ● complete breakdown. Aids to determining faults, e.g.: ● system specification ● system diagram, component data sheets ● operation and maintenance manual ● fault codes ● previous fault/repair reports ● functional and troubleshooting charts ● final test and handover procedures ● software-based records and data ● instruments (such as multimeter, signal generator, oscilloscope, logic probe, signal tracer, light meter, continuity tester) ● component data sheets. *continued*

What needs to be learnt
Fault-finding techniques, e.g.: ● six point (collect evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system) ● half split ● input/output ● unit substitution ● emergent sequence ● visual examination ● unit substitution. **Topic C.2: Fault rectification** Equipment, including: ● solder ● soldering irons ● crimping pliers ● hand tools ● screwdrivers ● other assorted hand tools ● cleaning materials. Removing and replacing faulty components, e.g.: ● components – remove, test, repair, source replacement, re-fit ● procedures – remove mechanical fixings, un-clip electrical connectors, unplug/de-solder, dismantle, align ● post-rectification tests and checks. Recording actions, e.g.: ● job card ● checklist.

What needs to be learnt
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on electronic systems and their components
Topic D.1: Routine maintenance Inspection checks and tests, e.g.: ● wear ● chafing ● fouling ● security of attachment ● missing or loose fittings ● adjustments ● performance ● continuity ● input/output. Maintenance procedures, e.g.: ● adjustments ● replacing components ● replacing/changing consumables ● testing against specification. Recording actions, e.g.: ● job card ● checklist ● routine maintenance report ● sign-off documentation. *continued*

What needs to be learnt
Topic D.2: Safety Safety awareness while carrying out maintenance on electronic systems, including: ● hazards and risk ● people at risk ● control measures and their effectiveness ● risk assessment documentation. Workplace hazards, including: ● flammable substances ● hot surfaces ● electronic equipment ● electrostatic hazards ● unfenced machinery ● toxic substances and fumes ● falling objects ● liquid spillage ● untidy work area ● badly maintained tools and equipment. Keeping safe in an electronic maintenance environment, including: ● personal protective equipment (PPE) ● safe working practices – permit to work, danger tags, warning notices, safety barriers, isolation, treatment for eye injury (fluid and particle penetration) and other procedures in case of injury, accident reporting ● approved working procedures.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the operation of electronic systems and the function and operation of components used in them			
1A.1 Describe the function of a given electronic system.	2A.P1 Describe, with the aid of a diagram, the function and operation of an electronic system.		
1A.2 Describe the function of two different components used in a given electronic system.	2A.P2 Describe the function and operation of four different components used in an electronic system.	2A.M1 Explain the relationship between component faults and the malfunction of an electronic system.	2A.D1 Evaluate the impact that individual components have on the reliability of an electronic system.
Learning aim B: Be able to select components used in electronic systems when carrying out maintenance procedures			
1B.3 Identify, from a given source, the components to be used in a maintenance procedure for an electronic system.	2B.P3 Select components to be used in a maintenance procedure for an electronic system, using system and component data sources.	2B.M2 Justify the selection of components to be used in a maintenance procedure for an electronic system.	2B.D2 Analyse a given electronic system for ease of maintenance.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification procedures on electronic systems and their components			
1C.4 Identify faults in an electronic system using a given fault-finding technique.	2C.P4 Identify faults in an electronic system using two different fault-finding techniques.	2C.M3 Compare two fault-finding techniques used when carrying out rectification work on electronic systems.	2C.D3 Justify the use of two fault-finding techniques when carrying out rectification work on electronic systems.
1C.5 Safely replace specified components in an electronic system.	2C.P5 Safely replace the identified faulty components in an electronic system, checking for serviceability and record actions.	2C.M4 Explain the reasons for carrying out correct procedures and post-rectification tests and checks when undertaking fault-rectification on electronic systems.	
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on electronic systems and their components			
1D.6 Safely carry out a routine maintenance procedure on an electronic system.	2D.P6 Safely carry out a routine maintenance procedure on an electronic system and record actions.		2D.D4 Risk assess a maintenance procedure for an electronic system and explain the effectiveness of the control measures found within it.
1D.7 Identify the main hazards and people at risk when carrying out maintenance on electronic systems.	2D.P7 Describe the hazards and risks when carrying out maintenance on electronic systems and suggest control measures.	2D.M5 Risk assess a maintenance procedure for an electronic system.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a range of industry standard electronic circuits, equipment, rigs and systems and their associated components and consumables
- appropriate fault-finding instruments, safety equipment and tools
- manufacturers' data books and specifications
- maintenance manuals, parts catalogues and/or databases, flow charts, electronic circuit and system diagrams
- British/International Standards, health and safety publications and local workshop safety documentation and procedures
- HSE risk assessment guidance – www.hse.gov.uk/risk/guidance.htm

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment*.

The assessor must carefully monitor the practical activities specified in this unit. It is important that when designing assignment briefs, the assessor makes it quite clear to learners that they must follow specified safety procedures to minimise risk to themselves and others. Some criteria are addressed through tasks involving diagrams/sketches and written text; it is acceptable to use graphics clipped from data sources (these must be acknowledged), but the writing that goes with them must be the learner's own work. Descriptive text cut and pasted from the web is not acceptable evidence. At level 1, a learner can make very basic statements when asked to 'identify' and 'describe'.

Criteria for learning aim A at level 2 should be linked so that learners only have to investigate a single electronic system taken from the list in the unit content. It is expected that they will investigate at least four different components found within the system. These should be of different types, for example not just four resistors or capacitors of varying sizes. It is important that learners understand the difference between 'function' and 'operation'. Function is about purpose, operation is about how that purpose is achieved. For example, the function of a battery is to provide a DC voltage to a system; its operation relies on the conversion of stored chemical energy into electrical energy. Learners should be encouraged to make their own selection of components from the given system. The description of the system operation should be supported with a block or circuit diagram and references made to inputs and outputs.

For 2A.M1 and 2A.D1, learners are expected to consider in more generic terms the effects of component faults on the operating performance of an electronic system. They should consider full and partial system malfunction and the consequences if a system is not reliable.

For learning aim A at level 1, learners are only required to provide very basic descriptions of the function of the system and its components; the components can be identified for them.

For Learning aim B at level 2 learners should be given an electronic system circuit or block diagram, and a suitable maintenance procedure. For a Pass they should select appropriate components to be replaced during a maintenance procedure. Having selected the relevant components, learners should access published data so that they can specify part numbers on a parts schedule. To help generate appropriate evidence, the assignment task can be made more meaningful if learners are asked to cost the replacement components and to fill out a dummy online order form.

For 2B.M2, learners must present a detailed justification for selecting particular components; for example, given the selection of an original equipment manufacturer (OEM) component or one from a much cheaper third party supplier, which is the more cost effective option? For 2B.D2, learners should present a detailed written analysis based on a given electronic system. This could be the one used for 2B.P3 but it may be more appropriate to work with a more complex one. Learners should include a consideration of the economic issues relating to the maintenance of a system – e.g. cost of labour, consumables, replacement components and system downtime.

For 1B.3, learners are only required to identify components. They can do this by marking up a hard copy of the system diagram with single word identifiers.

Centres should select one of the electronic systems from the range given in the unit content. The system should be non-complex and have a small number of faults that are straightforward to identify for a learner working at level 2.

For 2C.P4, learners should apply at least two of the fault-finding techniques listed in the unit content. This criterion can be linked to 2C.P5 and for both, it is important that written evidence is supported by assessor-signed observation records. After replacing faulty components learners must run post-rectification tests to ensure that the system is operating to specification. Identifying and replacing two or three faulty components would be a suitable number. To achieve 2C.M3, learners should reflect on the procedures carried out for 2C.P4. This will include comparing how straightforward the techniques were to follow, ease of identification of fault/s, equipment requirements, reliability of findings and how they documented their actions. For 2C.M4, the explanation of the reasons for carrying out correct procedures should include references to maintaining system integrity and efficiency of operation, health and safety and completing the procedure within a designated timeframe. Learners should also consider the significance of carrying out follow-up checks after a procedure has been completed, for example the operation of a computer after it has been serviced. For 2C.D3, learners will have extended their comparison for the merit activity and show a justification for each of the two fault-finding techniques used or others.

For 1C.4, just a single fault-finding technique need be used, for example substitution.

1C.5 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that have easily identifiable faults, for example substitution. Learners should replace two components.

To achieve 2D.P6, learners should follow a given maintenance procedure. There is no requirement in the unit content for learners to write their own procedure. There must be a proper written record of the actions carried out, i.e. inspection and tests done, consumables used, parts replaced, identification of parts which are wearing out and may need future replacement, etc.

For 2D.P7 learners must present evidence about hazards and risks specific to maintenance procedures carried out on electronic systems. The more generic aspects of health and safety are fully covered in *Unit 3: Health and Safety in Engineering*. Before a learner embarks on the practical aspects of this learning aim, they must present evidence to the assessor that shows that they know how to keep safe when working with electronic systems. To achieve 2D.M5, learners should present their risk assessment in a template, which follows the recommendations of the HSE. For 2D.D4, learners must reflect on what they have learnt about routine maintenance but may wish to also draw on the experience they gained by carrying out fault-finding by explaining the effectiveness of the control measures suggested in their risk assessment. The risk assessment carried out for 2D.M5 will only need to show the control measures but to achieve the distinction criterion learners must explain their effectiveness when applied to the maintenance procedure.

Again, 1D.6 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that require relatively simple routine procedures.

For 1D.7, learners are only required to identify main hazards and people at risk; this can be recorded using a simple checklist. Learners could be placed in a maintenance workshop or be given photographs of one and then asked to match hazards against a given list.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Electronic Systems and Components	You have recently started work as an apprentice. Your company manufactures and installs automated assembly machines. The training manager asks you to familiarise yourself with the electronic systems that are fitted to the machines. They require you to produce a PowerPoint® presentation of your findings.	A PowerPoint® slide show with notes or speech cards to deliver a presentation that includes diagrams and images. These can be taken from reference sources, as long as they are supported by learners' 'own writing' and sources are referenced. There is no need to carry out the presentation.
1B.3, 2B.P3, 2B.M2, 2B.D2	Selecting Components used in Electronic Systems	Your training manager decides to team you up with a service engineer. They visit manufacturing businesses to service and repair the machinery supplied by your company. They expect you to be able to investigate any components that need replacing due to wear and tear or breakdown.	A written report, which includes a system diagram, circuit or assembly drawing, a given maintenance procedure and evidence of where data about components was found. This evidence could be screenshots and marked-up photocopies of pages taken from manufacturers' catalogues.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.4, 1C.5, 2C.P4, 2C.P5, 2C.M3, 2C.M4, 2C.D3	System Fault-finding and Rectification	A new design of assembly machine is being put through a pre-production test. You are helping the technician who is running the test. A number of fault codes show up on the control panel and they ask you to investigate.	A portfolio, which includes: 1. a written report covering the fault-finding techniques used relating to the rectification work of an electronic system (for level 1, a transcript of oral questioning is acceptable) 2. a written record of the fault-finding steps followed, and subsequent actions on a job card or checklist, supported by an observation record and annotated photographs.
1D.6, 1D.7, 2D.P6, 2D.P7, 2D.M5, 2D.D4	Routine Maintenance	Your manager asks you to carry out routine maintenance on an electronic system such as the power supply of a workshop machine.	A portfolio, which includes a written record of the maintenance procedure followed and the Risk Assessment for that maintenance procedure, plus an observation record and annotated photographs.

Unit 26: Operation and Maintenance of Electrical Systems and Components

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever thought about the consequences of a factory electrical system developing a fault or breaking down completely? As well as the inconvenience of having machines out of action, the resulting loss of production will affect company profits and possibly jobs.

The first step when inspecting an electrical system is to see if the power supply has been cut off by the main circuit breaker. This is comparable to checking whether the fuse in the plug of a washing machine has blown if the machine gets stuck halfway through a wash cycle. If the fuse is intact, the fault must be with one or more of the components in the washing machine. How do you or a service technician identify and rectify the fault?

In this unit, you will start by investigating the operation of simple electrical systems and the components within them. Knowing how a system works puts someone in a much better position to carry out fault finding, particularly if there is a set routine to follow.

You will then go on to identify faults in electrical systems and correct them by replacing components. Referring to manufacturers' data sheets and spares lists will help you with this. Any type of maintenance must be carried out in a safe manner. It is very important that machinery is locked out and electrical equipment isolated.

It is important to keep written records of repair work, particularly if the same fault keeps reappearing as it may indicate a design flaw. These records will also hold details of post-rectification tests performed on the system. Is it now working to specification? Voltage and current readings might be taken and checked against figures in the system specification. In the final part of the unit, you will carry out routine maintenance procedures and investigate their significance in helping to prevent faults and breakdowns.

Learning aims

In this unit you will:

A know about the operation of electrical systems and the function and operation of components used in them

B be able to select components used in electrical systems when carrying out maintenance procedures

C be able to prepare for and safely carry out fault-finding techniques and fault-rectification on electrical systems and their components

D be able to prepare for and safely carry out maintenance procedures on electrical systems and their components.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the operation of electrical systems and the function and operation of components used in them
Topic A.1: Electrical systems Function and operation of a system, e.g.: ● single phase alternating current ● three phase alternating current ● direct current ● switch and distribution ● electrical plant ● portable appliance ● motor and starter ● generator ● compressor ● control ● lighting ● alarm, safety. Diagrammatic representation of the system, e.g.: ● block diagram ● circuit diagram. **Topic A.2: System components** Function and operation of components, e.g.: ● circuit board – capacitor, resistor, inductor, diode, transistor, integrated circuit, light emitting diode, sounder ● switch, cabling, connector ● thermocouple, thermistor, thermostat ● battery ● transformer, rectifier ● solenoid, relay ● position sensor ● circuit breaker, overload protection ● motor ● display panel ● luminaire ● mechanical fixings – nuts, bolts, screws, locking, retaining.

What needs to be learnt
Learning aim B: Be able to select components used in electrical systems when carrying out maintenance procedures
Topic B.1: System data Sources of system information, including: ● circuit diagram ● assembly drawing ● parts schedule ● block diagram ● maintenance procedure. **Topic B.2: Component data** Sources of component data, including: ● manufacturer's catalogue ● data sheet ● repair manual ● parts list. **Topic B.3: Component selection** Select components to be used in a maintenance procedure.
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification on electrical systems and their components
Topic C.1: Identification of faults in an electrical system Types of fault, e.g.: ● intermittent operation ● partial failure/out-of-specification output ● complete breakdown. Aids to determining faults, e.g.: ● system specification ● system diagram, component data sheets ● operation and maintenance manual ● fault codes ● previous fault/repair reports ● functional and troubleshooting charts ● final test and handover procedures ● software-based records and data ● instruments – multimeter, insulation resistance tester, portable appliance tester, earth loop impedance tester. Fault-finding techniques, e.g.: ● six point (collect evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system) ● half split ● unit substitution ● visual examination. *continued*

What needs to be learnt
Topic C.2: Fault rectification Equipment, including: ● soldering iron ● de-soldering tool ● pliers and crimping tools ● screwdrivers, hex keys, spanners ● other assorted hand tools. Remove and replace faulty components, e.g.: ● components – remove, test, repair, source replacement, re-fit ● procedures – solder, re-solder, remove mechanical fixings, unclip electrical connectors ● post-rectification tests and checks. Record actions, e.g.: ● job card ● checklist.
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on electrical systems and their components
Topic D.1: Routine maintenance Inspection checks and tests, e.g.: ● visual examination ● electrical current and voltage ● insulation – portable appliance test (PAT). Maintenance procedures, e.g.: ● adjustments ● replace components ● test against specification. Record actions, e.g.: ● job card ● checklist ● routine maintenance report ● sign-off documentation.

What needs to be learnt
Topic D.2: Safety Safety awareness while carrying out maintenance on electrical systems, including: ● hazards and risk ● people at risk ● control measures and their effectiveness ● risk assessment documentation. Workplace hazards, including: ● electrostatic and high voltages ● pressurised systems ● unfenced machinery ● incorrect isolation of electrical supplies ● non-lockout of moving parts ● badly maintained tools and equipment. Keeping safe in an electrical maintenance environment, including: ● personal protective equipment (PPE) ● safe working practices – permit to work, danger tags, warning notices, safety barriers, isolation, treatment for electric shock and other procedures in case of injury, accident reporting ● approved working procedures.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the operation of electrical systems and the function and operation of components used in them			
1A.1 Describe the function of a given electrical system.	2A.P1 Describe, with the aid of a diagram, the function and operation of an electrical system.		
1A.2 Describe the function of two different components used in a given electrical system.	2A.P2 Describe the function and operation of four different components used in an electrical system.	2A.M1 Explain the relationship between component faults and the malfunction of an electrical system.	2A.D1 Evaluate the impact that individual components have on the reliability of an electrical system.
Learning aim B: Be able to select components used in electrical systems when carrying out maintenance procedures			
1B.3 Identify, from a given source, the components to be used in a maintenance procedure for an electrical system.	2B.P3 Select components to be used in a maintenance procedure for an electrical system, using system and component data sources.	2B.M2 Justify the selection of components to be used in a maintenance procedure for an electrical system.	2B.D2 Analyse a given electrical system for ease of maintenance.

Level 1	**Level 2 Pass**	**Level 2 Merit**	**Level 2 Distinction**
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification procedures on electrical systems and their components			
1C.4 Identify faults in an electrical system using a given fault-finding technique.	2C.P4 Identify faults in an electrical system using two different fault-finding techniques.	2C.M3 Compare two fault-finding techniques used when carrying out rectification work on electrical systems.	2C.D3 Justify the use of two fault-finding techniques when carrying out rectification work on electrical systems.
1C.5 Safely replace specified components in an electrical system.	2C.P5 Safely replace the identified faulty components in an electrical system, checking for serviceability and record actions.	2C.M4 Explain the reasons for carrying out correct procedures and post-rectification tests and checks when undertaking fault-rectification on electrical systems.	
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on electrical systems and their components			
1D.6 Safely carry out a routine maintenance procedure on an electrical system.	2D.P6 Safely carry out a routine maintenance procedure on an electrical system and record actions.	2D.M5 Risk assess a maintenance procedure for an electrical system.	2D.D4 Risk assess a maintenance procedure for an electrical system and explain the effectiveness of the control measures found within it.
1D.7 Identify the main hazards and people at risk when carrying out maintenance on electrical systems.	2D.P7 Describe the hazards and risks when carrying out maintenance on electrical systems and suggest control measures.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- access to a workshop environment suitable for carrying out maintenance activities
- electrical systems, which have faults that are straightforward to identify and can be rectified by substitution of components
- test instruments, tools and safety equipment
- relevant manufacturers' service manuals, data sheets, components lists, drawings and diagrams
- HSE risk assessment guidance – www.hse.gov.uk/risk/guidance.htm

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

The assessor must carefully monitor practical activities specified in this unit. It is important that when designing assignment briefs, the assessor makes it quite clear to learners that they must follow specified safety procedures to minimise risks to themselves and others. Some criteria are addressed through tasks involving diagrams/sketches and written text; it is acceptable to use graphics clipped from data sources (these must be acknowledged), but the writing that goes with them must be the learner's own work. Descriptive text, cut and pasted from the web is not acceptable evidence. At level 1, a learner can make very basic statements when asked to 'identify' and 'describe'.

Criteria for learning aim A at level 2 should be linked so that learners only have to investigate a single electrical system taken from the list in the unit content. It is expected that they will investigate at least four different components found within the system. These should be of different types, for example not just four electric motors of varying sizes. It is important that learners know the difference between 'function' and 'operation'. Function is about purpose, operation is about how that purpose is achieved. For example, the function of a thermocouple is to measure temperature; its operation relies on the Seebeck effect. Learners should be encouraged to make their own selection of components from the system. The description of the system operation should be supported with a block or circuit diagram and references made to inputs and outputs.

For 2A.M1 and 2A.D1, learners are expected to consider in more generic terms the effects of component faults on the operating performance of an electrical system. They should consider full and partial system malfunction and the consequences if a system is not reliable.

For learning aim A at level 1, learners are only required to provide very basic descriptions of the function of the system and its components; the components can be identified for them.

For learning aim B at level 2 learners should be given an electrical system circuit or block diagram and a suitable maintenance procedure. For a Pass they should select appropriate components to be replaced during a maintenance procedure. Having selected the relevant components, learners should access published data so that they can specify part numbers on a parts schedule. To help generate appropriate evidence, the assignment task can be made more meaningful if learners are asked to cost the replacement components and to fill out a dummy online order form.

For 2B.M2, learners must present a detailed justification for selecting particular components; for example, given the selection of an original equipment manufacturer (OEM) component or one from a much cheaper third party supplier, which is the more cost effective option? For 2B.D2, learners should present a detailed written analysis based on a given electrical system. This could be the one used for 2B.P3, but it may be more appropriate to work with a more complex one. Learners should include a consideration of the economic issues relating to the maintenance of a system – e.g. cost of labour, consumables, replacement components and system downtime.

For learning aim B at level 1, learners are only required to identify components. They can do this by marking up a hard copy of the system diagram with single word identifiers.

Centres should select one of the electrical systems from the range given in the unit content. The system should be non-complex and have a small number of faults that are straightforward to identify for a learner working at level 2. It is recommended that maintenance only be carried out on low voltage systems.

For 2C.P4, learners should apply at least two of the fault-finding techniques listed in the unit content. This criterion can be linked to 2C.P5 and for both it is important that written evidence is supported by assessor-signed observation records. After replacing faulty components learners must run post-rectification tests to ensure that the system is operating to specification. Identifying and replacing two or three faulty components would be a suitable number. To achieve 2C.M3, learners should reflect on the procedures carried out for 2C.P4. This will include comparing how straightforward the techniques were to follow, ease of identification of fault/s, equipment requirements, reliability of findings and how they documented their actions. For 2C.M4, the explanation of the reasons for carrying out correct procedures should include references to maintaining system integrity and efficiency of operation, health and safety and completing the procedure within a designated timeframe. Learners should also consider the significance of carrying out follow-up checks after a procedure has been completed, for example putting a washing machine through a full wash cycle after it has been serviced. For 2C.D3, learners will have extended their comparison for the merit activity and show a justification for each of the two fault-finding techniques used or others.

For 1C.4, just a single fault-finding technique need be used, for example substitution.

1C.5 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that have easily identifiable faults, for example a visual inspection to identify an electrical connector that has become unplugged. Learners should replace two components.

To achieve 2D.P6, learners should follow a given maintenance procedure. There is no requirement in the unit content for learners to write their own procedure. There must be a proper written record of the actions carried out, i.e. consumables used, parts replaced, identification of parts that are wearing out and may need future replacement, etc.

For 2D.P7, learners must present evidence about hazards and risks specific to maintenance procedures carried out on electrical systems. The more generic aspects of health and safety are fully covered in *Unit 3: Health and Safety in Engineering*. Before a learner embarks on the practical aspects of this learning aim, they must present evidence to the assessor that shows that they know how to keep safe when working with electrical systems. To achieve 2D.M5, learners should present their risk assessment in a template, which follows the recommendations of the HSE. For 2D.D4, learners must reflect on what they have learnt about routine maintenance but may wish to also draw on experience gained when carrying out fault-finding by explaining the effectiveness of the control measures suggested in their risk assessment. The risk assessment carried out for 2D.M5 will only need to show the control measures but to achieve the distinction criterion learners must explain their effectiveness when applied to the maintenance procedure.

Again, 1D.6 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that require relatively simple routine procedures.

For 1D.7, learners are only required to identify the main hazards and people at risk; this can be recorded using a simple checklist. Learners could be placed in a maintenance workshop or be given photographs of one and then asked to match hazards against a given list.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Electrical Systems and Components	You have recently started work as an apprentice. Your company manufactures and installs food-packaging machinery. The training manager asks you to familiarise yourself with the electrical systems that are fitted to the machines. They require you to produce a PowerPoint® presentation of your findings.	A PowerPoint® slide show with notes or speech cards to deliver a presentation that includes diagrams and images. These can be taken from reference sources, as long as they are supported by learners' 'own writing' and sources are referenced. There is no need to carry out the presentation.
1B.3, 2B.P3, 2B.M2, 2B.D2	Selecting Components used in Electrical Systems	Your training manager decides to team you up with a service engineer. They visit food-manufacturing plants to service and repair the packaging machines supplied by your company. They expect you to be able to investigate any components that need replacing due to wear and tear or breakdown.	A written report, which includes a system or circuit diagram, a given maintenance procedure and evidence of where data about components was found. This evidence could be screenshots and marked-up photocopies of pages taken from manufacturers' catalogues.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.4, 1C.5, 2C.P4, 2C.P5, 2C.M3, 2C.M4, 2C.D3	System Fault-finding and Rectification	A new design of packaging machine is being put through a pre-production test. You are helping the technician who is running the test. A number of fault codes show up on the control panel and they ask you to investigate.	A portfolio, which includes: 1. a written report covering the fault-finding techniques used relating to the rectification work of an electrical system (for level 1, a transcript of oral questioning is acceptable) 2. a written record of the fault-finding steps followed, and subsequent actions on a job card or checklist, supported by an observation record and annotated photographs.
1D.6, 1D.7, 2D.P6, 2D.P7, 2D.M5, 2D.D4	Routine Maintenance	Your manager asks you to carry out routine maintenance on the electrical system fitted to a workshop machine.	A portfolio, which includes a written record of the maintenance procedure followed and the risk assessment for that maintenance procedure, plus an observation record and annotated photographs.

Unit 27: Operation and Maintenance of Fluid Power Systems and Components

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how aircraft wheels extend and retract? Did a dentist ever use a drill to remove a cavity from your tooth? Have you ever seen a bulldozer move a lot of earth where a new road is being constructed? When you are riding in a car or on a bus and the driver pushes the brake pedal, you start to slow down. These are all examples of how engineers use fluid power to solve problems in our everyday lives. Fluid power can use either a gas (pneumatics) or a liquid (hydraulics). Most people don't even realise that fluid power is allowing us to perform jobs more quickly, efficiently, accurately and more powerfully than ever before.

All the above engineering operations require maintaining. The maintenance engineer is a key member of staff in ensuring the engineering process or service continues to operate efficiently and safely. This unit is about understanding fluid power components and systems maintenance employed in modern industry.

In this unit you will explore the operation and application of simple fluid power systems (pneumatic and hydraulic) and the components within them. You will gain an understanding of fluid power systems and their components, and how these systems are represented as symbols in circuit diagrams. You will also investigate components such as pumps, valves, actuators, and equipment that make up these systems.

Knowing how a system works puts someone in a much better position to carry out fault-finding, particularly if there is a set routine to follow.

You will develop the skills required to safely locate faults and carry out maintenance activities on fluid power systems and equipment used in modern industrial applications. You will learn how to carry out tests to ensure that the system performs to the required specification.

You will also learn the safety precautions and practices necessary when carrying out fault location and maintenance activities on fluid power systems, in order to maintain your own safety and that of others in the workplace.

Learning aims

In this unit you will:

A know about the operation of fluid power systems and the function and operation of components used in them

B be able to select components used in fluid power systems when carrying out maintenance procedures

C be able to prepare for and safely carry out fault-finding techniques and fault-rectification on fluid power systems and their components

D be able to prepare for and safely carry out maintenance procedures on fluid power systems and their components.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about the operation of fluid power systems and the function and operation of components used in them
Topic A.1: Fluid power systems Function and operation of pneumatic and hydraulic systems, e.g.: ● hydraulic – fuel pump, brake system, jack, lift, adjustable chair, machine tool slide ● pneumatic – brake system, air tool, automated conveyor system, pick and place unit, dentist drills, door operating system. Diagrammatic representation of the system, e.g.: ● circuit diagrams ● block diagrams ● system layout diagrams. **Topic A.2: System components** Methods of actuation including linear and rotary actuators. Function and operation of hydraulic components, e.g.: ● hoses, pipework and fittings ● pumps, supply tank, reservoirs, seals, and hydraulic fluids ● valves – directional, flow control, pressure relief, non-return. Function and operation of pneumatic components, e.g.: ● pipework and fittings ● air compressors, receivers and air service units ● valves – directional, flow, pressure relief, non-return valves.

What needs to be learnt
Learning aim B: Be able to select components used in fluid power systems when carrying out maintenance procedures
Topic B1: System data Sources of system information, including: ● circuit diagram ● block diagram ● assembly drawings ● construction diagrams ● maintenance procedures ● computer software-based packages/fluid system simulation packages. **Topic B.2: Component data** Sources of component data, including: ● manufacturer's catalogue ● data sheet ● repair manual ● parts list ● computer software-based packages/fluid system simulation packages. **Topic B.3: Component selection** Selecting components to be used in a maintenance procedure.

What needs to be learnt
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification on fluid power systems and their components
Topic C.1: Identification of faults in a fluid power system Types of fault, e.g.: ● intermittent operation ● partial failure/out-of-specification output ● complete breakdown. Aids to determining faults, e.g.: ● system specification ● system diagram, component data sheets ● operation and maintenance manual ● fault codes ● previous fault/repair reports ● functional and troubleshooting charts ● final test and handover procedures ● software-based records and data ● instruments – measuring equipment. Fault-finding techniques, e.g.: ● six point (collect evidence, analyse evidence, locate fault, determine and remove cause, rectify fault, check system) ● half split ● unit substitution ● visual examination.

What needs to be learnt
Topic C.2: Fault rectification Equipment, including: ● taps, dies, easy-outs, drills ● torque wrench ● circlip pliers ● meters ● gauges ● load and pressure testing devices ● puller ● screwdrivers, hex keys, spanners ● other assorted hand tools ● cleaning materials ● jointing compound. Removing and replacing faulty components, e.g.: ● components – remove, test, repair, source replacement, re-fit ● procedures – remove fluid power fixings, un-clip electrical connectors, dismantle, align ● post-rectification tests and checks. Recording actions, e.g.: ● job card ● checklist.
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on fluid power systems and their components
Topic D.1: Routine maintenance Inspection checks and tests, e.g.: ● visual examination – leak detection, wear, chafing, fouling, corrosion ● security of attachment/fixings ● noise ● fluid levels ● pressures. Maintenance procedures, e.g.: ● adjustments ● replacing components ● replacing/changing consumables ● testing against specification. Recording actions, e.g.: ● job card ● checklist ● routine maintenance report ● sign-off documentation.

What needs to be learnt
Topic D.2: Safety Safety awareness while carrying out maintenance on mechanical systems, including: ● hazards and risk ● people at risk ● control measures and their effectiveness ● risk-assessment documentation. Workplace hazards, including: ● pressurised systems ● unfenced machinery ● incorrect isolation of prime movers ● non-lockout of moving parts ● toxic substances ● badly maintained tools and equipment. Keeping safe in a fluid power maintenance environment, including: ● personal protective equipment (PPE) ● safe working practices – permit to work, danger tags, warning notices, safety barriers, isolation, treatment for eye injury (fluid and particle penetration) and other procedures in case of injury, accident reporting ● approved working procedures.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about the operation of fluid power systems and the function and operation of components used in them			
1A.1 Describe the function of a given fluid power system.	2A.P1 Describe with the aid of a diagram the function and operation of a given fluid power system.		
1A.2 Describe the function of two different components used in a given fluid power system.	2A.P2 Describe the function and operation of four different components used in a fluid power system.	2A.M1 Explain the relationship between component faults and the malfunction of a fluid power system.	2A.D1 Evaluate the impact that individual components have on the reliability of a fluid power system.
Learning aim B: Be able to select components used in fluid power systems when carrying out maintenance procedures			
1B.3 Identify, from a given source, the components to be used in a maintenance procedure for a fluid power system.	2B.P3 Select components to be used in a maintenance procedure for a fluid power system, using system and component data sources.	2B.M2 Justify the selection of components to be used in a maintenance procedure for a fluid power system.	2B.D2 Analyse a given fluid power system for ease of maintenance.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to prepare for and safely carry out fault-finding techniques and fault-rectification procedures on fluid power systems and their components			
1C.4 Identify faults in a fluid power system using a given fault-finding technique.	2C.P4 Identify faults in a fluid power system using two different fault-finding techniques.	2C.M3 Compare two fault-finding techniques used when carrying out rectification work on fluid power systems.	2C.D3 Justify the use of two fault-finding techniques when carrying out rectification work on fluid power systems.
1C.5 Safely replace specified components in a fluid power system.	2C.P5 Safely replace the identified faulty components in a fluid power system, checking for serviceability and record actions.	2C.M4 Explain the reasons for carrying out correct procedures and post-rectification tests and checks when undertaking fault-rectification on fluid power systems.	
Learning aim D: Be able to prepare for and safely carry out maintenance procedures on fluid power systems and their components			
1D.6 Safely carry out a routine maintenance procedure on a fluid power system.	2D.P6 Safely carry out a routine maintenance procedure on a fluid power system and record actions.	2D.M5 Risk assess a maintenance procedure for a fluid power system.	2D.D4 Risk assess a maintenance procedure for a fluid power system and explain the effectiveness of the control measures found within it.
1D.7 Identify the main hazards and people at risk when carrying out maintenance on fluid power systems.	2D.P7 Describe the hazards and risks when carrying out maintenance on fluid power systems and suggest control measures.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- access to fluid power systems and components, test instruments and fault-finding equipment
- access to workshops/labs equipped with modern test equipment, components and rigs
- a range of textbooks and learning materials, relevant British/International Standards, approved codes of practice, BFPA and health and safety publications
- access to FESTO equipment or similar and/or computer based fluid power simulation packages
- test equipment, tools and safety equipment
- relevant manufacturers' service manuals, data sheets, components lists, drawings and diagrams
- HSE risk assessment guidance – www.hse.gov.uk/risk/guidance.htm

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with *Section 8 Internal assessment.*

The assessor must carefully monitor the practical activities specified in this unit. It is important that when designing assignment briefs, the assessor makes it quite clear to learners that they must follow specified safety procedures to minimise risk to themselves and others. Some criteria are addressed through tasks involving diagrams/sketches and written text; it is acceptable to use graphics clipped from data sources (these must be acknowledged) but the writing that goes with them must be the learner's own work. Descriptive text cut and pasted from the web is not acceptable evidence. At level 1, a learner can make very basic statements when asked to 'identify' and 'describe'.

Criteria for learning aim A at level 2 should be linked so that learners only have to investigate a single fluid power system taken from the list in the unit content. It is expected that they will investigate at least four different components found within the system. These should be of different types, for example not just four valves or hoses of varying sizes. It is important that learners know the difference between 'function' and 'operation'. Function is about purpose, operation is about how that purpose is achieved. For example, the function of a hose is to connect other components together and contain the fluid; its operation relies on the shape and the strength of material from which it is made. Learners should be encouraged to make their own selection of components from the system. The description of the system operation should be supported with a block or circuit diagram and references made to inputs and outputs.

For 2A.M1 and 2A.D1, learners are expected to consider in more generic terms the effects of component faults on the operating performance of a fluid power system. They should consider full and partial system malfunction and the consequences if a system is not reliable.

For learning aim A at level 1 learners are only required to provide very basic descriptions of the function of the system and its components; the components can be identified for them.

For learning aim B at level 2 learners should be given a fluid power system circuit or block diagram or a system layout diagram, and carry out a suitable maintenance procedure. For a Pass they should select appropriate components to be replaced during a maintenance procedure. Having selected the relevant components, learners should access published data so that they can specify part numbers on a parts schedule. To help generate appropriate evidence, the assignment task can be made more meaningful if learners are asked to cost the replacement components and to fill out a dummy online order form.

For 2B.M2, learners must present a detailed justification for selecting particular components; for example, given the selection of an original equipment manufacturer (OEM) component or one from a much cheaper third-party supplier, which is the more cost-effective option? For 2B.D2, learners should present a detailed written analysis based on a given fluid power system. This could be the one used for 2B.P3 but it may be more appropriate to work with a more complex one. Learners could include a consideration of the economic issues relating to the maintenance of a system – e.g. the cost of labour, consumables, replacement components and system downtime.

For learning aim B at level 1 learners are only required to identify components. They can do this by marking up a hard copy of the system diagram with single word identifiers.

Centres should select one of the fluid power systems from the range given in the unit content. The system should be non-complex and have a small number of faults that are straightforward to identify for a learner working at level 2.

For 2C.P4, learners should apply at least two of the fault-finding techniques listed in the unit content. This criterion can be linked to 2C.P5 and for both it is important that written evidence is supported by assessor-signed observation records. After replacing faulty components learners must run post-rectification tests to ensure that the system is operating to specification. Identifying and replacing two or three faulty components would be a suitable number. To achieve 2C.M3, learners should reflect on the procedures carried out for 2C.P4. This will include comparing how straightforward the techniques were to follow, ease of identification of fault/s, equipment requirements, reliability of findings and how they documented their actions. For 2C.M4, the explanation of the reasons for carrying out correct procedures should include references to maintaining system integrity and efficiency of operation, health and safety and completing the procedure within a designated timeframe. Learners should also consider the significance of carrying out follow-up checks after a procedure has been completed, for example operating a pick and place unit after it has been maintained. For 2C.D3, learners will have extended their comparison for the merit activity and show a justification for each of the two fault-finding techniques used or others.

For 1C.4, just a single fault-finding technique need be used, for example substitution.

1C.5 requires a learner to carry out a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that have easily identifiable faults, for example a visual inspection to find a damaged hose. Learners should replace two components.

To achieve 2D.P6, learners should follow a given maintenance procedure. There is no requirement in the unit content for learners to write their own procedure. There must be a proper written record of the actions carried out, i.e. inspection and tests done, consumables used, parts replaced, identification of parts which are wearing out and may need future replacement, etc.

For 2D.P7, learners must present evidence about hazards and risks specific to maintenance procedures carried out on fluid power systems. The more generic aspects of health and safety are fully covered in *Unit 3: Health and Safety in Engineering*. Before a learner embarks on the practical aspects of this learning aim they must present evidence to the assessor that shows they know how to keep safe when working with fluid power systems. To achieve 2D.M5, learners should present their risk assessment in a template, which follows the recommendations of the HSE. For 2D.D4, learners must reflect on what they have learnt about routine maintenance but may wish to also draw on experience gained when carrying out fault-finding by explaining the effectiveness of the control measures suggested in their risk assessment. The risk assessment carried out for 2D.M5 will only need to show the control measures but to achieve the distinction criterion learners must explain their effectiveness when applied to the maintenance procedure.

Again, 1D.6 requires a simple practical exercise and can be evidenced by witness statements, images and checklists. Learners should be presented with systems that require relatively simple routine procedures.

For 1D.7, learners are only required to identify main hazards and people at risk; this can be recorded using a simple checklist. Learners could be placed in a maintenance workshop or be given photographs of one and then asked to match hazards against a given list.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Fluid Power Systems and Components	You have recently started work as an apprentice. Your company manufactures and installs automated assembly machines. The training manager asks you to familiarise yourself with the fluid power systems that are fitted to the machines. They require you to produce a PowerPoint® presentation of your findings.	A PowerPoint® slide show with notes or speech cards to deliver a presentation that includes diagrams and images. These can be taken from reference sources, as long as they are supported by learners' 'own writing' and sources are referenced. There is no need to carry out the presentation.
1B.3, 2B.P3, 2B.M2, 2B.D2	Selecting Components used in Fluid Power Systems	Your training manager decides to team you up with a service engineer. They visit manufacturing businesses to service and repair the machinery supplied by your company. They expect you to be able to investigate any components that need replacing due to wear and tear or breakdown.	A written report, which includes a system diagram, circuit or assembly diagram, a given maintenance procedure and evidence of where data about components was found. This evidence could be screenshots and marked up photocopies of pages taken from manufacturers' catalogues.
1C.4, 1C.5, 2C.P4, 2C.P5, 2C.M3, 2C.M4, 2C.D3	System Fault-finding and Rectification	A new design of assembly machine is being put through a pre-production test. You are helping the technician who is running the test. A number of fault codes show up on the control panel and they ask you to investigate.	A portfolio, which includes: 1. a written report covering the fault finding techniques used relating to the rectification work of a fluid power system (for level 1, a transcript of oral questioning is acceptable) 2. a written record of the fault-finding steps followed, and subsequent actions on a job card or checklist, supported by an observation record and annotated photographs.

Criteria covered	Assignment	Scenario	Assessment evidence
1D.6, 1D,7, 2D.P6, 2D.P7, 2D.M5, 2D.D4	Routine Maintenance	Your manager asks you to carry out routine maintenance on the pneumatic door operating system in a refrigeration unit.	A portfolio, which includes a written record of the maintenance procedure followed and the risk assessment for that maintenance procedure, plus an observation record and annotated photographs.

Unit 28: Fabrication Techniques

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how the parts of a computer fit so neatly and precisely into a computer case? The answer is thanks to precise fabrication techniques. They enable a sheet of thin metal to be formed and shaped with accuracy and precision to allow all of the computer parts to be fitted securely inside.

This unit will help you to understand the fabrication techniques used in industry to prepare, form and assemble materials and components. This is a predominantly practical unit and you will have the opportunity to use and investigate materials and material sections, along with fixtures and fittings used in fabricating, joining and assembling products.

Health and safety is a vital consideration when carrying out fabrication exercises, and you will learn about handling and using materials and tools/equipment safely.

You will refer to specifications in order to measure and mark out materials ready for fabrication and use cutting and forming techniques to prepare for final assembly. To complete the assembly you will use a variety of tools and techniques, including joining techniques, and you will also use specifications to ensure you have met all stated requirements in the practical activities you carry out.

Learning aims

In this unit you will:

A be able to safely measure and mark out materials for fabricated structures

B be able to safely cut and form materials in a sheet metal fabrication environment

C be able to safely join and accurately assemble fabricated structures.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to safely measure and mark out materials for fabricated structures
Topic A.1: Measuring and marking out Safe use of tools and equipment for measuring and marking out: ● measuring tools, e.g. rule, tape rule, protractor, height gauge ● marking out tools, e.g. scriber, centre punch, chalk line, square, trammel, dividers, templates, surface plate, chalk, engineers blue, laser measuring and marking equipment ● features, e.g. datum lines and centre lines, square and rectangular profiles, circles, curved profiles, cutting detail, hole centring, circular outlining, linear outlining. **Topic A.2: Material types** Standard fixtures and forms of supply of common engineering materials: ● sheet, plate and material sections, e.g. hot-rolled black, cold-rolled ● up to and including 3mm thickness of standard sections ● material forms used in fabrication and assembly, e.g. standard bar and section lengths, standard profiles, cutting detail for flat covers and plates, frames, pipe and tube sections, columns, beams, struts ● fixtures and fittings used in fabrication, e.g. seals, gaskets, trims, panels, screens, fish plates, gussets, spars and brackets, structural support pads, bed plates. **Topic A.3: Materials** Types of material used in fabrication: ● metallic – ferrous and non-ferrous, e.g. mild steel, tinned steel, galvanised steel, aluminium, stainless steel, brass, copper ● non-metallic – plastics, rubbers, e.g. mouldings, sheets and extrusions. **Topic A.4: Safety** Legislation – relevant legislation applicable to fabrication, e.g. Health and Safety at Work Act (HASAWA), Control of Substances Hazardous to Health (COSHH) Regulations, Supply of Machinery (Safety) Regulations, Provision and Use of Work Equipment Regulations (PUWER), Health and Safety (First Aid) Regulations, Manual Handling Operations Regulations, Lifting Operations and Lifting Equipment Regulations, Personal Protective Equipment at Work Regulations, Control of Noise at Work Regulations. General safety awareness when carrying out fabrication techniques, including: ● equipment set-up ● guards and screens ● personal protective equipment (PPE) ● manual handling techniques ● identification of hazards.

What needs to be learnt
Learning aim B: Be able to safely cut and form materials in a sheet metal fabrication environment
Topic B.1: Cutting Safe use of cutting tools and techniques: ● hand tools, e.g. tin snips, hacksaw, files ● hand power tools – drill, nibbler ● machine tools, e.g. bench shears, band saw, guillotine, pillar drill, punch, cropping machine ● cutting operations – straight cuts, external contoured cuts, round holes ● filing ● drilling. **Topic B.2: Forming** Safe use of forming tools and techniques: ● tools and equipment, e.g. hammers, mallets, stakes, formers, hand bending, powered bending machines, hand rolling, powered rolling machines ● safety checks on tools and equipment, e.g. hammer shafts are secure, striking faces on stakes and formers are free from burrs and defects, machine guards and devices are operational ● operations – bends, folds, curved panels, cylindrical section, ducting/trunking. **Topic B.3: Safety** Legislation – relevant legislation applicable to fabrication, e.g. Health and Safety at Work Act (HASAWA), Control of Substances Hazardous to Health (COSHH) Regulations, Supply of Machinery (Safety) Regulations, Provision and Use of Work Equipment Regulations (PUWER), Health and Safety (First Aid) Regulations, Manual Handling Operations Regulations, Lifting Operations and Lifting Equipment Regulations, Personal Protective Equipment at Work Regulations, Control of Noise at Work Regulations. General safety awareness when carrying out fabrication techniques, including: ● equipment set-up ● guards and screens ● personal protective equipment (PPE) ● manual handling techniques ● identification of hazards.

What needs to be learnt
Learning aim C: Be able to safely join and accurately assemble fabricated structures
Topic C.1: Joining processes Types of permanent and non-permanent joining: ● thermal, e.g. tack welding, brazing, soldering, resistance spot welding ● mechanical fasteners, e.g. hollow rivets, solid rivets, self piercing rivets, threaded inserts, structural fasteners, bolts, screws ● adhesives, e.g. structural adhesives, epoxides, acrylics, cyanoacrylates. **Topic C.2: Assemblies** ● Types of assembly – straightforward assemblies (characterised by linear edges, perpendicular changes of section and regular joins), e.g. regular shaped frames/hoods/guards/panels, regular sectioned ducting/trunking, square, rectangular and box sections, cylindrical sections; more complex assemblies (characterised by non-linear edges, changes of section which are not necessarily perpendicular and irregular joins), e.g. reduction pieces, irregular shaped frames/hoods/guards/panels, sectioned ducting/trunking incorporating changes in section/cross sectional area, irregular shaped box sections, oval and tapered cylindrical sections. ● Types of components in the assemblies – straightforward components, e.g. regular sheet metal covers, pre-fabricated square and rectangular components, pre-fabricated cylindrical and conical components, brackets. Light rolled angle or tee section; more complex types of component, e.g. irregular sheet metal covers, pre-fabricated non-square/rectangular components, pre-fabricated non-circular cylindrical and conical profiles, flanges, pipes, light rolled channel or I form section. **Topic C.3: Quality and accuracy standards** Joining and assembling within tolerance: ● aligning parts in accordance with given specifications ● ensuring overall linear dimensions meet specification ● ensuring overall dimensions are within geometrical tolerances, e.g. square, straight, free from twists, pitches of erection holes meet specification requirements ● assemblies have secure and firm joints ● assemblies are clean and free from burrs and sharp edges.

What needs to be learnt
Topic C.4: Safety Legislation – relevant legislation applicable to fabrication, e.g. Health and Safety at Work Act (HASAWA), Control of Substances Hazardous to Health (COSHH) regulations, Supply of Machinery (Safety) Regulations, Provision and Use of Work Equipment Regulations (PUWER), Health and Safety (First Aid) Regulations, Manual Handling Operations Regulations, Lifting Operations and Lifting Equipment Regulations, Personal Protective Equipment at Work Regulations, Control of Noise at Work Regulations. General safety awareness when carrying out fabrication techniques, including: ● equipment set-up ● guards and screens ● personal protective equipment (PPE) ● manual handling techniques ● identification of hazards.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to safely measure and mark out materials for fabricated structures			
1A.1 Safely select tools and techniques, fixtures and fittings and material in preparation for the fabrication of a straightforward fabricated structure.	2A.P1 Safely select tools and techniques, fixtures and fittings and material in preparation for the fabrication of a complex fabricated structure.	2A.M1 Explain the reasons for selecting specific tools and equipment, fixtures and fittings and material in preparation for the fabrication of a complex fabricated structure.	2A.D1 Justify the selection of specific measuring and marking out tools and the techniques used when marking out different materials.
1A.2 Safely measure and mark out a single material for a straightforward fabricated structure.*	2A.P2 Safely measure and mark out different types of material for a complex fabricated structure.*		
Learning aim B: Be able to safely cut and form materials in a sheet metal fabrication environment			
1B.3 Demonstrate the safe use of cutting tools and techniques in the production of a straightforward fabrication.	2B.P3 Demonstrate the safe use of cutting tools and techniques in the production of a complex fabrication.	2B.M2 Explain the reasons for selecting specific cutting and forming tools and techniques in the production of a complex fabrication.	2A.D2 Justify the selection of specific cutting and forming tools and techniques in the production of a complex fabrication.
1B.4 Demonstrate the safe use of forming tools and techniques in the production of a straightforward sheet metal fabrication.	2B.P4 Demonstrate the safe use of forming tools and techniques in the production of a complex sheet metal fabrication.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to safely join and accurately assemble fabricated structures			
1C.5 Use quality standards to safely and accurately join and assemble a straightforward fabricated structure.*	2C.P5 Use quality standards to safely and accurately join and assemble a complex fabricated structure featuring permanent and non-permanent joints.*	2C.M3 Explain the use of permanent and non-permanent joints when joining and assembling a complex fabricated structure.#	2C.D3 Justify the selection of a chosen type of a permanent and non-permanent joining technique.#
1C.6 Outline safe working practices used in the joining and assembly of fabricated structures and identify relevant health and safety legislation.	2C.P6 Describe safe working practices used in the joining and assembly of fabricated structures and link these practices to relevant health and safety legislation.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to an appropriately equipped workshop with a range of cutting and forming tools and equipment
- a range of measuring tools and equipment
- access to appropriate materials and fixtures in order to carry out fabrication exercises
- access to appropriate tools and equipment in order to facilitate permanent and non-permanent joining techniques.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment.*

Evidence of achievement of the learning aims and assessment criteria may be obtained from practical activities; learners need to present evidence of being able to safely measure, mark out, cut, form, join and assemble materials for fabricated structures. A variety of evidence could be used, including witness statements, annotated photographs, diaries/logs and detailed learner observation records.

As the learning aims require the measuring and marking out, cutting and forming and joining and assembling of a fabricated structure the assessment for this unit could be project-based allowing learners to concentrate on a complex fabrication at level 2 and a more straightforward fabrication at level 1.

For 2A.P1, learners could be given a complex specification, broken down into several parts with the use of separate documents or drawings. From this specification they should select the tools and equipment needed for the complex fabrication activity. This activity is likely to require a range of tools, equipment, fixtures and fittings outlined in the unit content. For 2A.M1 learners should consider the reasons for selecting the specific tools, equipment, fixtures, fittings and materials and explain their use in fabrication activities. For 2A.P2, a follow-on marking out exercise using different selected materials could be used. Photographic evidence would be useful to indicate the stages in the process with appropriate annotations. On completion of this activity a written justification of the techniques and tools used in the marking out exercise would allow learners to evidence 2A.D1.

For 1A.1, learners could be given a more straightforward specification or complete a straightforward part of the complex specification given to level 2 learners. Similarly, the evidence presented for 1A.2 could be a single part of the more detailed exercise requiring the marking out of a single material.

For 2B.P3 and 2B.P4, learners could use the same specification as used to evidence learning aim A. Having completed the marking out exercise, they should use cutting and forming techniques to produce one or more complex sheet metal fabrications. For 2B.M2, learners must explain how the fabrication was developed, with particular reference to the selection of cutting and forming tools and techniques used. A comparison of different forming tools and techniques could be used to evidence 2B.D2, with learners clearly justifying why they were chosen in preference to others.

For 1B.3 and 1B.4, learners could extend the exercise used for learning aim A. Having completed the straightforward marking out exercise, they could use cutting and forming tools and techniques to produce a straightforward sheet metal fabrication.

For 2C.P5, learners could continue the exercise used to evidence learning aims A and B by referring to the quality standard to accurately join and assemble the previously fabricated component, or components, and other components and fittings in order to complete the fabricated structure. The process should also focus on the use of safe working practices and should be linked to key legislation in order to evidence 2C.P6. This process should involve the use of permanent and non-permanent joining techniques so that learners can compare and contrast their use for 2C.M3 and justify an example of the use of both techniques for 2C.D3.

For 1C.5, learners could, similarly, continue the previous exercise used to evidence learning aims A and B by accurately joining and assembling the previously fabricated straightforward component and other components and fittings in order to complete the fabricated structure. In order to evidence 1C.P6, learners should ensure that they can outline the safe working practices being used, and identify the key health and safety legislation, in the joining and assembly process being considered.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Safely Measure and Mark Out Materials for Fabricated Structures	You have just started work in a fabrication workshop and have been asked by your team leader to safely measure and mark out a structure and prepare a PowerPoint® presentation, for a group of visitors, showing how the structure was safely measured and marked out ready for fabrication.	A PowerPoint® presentation, including: 1. appropriate annotations and explanations showing the selection of tools, equipment, fixtures and fittings 2. the measuring and marking out of a complex fabricated structure, with justifications of the measuring and marking out tools used. Observation/witness statements, detailed learner observation records, annotated photographs, diaries/logs.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.D2	Safely Cut and Form Materials in a Sheet Metal Fabrication Environment	Your team leader is impressed with your presentation and would like you to prepare another PowerPoint® presentation and demonstrate the safe use of cutting and forming equipment. You will also need to demonstrate safe cutting and forming techniques.	A PowerPoint® presentation, including: 1. appropriate annotations and explanations of the selection of specific cutting and forming tools 2. a demonstration of their safe use in the production of a complex sheet metal fabrication, with justification of the tools and techniques. Observation/witness statements, detailed learner observation records, annotated photographs, diaries/logs.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.5, 1C.6, 2C.P5, 2C.P6, 2C.M3, 2C.D3	Safely Join and Accurately Assemble Fabricated Structures	Your team leader would like you to complete the set of PowerPoint® presentations with one showing the use of a quality standard and a demonstration of the accurate joining and assembly of a complex fabricated structure. You will need to demonstrate safe joining and assembling techniques with links to the appropriate legislation.	A PowerPoint presentation, including: 1. appropriate annotations and explanations of the process of joining and assembling a complex fabricated structure 2. justification of the use of permanent and non-permanent joining techniques 3. linking the safe working practice to appropriate legislation. Observation/witness statements, detailed learner observation records, annotated photographs, diaries/logs.

Unit 29: Casting Processes and Techniques

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how a block of metal can be made into a complex shape such as a car engine or gearbox? To try to use material removal techniques would be very difficult, time consuming and expensive. Instead the metal is melted and poured or forced into a prepared sand, wax or metal mould. This process is known as casting. In this unit you will learn about the various casting processes that can be used to produce different shapes and components.

You will learn about the use of different types of mould, how they are designed and constructed and how materials are melted and poured or forced into them. You will also learn how finished components are removed from these moulds at the end of the casting process. After the component is removed from the mould a relatively small amount of machining is sometimes required. Some casting processes can produce components of such high quality that no further material removal processes are required.

Health and safety is a key consideration when dealing with casting processes and materials, such as molten metals at high temperature, and you will learn about the precautions taken to ensure all processes are performed safely.

Learning aims

In this unit you will:

A know how sand and investment casting processes, including mould-making, are safely used

B know how material melting processes and component removal processes and techniques are safely used in the casting process

C know how gravity and pressure die-casting processes are safely used.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know how sand and investment casting processes, including mould-making, are safely used
Topic A.1: Sand casting Sand casting processes: ● parts of a mould – boxes, drag, cope, pattern, runners, risers, cores, boxless moulds ● moulding sand, e.g. oil sand, green sand, chemically bonded gas activated sand, chemically bonded resin catalyst activated sand, resin bonded heat activated sand ● mould and core production by hand ● mould and core production by machine, e.g. jolt/squeeze, jolt/squeeze/rollover, mixer/slinger, mixer/vibratory table, squeeze, blown, blown vibratory, blow/blow squeeze. **Topic A.2: Investment casting** Investment casting processes: ● use of wax patterns, e.g. single waxes, wax assemblies ● mounting of wax patterns, e.g. handles, bars, hangers ● use of slurry in pattern making ● producing shells/moulds, e.g. manually, automatically, combined manual and semi-automatic, single, multiple ● curing shells/moulds, e.g. natural air, forced air, gas activated. **Topic A.3: Safety** General safety awareness when carrying out casting processes, including: ● guards and screens ● personal protective equipment (PPE) ● identification of hazards.
Learning aim B: Know how material melting processes and component removal processes and techniques are safely used in the casting process
Topic B.1: Methods of melting material Melting processes: ● scale of production, e.g. single melt, batch melt, continuous melt, combined methods ● types of furnace, e.g. cupola, induction, rotary, bale out, lift out crucible, tilting crucible, direct or indirect arc ● types of material, e.g. pure metals, ferrous alloys, non-ferrous alloys ● measurement of temperature using pyrometers.

What needs to be learnt

Topic B.2: Component removal

Component removal processes and techniques:

- processes used in component removal, e.g. manual, vibratory tables/grids, punch-out mechanisms, chemical leaching
- techniques for component removal, e.g. knocking castings out of moulds, removing components from the moulding material or dies, de-coring, removing runner/riser/feeder system
- tooling used in component removal, e.g. work-holding devices (vice, clamps, jigs and fixtures), disc/angle grinder, pedestal grinder, slitting saw, band saw, laser cutter, linisher, pneumatic chipping hammers, wire brush, scraper, hacksaw, file, abrasive stone, abrasive paper, hammer
- blasting to remove burrs/rough edges etc, e.g. sand, air, water.

Topic B.3: Safety

General safety awareness when carrying out material melting processes and component removal, including:

- guards and screens
- personal protective equipment (PPE)
- identification of hazards.

Learning aim C: Know how gravity and pressure die-casting processes are safely used

Topic C.1: Gravity die-casting

Gravity die-casting processes:

- die location, e.g. floor, fixed base, movable base, carousel, conveyor/roller track
- types of die, e.g. split die with no secondary movement, split die with one secondary movement, split die with two or more secondary movements, split die with no cores, split die with one core, split die with two or more cores, water cooled
- use of cores.

Topic C.2: Pressure die-casting

Pressure die-casting processes:

- types of pressure die-casting – high pressure hot chamber, high pressure cold chamber, squeeze process
- types of die, e.g. split die with no secondary movement, split die with one secondary movement, split die with two or more secondary movements, split die with no cores, split die with one core, split die with two or more cores, water cooled
- use of cores.

Topic C.3: Safety

General safety awareness when carrying out gravity and pressure die-casting processes, including:

- guards and screens
- personal protective equipment (PPE)
- identification of hazards.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know how sand and investment casting processes, including mould-making, are safely used			
1A.1 Outline the process of safely producing a mould that contains cores for a sand casting process.	2A.P1 Describe the process of safely producing a mould that contains cores for a sand casting process.	2A.M1 Explain why sand casting and investment casting processes are used for different components.	2A.D1 Evaluate the effectiveness of sand casting and investment casting processes for different components.
1A.2 Outline the process of safely producing a mould for an investment casting process.	2A.P2 Describe the process of safely producing a mould for an investment casting process.		
Learning aim B: Know how material melting processes and component removal processes and techniques are safely used in the casting process			
1B.3 Outline the safe use of melting processes when producing a casting.	2B.P3 Describe the safe use of melting processes when producing a casting.	2B.M2 Explain why the scale of production has an impact on melting processes.	2B.D2 Justify a chosen type of melting process and component removal technique for a given casting.
1B.4 Outline the safe use of component removal processes and techniques when producing a casting.	2B.P4 Describe the safe use of component removal processes and techniques when producing a casting.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Know how gravity and pressure die-casting processes are safely used			
1C.5 Outline the safe use of dies and cores in a gravity die-casting process.	2C.P5 Describe the safe use of dies and cores in a gravity die-casting process.	2C.M3 Explain why gravity and pressure die-casting processes are used for different components.	2C.D3 Evaluate the effectiveness of gravity and pressure die-casting processes for different components.
1C.6 Outline three different types of pressure die-casting processes.	2C.P6 Describe three different types of pressure die-casting processes.	2C.M4 Explain the reasons for using die-casting techniques in preference to sand casting or investment casting techniques.	
1C.7 Outline the safe use of dies and cores in a pressure die-casting process.	2C.P7 Describe the safe use of dies and cores in a pressure die-casting process.		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- a variety of finished components, which illustrate the use of different casting techniques.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of achievement of the learning aims and assessment criteria may be obtained from well-planned investigative assignments or reports of workplace visits or practical activities. It is anticipated that integrative assignments might be used to link this unit with other, more practical or project-related units in the programme. If this approach is adopted, the evidence for the specific learning aims and associated assessment criteria will need to be clearly and separately identified.

For 2A.P1, learners could base their work on an industrial visit or video case study of a casting process including the production and preparation of a sand-casting mould. A similar approach could be taken for investment casting for 2A.P2. In both cases, learners must identify health and safety considerations and describe the mould-making process in full. For 2A.M1, learners could use the same case studies or visits, comparing the processes and explaining their different applications.

To achieve 2A.D1, learners must go beyond a straightforward comparison of the two processes that they have observed/considered and investigate a range of manufacturing processes that might be used to produce components, in order to effectively evaluate the use of both sand casting and investment casting processes.

For 1A.1, learners are required to outline the process of safely producing moulds for sand-casting processes. The evidence for this could be in the form of annotated diagrams or photographs with a similar approach being taken for investment casting for 1A.2.

For learning aim B at level 2, learners could use the same industrial visits or video case studies as used for learning aim A. Following on from the production and preparation of sand/investment casting moulds, for 2B.P3, learners need to consider the melting processes used in casting and, for 2B.P4, processes and techniques used to remove finished components from their moulds. Learners must identify health and safety considerations and describe the processes in full. For 2B.M2, learners must go beyond simply describing different scales of production and consider the implications of producing different batch sizes in terms of both material requirements and casting processes. Similarly, to evidence 2B.D2, learners should consider an exemplar product and justify the method of component removal and the melting process they would use when casting the product.

For 1B.3, learners must outline the safe use of melting processes used in casting. Evidence such as annotated photographs and tables of information could be used to demonstrate a basic understanding. This approach could also be used when outlining the safe use of component removal tooling, processes and techniques used in casting for 1B.4.

For 2C.P5 and 2C.P7, learners could base their work on an industrial visit or video case study of the use of cores and dies in gravity die-casting and pressure die-casting processes. In both cases, learners must identify health and safety considerations and describe the process in full. A research activity could be used to enable learners to compare different types of pressure die-casting processes for 2C.P6.

To achieve 2C.M3, learners should consider the different die-casting processes, in order to explain the relative merits of each. This could be developed into an analysis of the characteristics of artefacts produced using the two different die-casting processes, in order to evaluate the effectiveness of each process for 2C.D3.

For 2C.M4, learners should consider the use of die-casting techniques in comparison with sand casting or investment casting techniques. Typical comparisons would include the scale and speed of production, quality of finish, cost etc.

For 1C.5 and 1C.7, learners need to outline the safe use of dies and cores in gravity die-casting and pressure die-casting. Evidence could be in the form of annotated diagrams or photographs. Annotated diagrams of three different types of pressure die-casting process could be used as evidence for 1C.6.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	How Sand and Investment Casting Mould-Making Processes are Safely Used	You have just started work in an engineering workplace and have been asked by your team leader to observe sand and investment casting mould-making processes and report on them.	A written report or presentation, which should: 1. describe the safe production of moulds for sand casting and investment casting 2. explain why each process is used, depending upon the component being produced 3. evaluate the effectiveness of each process.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.D2	Material Melting Processes and Component Removal Processes and Techniques	Your team leader is impressed with your report and asks you to investigate different material melting processes and component removal processes and techniques.	A written report or presentation describing the safe use of melting and component removal processes and techniques, with an explanation of why scale of production is an important consideration.
1C.5, 1C.6, 1C.7, 2C.P5, 2C.P6, 2C.P7, 2C.M3, 2C.M4, 2C.D3	How Gravity and Pressure Die-Casting Processes are Used	Your team leader is considering investing in a casting process and wants you to investigate gravity and pressure die-casting processes.	A written report or presentation describing the safe use of dies and cores in gravity and pressure die-casting, including a description of three different types of die-casting. In addition, an explanation of why gravity and pressure die-casting techniques are used for different components in preference to sand/investment casting techniques, with an evaluation of the die-casting processes for different components.

Unit 30: Vehicle Maintenance Techniques

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how cars are serviced? The aim of this unit is to enable you to select and use appropriate information, tools and equipment to carry out vehicle maintenance and complete maintenance records correctly. This could be anything from checking oil levels or the operation of lights to fitting new parts.

You will learn to apply the procedures necessary to maintain vehicles (including hybrid/alternative fuel and electric vehicles) and deal with the principles and practical aspects in a generic manner so the skills are transferable, regardless of manufacturer or application.

There are many types of maintenance, such as the pre-delivery inspection (conducted before the customer collects the vehicle after purchase or major repair), the initial service after a short duration of use, fixed inspection service and the major service (each of which could be time-based or mileage-based).

You will need to apply the knowledge gained from vehicle maintenance procedures. This will include keeping an extensive list of items that are liable to wear over a period of time and that need to be checked on a regular basis. You will learn how to replace items such as engine oil, filters and spark plugs. Other items may need replacing according to age and mileage, for example the cam belt, antifreeze and brake fluid. Regular maintenance is a preventative measure – often breakdowns or major problems arise because early warning signs were not detected.

As well as learning theory, you will carry out and be assessed on practical activities such as changing filters and engine oil, ensuring all of the equipment on the vehicle works and visual inspections.

Learning aims

In this unit you will:

A be able to select information and data for vehicle maintenance procedures

B be able to select appropriate equipment, components and materials for vehicle maintenance

C be able to safely carry out vehicle maintenance and complete maintenance records.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to select information and data for vehicle maintenance procedures
Topic A.1: Information and data Know how to find, interpret and use sources of information and data for scheduled maintenance procedures, including: Information and data sources for scheduled maintenance procedures: ● vehicle technical data and repair processes, including tightening torques, pressures, MOT requirements, vehicle specifications ● records of vehicle inspection and customer instructions to show any history for the vehicle or customer aligned to the direct customer instructions ● safety and legal requirements, e.g. MOT, COSHH, environmental ● schedules of service/inspection and their reasons for use on high-mileage vehicles, e.g. by time, by mileage, expected inspection or service areas to be completed ● service data, e.g. on-board diagnostic displays, manufacturers' and non-manufacturers' workshop manuals, CD ROM, online information, technical service bulletins (TSBs), parts lists, comparison of manual and computer-based sources. Customer instructions: ● typical scenario, e.g. breakdown, service, inspection, parts replacements, adjustments, modifications. **Topic A.2: Maintenance procedures for specific vehicles** Know about maintenance procedures and their use for low- and high-mileage vehicles: ● routine vehicle servicing – initial/basic, fixed and major service ● vehicle breakdown repair – component failure or wear.

What needs to be learnt
Learning aim B: Be able to select appropriate equipment, components and materials for vehicle maintenance
Topic B.1: Equipment The selection and use of equipment can be very varied but will include test instruments for: ● brake fluid to test fluid hygroscopicity to ensure no water absorption ● antifreeze levels to maintain protection of the system ● tension measurement as over-tightening can cause more damage than slackly adjusted components ● brake efficiency for MOT requirements, not only to pass a test but to ensure maximum safety of all passengers and the public ● tyre tread depth that could also help identify other areas of maintenance ● emissions analysis to maximise economy, minimise environmental impact of harmful gases ● wheel alignment to maximise tyre life and vehicle performance. Comparison and the associated advantages/disadvantages of using equipment, including: ● cost ● performance ● guarantee implications. **Topic B.2: Components and materials** The selection and use of components and materials which can be split between those directly needed for the procedures, including: ● filters, e.g. air, oil, fuel, pollen systems ● drive belts, e.g. alternator, power steering, camshaft ● spark plugs ● lubricants, e.g. brake fluid, antifreeze, oil ● gaskets and seals. and others that are naturally fitted at the same time, e.g.: ● wiper blades ● brake pads or linings ● light bulbs ● tyres. Comparison and the associated advantages/disadvantages of using components and materials, including: ● cost ● performance ● guarantee implications.

What needs to be learnt
Learning aim C: Be able to safely carry out vehicle maintenance and complete maintenance records
Topic C.1: Examination methods The application of the different methods and the associated advantages/disadvantages of using them: ● how to work safely avoiding damage to the vehicle and its systems (including special precautions that may be required when working on hybrid/alternative fuel and electric vehicles) ● listening to warning systems, on-board diagnostic devices, the running engine as well as the wheels spinning manually ● visually checking lights for damage or security, glass and components for visual damage, signs of corrosion or wear ● checking functioning of lights and components for operation, additional equipment operation such as heating systems, security systems ● measurements to include tyre depth and pressures, antifreeze content, brake fluid condition, vehicle geometry. **Topic C.2: Maintenance requirements and adjustments** Carrying out requirements and adjustments and giving reasons to the customer for doing so, including: ● malfunction, the component or systems not operating as per manufacturers' expectations ● levels, leaks, wear, security, condition, corrosion and serviceability or damaged components either mechanical, body or electrical ● alignment such as headlamps, body fittings ● tensions such as drive belts ● brake adjustments such as hand brake. **Topic C.3: Vehicle areas** Carrying out maintenance and adjustments on vehicle areas**,** which are subdivided into: ● engine, e.g. cooling systems, air supply and exhaust systems, fuel systems and ignition systems of vehicle on which you are working (including hybrid vehicles and alternative fuel vehicles) ● transmission, e.g. clutch operating systems, manual gearboxes, automatic gearboxes, drivelines and hubs (if appropriate) and final drive assemblies for the type of vehicle on which you are working (including hybrid/alternative fuel and electric vehicles) ● chassis, e.g. suspension systems, steering systems, braking systems, non-electrical body systems, wheels and tyres for the type of vehicle on which you are working (including regenerative braking systems and other energy-recuperation systems used on hybrid/electric and alternative fuel vehicles if fitted) ● electrical, e.g. operation and location of power storage systems (including batteries), power generating systems (including vehicle charging systems), starting systems, lighting systems and ancillary equipment for the type of vehicle on which you are working (including hybrid/alternative fuel and electric vehicles) ● body, how to recognise and report cosmetic damage to vehicle components and units outside normal service items. *continued*

What needs to be learnt
Topic C.4: Complete maintenance records Use records in accordance with manufacturers' or workplace requirements, including: ● vehicle service/inspection documents, service sheets ● manufacturers' documents ● company task card or customer job cards.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to select information and data for vehicle maintenance procedures			
1A.1 Identify the information and data required for a given maintenance procedure based on a scenario from customer instructions. #	2A.P1 Select data and information from various information and data sources for a given scenario from customer instructions. #	2A.M1 Compare the benefits of manual paper-based information and data sources with computer-based systems. #	2A.D1 Justify a planned servicing schedule for high-mileage vehicles.
1A.2 Identify the maintenance procedures for a specific vehicle.	2A.P2 Describe the maintenance procedures for a specific vehicle.	2A.M2 Compare different maintenance procedures for high- and low-mileage vehicles.	
Learning aim B: Be able to select appropriate equipment, components and materials for vehicle maintenance			
1B.3 Identify the equipment, components and materials required for a given maintenance procedure based on a scenario from customer instructions.	2B.P3 Select the equipment, components and materials from various information and data sources for a given scenario from customer instructions.	2B.M3 Compare alternative equipment, components and materials on cost, performance and guarantees.	2B.D2 Justify the use of high-cost equipment, components and materials.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to safely carry out vehicle maintenance and complete maintenance records			
1C.4 Use examination methods to carry out maintenance requirements and adjustments covering three vehicle areas.	2C.P4 Use examination methods to carry out maintenance requirements and adjustments covering five vehicle areas, and component replacement covering three vehicle areas.	2C.M4 Explain to the customer the reasons for the identified maintenance requirements and adjustments in terms of safety, reliability and performance.	2C.D3 Justify to the customer, in terms of expenditure, the use of a replacement component.
1C.5 Complete maintenance records including task/job card and service sheet on three areas in accordance with manufacturers'/ workplace requirements. #	2C.P5 Complete maintenance records including task/job card and service sheet and give feedback to the customer on all five areas in accordance with manufacturers'/ workplace requirements. #		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are related to the activities in a workshop to both develop and assess learners in maintenance techniques. The centre will need access to an array of resources such as vehicle(s), workshop and equipment, maintenance components, appropriate facilities for disposal of materials along with access to vehicle data and records. Access to live workshops to develop learning resources by 'learner observation' would be a major benefit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

At level 2, learners should select the data and information for the required activity in 2A.P1. Possible sources include the VOSA (Vehicle and Operator Services Agency) website for MOT data and technical data from a database. The structure of the assessment could challenge learners to compare the benefits of manual paper-based information and data sources with computerised systems for 2A.M1. Furthermore, the assessment must cover all five bullet points at the start of Topic A.1.

For 2A.P2, learners need to describe the maintenance procedures for a given vehicle, which should include both routine vehicle servicing and vehicle breakdown repair. Learners must cover the individual elements within the procedures, possibly evidenced by using specific documentation from industry. There is a good opportunity for a differentiated task to stretch and challenge learners to achieve 2A.M2, asking them to compare the different maintenance procedures for high- and low- mileage vehicles. For 2A.D1, learners need to justify a planned service schedule for high mileage vehicles, such as oil selection for replacement, the frequency of activities due to the mileage and life expectancy of components.

For 1A.1, assessment could be based on learners' studies of service users in a vehicle-related industry, such as service, fast fit or a franchised dealer. Learners will be expected to identify the required data needed from the customer's instructions, such as service/technical data, legal requirements and customer records.

For 1A.2, learners need to identify from supplied data the maintenance procedures for a given vehicle.

During the selection process for 2B.P3, learners will come across certain equipment, components or materials that will not be needed, but should be documented to keep an audit trail. A visit to a 'live' establishment would be beneficial to develop opportunities for learners or for the actual assessment, with pre-set outcomes developed beforehand. This would also stretch learners for 2B.M3, enabling them to make comparisons that include cost, performance and guarantees and a justification for 2B.D2.

For learning aim B at level 1, learners are expected to identify the equipment, components and materials for a given maintenance procedure, which is based on a scenario from a customer. It is expected that this will include filters, lubricants and other periodicals such as spark plugs or belts if applicable.

For learning aim C at level 2, learners must cover all five vehicle areas set out in Topic C.3 when carrying out maintenance requirements, but are not expected to cover all of the elements within those areas. This is because there is such a wide variation in types of vehicles, e.g. hybrid, petrol or diesel.

For 2C.P4, there is a requirement for adjustments and replacements. The adjustment could be belt tension (engine) and hand brake (chassis) with replacements in the same or different area, such as a steering component (chassis) and hub bearing (transmission).

It is essential to consider individual circumstances when planning 1C.4/2C.P4 as this is not a shared activity. This could affect resources, time management and issues connected with the number of individuals. At level 1, it is acceptable for learners to complete a basic/initial service that does not cover all five areas set out in Topic C.3.

This may be the first opportunity for learners to work independently and it is paramount during assessment that health and safety is closely monitored, with hazards fully risk assessed prior to assessment. It is also expected that the vehicles being worked on actually require maintenance, with problems such as brakes in need of adjustment, bulbs not working, belt tension issues and leaks of some description.

For 2C.P5, learners must complete all records and give feedback to the customer on all five areas, either in writing or in an audio recording. This is a good opportunity to attain evidence for 2C.M4 by explaining the reasons to the customer in terms of safety, reliability and performance. For 2C.D3, learners must also justify the cost of the replacement components.

Using the same scenarios for assessments would be practical and effective to assess 1C.5 when completing basic records. These records could be in the format of standard printed service sheets with spaces for ticking completion and writing comments. Learners only need to cover three of the five areas listed in the Unit content.

If a learner is employed or has a suitable work placement where the evidence for these activities can be gathered this would be very appropriate. The evidence would be acceptable if suitably aligned to an audit trail demonstrating that the work is authentic.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 2A.P1, 1A.2, 2A.P2, 1B.3, 2B.P3, 2A.M1, 2A.M2, 2B.M3, 2A.D1, 2B.D2	Preparing to Complete a Practical Activity	In preparation for a maintenance activity in the workshop, gather all the necessary information and data for maintenance procedures. For the customer you will need to describe the identified maintenance procedures and the data and information you have used. You will be provided with customer instructions and expectations. For the vehicle you are to work on, you must also book the equipment you need and order the materials and parts required, setting a date to do the activity.	Written task sheets/logbook/diary of the collated data, information and procedures. This could be a mini portfolio with annotations and references. Alternatively this could be in the form of a mini presentation with laminated sheets for reuse in the workshop.
1C.4, 2C.P4, 1C.5 2C.P5, 2C.M4, 2C.D3	A Day in the Life of a Trainee	The customer instructions have been provided and you are now to work in the garage to complete a basic service activity as you planned during the first assignment. Complete all records as directed, seeking approval before making any necessary adjustments or replacements. Upon completion of the service, you are challenged to explain the reasons for the identified adjustments and replacements and to justify the more expensive oil and components that could be used.	Learner records validated by signed observation records or witness testimonies. The feedback, explanations and justifications to the customer could be evidenced in writing or in audio format, properly documented and referenced, clearly showing the assessment decisions made by the assessor.

Unit 31: Production Planning for Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how a car, with all its parts, systems and sub-systems, can be manufactured so quickly, with such precision and quality? Think about the number of operations required to manufacture and assemble a laptop computer. Who decides the resource requirements for the production of bottled water? These are all questions that can only be answered if the production engineer has the correct knowledge and experience of production planning.

Planning is a necessary function for any organisation that manufactures products. This unit aims to give you a broad knowledge and experience of production planning. Within engineering this process is often very complex, whether because of the number of parts involved, the rate of change of a process or the occurrence of unplanned events. Effective production planning is essential in ensuring that activities and resources are co-ordinated over time to achieve targets or goals with as little resource consumption as possible, and without compromising on product quality.

Learning aim A will enable you to appreciate the fundamental requirements of selecting appropriate manufacturing processes, considering features such as scales of production and types of equipment used. It will develop your confidence in understanding the factors that affect the selection of appropriate processes for manufacturing organisations.

Learning aim B will give you an understanding of a product specification and a production plan and some of the information generated from them. This knowledge will enable you to use a product specification to identify materials and components for manufacture and a range of other resources and to prepare an outline production plan. At this point, it is important that you are able to interpret drawings to a level of competence to allow planning requirements to be clearly identified.

Learning aims

In this unit you will:

A know about scales of production and the processes and types of equipment used in manufacturing organisations

B be able to produce a production plan and product specification and prepare related information.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about scales of production and the processes and types of equipment used in manufacturing organisations
Topic A.1: Scales of production Features of the scales of production when manufacturing products: ● jobbing/one-off – features, e.g. tend to be one-off, made to order, wide range of general purpose equipment, skilled personnel, wide spectrum of jobs, inevitable changes/modifications, usually high costs involved; typical products, e.g. handmade jewellery, road bridge, prototype products, unique building structures, public sculptures ● batch – features, e.g. orders repeated regularly or irregularly over time, flexibility in the production process, ability to switch between products with relative ease; typical products, e.g. standard bearings, ceramic tiles, car exhaust pipes, tyres ● mass – features, e.g. dedicated machines for each product, repeated production of same product, different production lines for different products; typical products, e.g. family car, televisions, DVD players, cutlery, injection-moulded medical components ● continuous – features, e.g. relatively low cost per unit of manufactured products, continuous production without interval; typical products, e.g. oil, machine screws, paper clips and plastic sheet material. **Topic A.2: Manufacturing processes** Range of manufacturing processes, including: ● representation by block diagram ● key stages of production, including: o material and component preparation o material processing o product assembly and finishing o packaging and dispatch. **Topic A.3: Types of equipment** Types of equipment used in industry, including: ● special dedicated, e.g. jig, fixture, mechanical lifting devices ● general purpose, e.g. lathe, mill, drilling machine, grinder ● computerised, e.g. CNC, CAM, conveyor systems ● automated, e.g. pick and place unit, robot, ROVs, PLCs.

What needs to be learnt
Learning aim B: Be able to produce a production plan and product specification and prepare related information
Topic B.1: Production plans Features, modifications and applications of outline production plans, including: ● details required for an engineering activity: o sequence of activities/processes o drawings and specifications needed o raw and consumable materials to be used o bought in components needed o tools and equipment needed o speeds and feeds o quality and inspection needs o health and safety precautions o environmental or legislative requirements. **Topic B.2: Product specification** Features of a product specification, including: ● information required for product manufacture: o production drawings o production quantities and delivery rates o quality specifications o parts and materials to be used o processing methods specified in the design. **Topic B.3: Related data and information** Features, modifications and applications when using related data and information: ● calculation of processing time ● cost of plant and labour ● cost of materials and components.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about scales of production and the processes and types of equipment used in manufacturing organisations			
1A.1 State a feature and application of the different scales of production that are found in manufacturing organisations.	2A.P1 Describe the different scales of production that are found in manufacturing organisations.		
1A.2 Identify the key stages of production that are found in manufacturing organisations.	2A.P2 Describe, using a block diagram, the key stages of production that are found in manufacturing organisations.	2A.M1 Explain, using a block diagram, the key stages of production for a given product.	
1A.3 Identify a use for one type of equipment found in manufacturing organisations.	2A.P3 Describe a use for each of the different types of equipment found in manufacturing organisations.	2A.M2 Explain how different types of equipment relate to the different scales of production in manufacturing organisations.	2A.D1 Justify the use of different scales of production for a range of given products.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim B: Be able to produce a production plan and product specification and prepare related information			
1B.4 Identify production details required for a production plan from a given specification and the information required for product manufacture.	2B.P4 Produce an outline production plan from a given specification where only a small quantity is required. #	2B.M3 Modify an outline production plan for a given product specification where production quantities have increased. #	2B.D2 Justify an outline production plan for a manufactured product given its product specification.
1B.5 Identify an example of the use of related data and information.	2B.P5 Prepare related data and information to support an outline production plan.	2B.M4 Calculate the additional processing times, plant, labour, materials and component costs as a result of production plan modifications. *	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit include access to a range of production plans, product specifications, data handbooks and manufacturers' information manuals.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

It is important that the assessment strategies used suit the needs of learners and the local environment. Good assessment strategies are most likely to be supported by proper presentation of appropriate evidence. The portfolio should not contain course notes, research etc, unless it is to become part of the required evidence and assessment.

Criteria for learning aim A at level 2 can be assessed in a single assignment with a variety of tasks. Evidence of learners' knowledge of scales of production, processes and types of equipment used in an organisation can be in the form of a range of statements, descriptions and a well-presented block diagram. It is expected that learners working at Merit level will extend this range of evidence when explaining how different types of equipment might relate to the different scales of production and will also apply the block diagram of the key stages to a particular product. For a Distinction, learners need to justify the use of different scales of production for a range of given products, which should include one from each scale of production.

For learning aim A at level 1, learners are asked to state a feature and application of the different scales of production identified in the unit content. They must also identify the key stages of production, which should include material and component preparation, materials processing, product assembly and finishing, and finally packaging and dispatch. Learners at this level will also need to identify a use for one type of equipment.

For learning aim B, a typical scenario could be based around a prototype product produced by jobbing that needs to go into production to meet a customer's needs for a delivery in batches scheduled over a period of time. There needs to be enough scope in the scenario to alter a range of aspects of the outline production plan. Although the range must be appropriate to the product under consideration, it is expected that some processes, tools and equipment and speeds and feeds could be amended.

The level 2 criteria for learning aim B lend themselves to being assessed in a single assignment with a variety of tasks. Working to produce an outline production plan from a given product specification would be a suitable assignment. The given specification should have materials and parts lists to enable learners to calculate processing times, plant, labour, materials and component costs. The product specification needs to have scope to increase the quantities produced. This will depend on the type of product that centres are considering for use in the delivery of this unit. To achieve Merit, learners are expected to demonstrate greater knowledge and understanding by modifying an existing outline production plan to meet greater product demand and also by determining the extra times and costs involved. To achieve Distinction, learners must justify the use of the outline production plan, making full reference to the product specification.

For learning aim B at level 1, learners must identify production details required for a production plan to include activity sequences, drawings, specifications, tools and equipment, speeds and feeds, quality requirements and health and safety precautions. Learners must also identify the information required for product manufacture such as material requirements (raw, consumable and bought in components), production quantities, delivery rates and processing methods specific to the design. Learners must identify methods of calculating a range of production and processing costs.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.M2, 2A.D1	Scales of Production, Processes and Types of Equipment	You are due to work in a production planning department and your supervisor has asked you to investigate the different scales of production and how they relate to the manufacturing processes and equipment.	A written report, including a description of the different scales of production and the key stages involved, the use of different types of equipment, the relationship to scales of production, and a justification of this use for a given product.
1B.4, 1B.5, 2B.P4, 2B.P5, 2B.M3, 2B.M4, 2B.D2	Production Plans and Product Specifications	Your supervisor now needs you to produce an outline production plan using one of the company's product specifications and prepare related information. He is also expecting the quantity of the product required to be changed so will also ask you to modify the plan and other related data and information.	An outline production plan and a modified outline production plan for a given product. A written report showing the original and modified related data and information. A written report to justify the outline production plan.

Unit 32: Engineering Marking Out

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how engineered components for the Bloodhound supersonic car are made with such precision and minimum waste? This is a result of precise marking-out procedures. The manufacture of a product normally starts from raw materials that have to be formed and shaped into the component parts. In this unit you will gain the knowledge and skills needed to measure and mark out components in preparation for machining operations. This first step in the manufacture or development of a product is critical to all the processes that follow.

The unit will give you an opportunity to consider how to care for and use measuring and marking-out equipment. It also introduces work planning skills needed to enable you to carry out a range of marking-out exercises, including the selection of appropriate measuring, marking-out and work-holding equipment. You will work with square, rectangular, circular and irregular-shaped workpieces.

An important aspect of this unit is the consideration of safe working practices in the engineering workplace.

Learning aims

In this unit you will:

A know about marking-out methods and equipment for different applications

B be able to mark out engineering workpieces to specification using safe working practices.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about marking-out methods and equipment for different applications
Topic A.1: Measuring and marking-out methods and equipment Know about: ● measuring and marking-out methods: datum faces, reference points to be used ● equipment required: tooling, e.g. engineer’s rule, scriber, centre punch, dividers, odd-leg calipers, engineer’s square, scribing block, vernier protractor, vernier height gauge, dial test indicators, slip gauges; work-holding devices, e.g. surface tables/plates, angle plates, vee-blocks, clamps; marking-out mediums, e.g. marking blue, lacquer, whitewash ● the importance of calibration: measuring equipment, marking-out equipment. **Topic A.2: Marking out applications** Identify a range of applications when marking out workpieces, including: ● square/rectangular: bar stock, sheet material ● circular/cylindrical: bar stock, tubes, turned components, flat discs ● irregular shapes: castings, forgings, odd-shaped components.
Learning aim B: Be able to mark out engineering workpieces to specification using safe working practices
Topic B.1: Marking out Demonstrate how to prepare for a range of marking-out activities: ● work plan: reading engineering drawings/job instructions, planning the sequence of marking out operations, identifying materials and equipment required. Carry out marking-out activities: ● preparation of workpiece: checking for visual defects, removing burrs, component cleaning ● setting and positioning workpieces: e.g. using squares, dial test indicators, slip gauges, packing pieces, jacks ● marking out to a planned sequence of operations: datum and centre lines; features, e.g. square/rectangular profiles, angle/angular profiles, circles, linear hole positions, pattern developments (cones and pyramids). **Topic B.2: Safe working practices** Use a range of safe working practices when marking out material: ● personal protection and hygiene procedures: overalls, eye protection, barrier creams ● safe working environment: safe use of tools, cleaning of equipment, disposal of waste, storage of marking and measuring equipment.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about marking-out methods and equipment for different applications			
1A.1 Select a suitable measuring and marking-out method and equipment for one application.	2A.P1 Select suitable measuring and marking-out methods and equipment for three different applications.	2A.M1 Explain the importance of calibrating measuring and marking-out equipment.	2A.D1 Justify the choices of datum faces, work-holding devices and measurement and marking-out methods used to mark out the three different applications.
1A.2 Describe the measuring and marking-out equipment used for one application.	2A.P2 Describe the measuring and marking-out equipment used for three different applications.		
Learning aim B: Be able to mark out engineering workpieces to specification using safe working practices			
1B.3 Prepare a work plan for marking out one application.	2B.P3 Prepare a work plan for marking-out three different applications.	2B.M2 Explain the importance of setting and positioning workpieces correctly before carrying out a marking-out activity.	2B.D2 Analyse the content of a work plan and make recommendations for improvement.
1B.4 Prepare, set and position a workpiece, and mark out features to a work plan and sequence of operations using safe working practices. *	2B.P4 Prepare, set and position three different workpieces, and mark out features to work plans and sequences of operations using safe working practices. *		

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a workshop environment and the range of tools required to mark out and measure engineering components (essential)
- a range of workpiece materials, components and drawings to enable the learner to gain a range of experience in line with the coverage expected.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Much of the assessment evidence for this unit could come from practical activities. These can be carried out solely for the purpose of this unit but, equally, the activities could be associated with other units. It may be possible to integrate the work of this unit with other units in the qualification or to use work-based assessment evidence.

To achieve learning aim A at level 2, learners must select suitable measuring and marking-out methods and equipment for three different applications when marking out workpieces – square/rectangular, circular/cylindrical and irregular shapes. Learners should then describe the measuring and marking-out equipment to be used for these three applications. For 2A.M1, learners need to explain the importance of calibrating measuring and marking-out methods and equipment. For 2A.D1, they must justify the choices of datum faces, work-holding equipment and measurement and marking-out methods.

For learning aim A at level 1, learners only need to be concerned with one marking-out application. Evidence is likely to be a mixture of written responses for the descriptions and either an observation record of the selection of methods or some form of learner annotation on drawings or photographs.

To achieve learning aim B at level 2, learners must prepare a work plan for marking out each of the three different applications and mark them out using the prepared work plan. The measuring and marking-out activities for the three different applications must include square/rectangular, circular/cylindrical and irregular shapes (note that square/rectangular means either a square or rectangular application). For example, marking out a piece of sheet metal for an inspection cut-out and inspection cover location holes, marking out a circular shaft that needs to be drilled through its diameter and marking out a casting for holes to be drilled and tapped to receive a flange.

Careful choice of components ensures full coverage of the learning aim, all the criteria and the unit content with just these three applications. The choice of the three different applications should also provide for the widest possible coverage of the examples in the unit content. That is, the range of work-holding devices required for the three applications may include for task 1 – the use of a surface plate only; task 2 – surface plate, vee-block and clamps; and task 3 – surface table, angle plate and clamps or other variations applicable to the task. This should also be applied to the measuring and marking-out equipment. Likewise, if sheet metal is chosen for the square/rectangular application, then bar stock should be used for the circular/cylindrical application.
It would not be acceptable or sufficient to carry out three very similar tasks with similar marking out requirements and similar equipment demands. For each of these tasks to be completed satisfactorily learners must demonstrate safe working practices at all times.

For 2B.M2, learners need to explain the importance of setting and positioning workpieces correctly. For 2B.D2, they must analyse the content of a work plan and make recommendations for improvement. For learners to be able to suggest recommendations for improvements to a work plan it may be necessary to give them a plan with some flaws.

For learning aim B, level 1 learners only need to be concerned with one marking-out application.

This learning aim is all about practical application and therefore demands evidence that is process based. Typically, observation records will need to be supplemented by annotated photographs and the prepared work plan. Some written evidence will be expected against the higher grading criteria.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment method
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Marking Out Methods and Equipment	Your manager has asked you to prepare a work plan and investigate suitable measuring and marking-out methods and equipment. This is to include why it is important to calibrate measuring and marking-out equipment, and the choices of datum faces, work-holding equipment and measurement and marking-out methods used.	Written responses.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.D2	Engineering Marking Out	Your manager has asked you to carry out marking-out activities for three different applications including square/rectangular, circular/cylindrical and irregular shapes. You also need to investigate the importance of setting and positioning workpieces correctly, and the content of a work plan, and then make recommendations for improvement.	Practical assessment. Ideally, the evidence would be gathered naturally during work with three applications and would be captured through tutor observation records and supporting photos.

Unit 33: Preparing and Controlling Engineering Manufacturing Operations

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **30**

Assessment type: **Internal**

Unit introduction

Have you ever considered why it is important that engineering workshops are set up so that the manufacturing of products is carried out effectively and safely? Engineering businesses have to be very competitive on price and quality of product and to do this requires very efficient operation of the workplace. Customers are always looking for the best value for money. Think about something you bought recently and what factors influenced your choice.

In this unit you will start by investigating how to prepare a work area so that efficient manufacturing of a product can take place. This will involve thinking about what raw materials, tools and equipment are needed and also how the various manufacturing operations can be carried out safely and efficiently. This means following procedures, such as job instructions, and reporting back to a responsible person, such as your teacher, or in the workplace, your supervisor.

Once manufacturing has started it is important for you to understand how to monitor what is going on to ensure that the finished product is of the required quality and that production targets are being met.

Problems do occur when manufacturing products, for example raw materials may not be of the correct quality or cutting tools may break or go blunt. In the final part of this unit you will investigate how to identify some of these problems and think about ways of overcoming them. This requires the collection of data and making decisions based on what you have found out.

Learning aims

In this unit you will:

A be able to prepare a work area for a manufacturing operation in a safe manner according to defined procedures

B be able to control a manufacturing operation in a safe manner according to defined operating procedures.

Learning aims and unit content

What needs to be learnt
Learning aim A: Be able to prepare a work area for a manufacturing operation in a safe manner according to defined procedures
Topic A.1: Work area Preparing and maintaining an engineering work area in readiness for carrying out a manufacturing operation, including: ● procedures for the receipt and removal of materials ● procedures for the receipt and removal of tooling ● freedom from obstructions and hazards ● correct equipment and tooling layout. **Topic A.2: Procedures** Working procedures to be followed, including: ● job instructions ● equipment/tool operating instructions, e.g. machinery, process plant, tools, material handling, equipment specific to the operation ● reporting to an appropriate person, e.g. team leader, workshop supervisor, maintenance technician, quality assurance technician. **Topic A.3: Problems in preparation** Overcoming problems when preparing a work area, including: ● quality and availability of raw materials ● serviceability of equipment ● serviceability of tooling ● general condition of work area, e.g. lighting, ventilation, temperature, noise levels. **Topic A.4: Safe working** Safe operation of manufacturing operations within an engineering work area, including: ● health and safety legislation – the Health and Safety at Work Act (HASAWA) ● environmental regulation – the Workplace (Health, Safety and Welfare) Regulations (WHSWR) ● safe working practices, e.g. personal protective equipment (PPE), Manual Handling Operations, Control of Substances Hazardous to Health (COSHH).

What needs to be learnt
Learning aim B: Be able to control a manufacturing operation in a safe manner according to defined operating procedures
Topic B.1: Operating procedures Using operation procedures, including: ● job instructions ● equipment/tool operating instructions, e.g. machinery, process plant, hand-held and portable tools, material handing ● making adjustments from data. **Topic B.2: Control** Controlling the manufacturing operation, including: ● dealing with problems, e.g. variation from specification, discrepancies ● using collected data to influence decisions, e.g. making adjustments to the manufacturing operation. **Topic B.3: Manufacturing operation** Using a type of production method, e.g.: ● hand manufacturing operation ● manually operated machine tool ● automated machine tool ● combined manufacturing operation. **Topic B.4: Adjustments** Reviewing the manufacturing operation by identifying problems and making adjustments, including: ● process effectiveness, e.g. operational sequence, production time ● process characteristics, e.g. quality, accuracy of the finished product ● material utilisation, e.g. raw materials, consumables ● operational safety. **Topic B.5: Data** Collecting data about the manufacturing operation, including: ● quality of finished product, e.g. dimensional accuracy, surface finish, conformity to specification ● effective use of raw materials ● use of consumables, e.g. cutting tools, lubricants, cleaning fluids ● condition of machinery/equipment/tools ● meeting production targets. **Topic B.6: Operating in a safe manner** Operating safely in an engineering work area, including: ● adhering to health and safety legislation – the Health and Safety at Work Act (HASAWA) ● adhering to environmental regulation – the Workplace (Health, Safety and Welfare) Regulations (WHSWR) ● using safe working practices, e.g. personal protective equipment (PPE), Manual Handling Operations, Control of Substances Hazardous to Health (COSHH).

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Be able to prepare a work area for a manufacturing operation in a safe manner according to defined procedures			
1A.1 Safely prepare a work area.	2A.P1 Safely prepare a work area in readiness for carrying out a manufacturing operation.		
1A.2 Safely follow a given procedure and identify problems when preparing a work area.	2A.P2 Safely prepare a work area, following given procedures and overcoming problems.	2A.M1 Explain why following the correct procedures promotes a safe working environment.	2A.D1 Evaluate the importance of keeping a well-maintained work area.
Learning aim B: Be able to control a manufacturing operation in a safe manner according to defined operating procedures			
1B.3 Identify the operating procedures to control a manufacturing operation in a safe manner and make adjustments to overcome given problems.	2B.P3 Use operating procedures to control a manufacturing operation in a safe manner by identifying problems and making adjustments.	2B.M2 Justify the adjustments made to a manufacturing operation as problems are identified.	
1B.4 Identify the data needed to assess the condition of a manufacturing operation.	2B.P4 Assess the condition of a manufacturing operation using collected data.	2B.M3 Describe how the collection of data can help control a manufacturing operation.	2B.D2 Explain the importance of keeping good control over a manufacturing operation.

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources needed for this unit are:

- access to a workshop environment where manufacturing operations take place.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

The assessor must carefully monitor the practical activities specified in this unit. It is important that when designing assignment briefs, the assessor makes it quite clear to learners that they must follow specified safety procedures to minimise risk to themselves and others. Evidence for the Merit and Distinction criteria must not include any descriptive text that has been copied and pasted from the web. Learner evidence relating to practical activities should include annotated photographs and assessor signed observation records.

For 2A.P1, the learner must prepare a work area for the effective manufacturing of a product. They are not required to carry out the manufacturing operation but it will add interest if they do this by possibly linking with *Unit 7: Machining Techniques* (as an example). To achieve this criterion learners do not have to follow a prescribed procedure when preparing the work area. They can decide on how to do it and provided that they meet the content requirements of unit topics A.1 and A.2, and demonstrate safe working practices, the criterion can be awarded.

For 2A.P2, learners must follow given procedures and deal with problems as they occur. When preparing the assignment brief thought should be given to 'designing in' easily identifiable problems, which can be resolved in a straightforward manner.

For 2A.M1 and 2A.D1, learners are expected to consider in more generic terms why following correct procedures and keeping well-maintained work areas are beneficial to effective production and safe working. They may wish to reflect on what they have done for the Pass criteria. What is not acceptable is a simple review of what they did and how they might improve their actions next time around.

At level 1, learners need only make very basic statements when identifying procedures and data.

For 1A.1, learners will prepare their work area in a simplistic manner. Intervention may be required to complete the preparation, thereby ensuring health and safety compliance, before the manufacturing operation can begin. For 1A.2, they should be given a procedure to follow. This could be presented as a simple checklist, which they sign off. It is only necessary for learners to identify problems with the manufacturing operation.

The focus of learning aim B is the control of a manufacturing operation. As there is no particular requirement for learners to carry out the manufacturing themselves, their assessment evidence could be based on how they controlled a manufacturing operation being undertaken by another person (or persons).

For 2B.P3, learners should be given an operating procedure for the manufacturing operation they are going to control. What they have to do is effectively control what happens as production takes place. This criterion addresses the unit content listed in topics B.1, B.2, B.3 and B.4.

For 2B.P4, learners will collect data about the manufacturing operation and from their findings draw conclusions, e.g. is there dimensional conformity for components coming off a CNC lathe? If dimensional conformity has not been achieved then there is a problem with the machine and its settings must be adjusted or cutting tools replaced. Learners should be advised that it is not just machining problems that must be identified. The unit is about the complete process of manufacturing: raw materials, consumables, machinery, production targets etc. This provides scope for gathering a range of data. Although evidence could be presented from a separate activity about collecting data and assessing conditions, for this criterion it is recommended that a holistic activity is set to enable learners to address both 2B.P3 and 2B.P4.

2B.M2 can be linked to 2B.P3. Having identified problems and made adjustments, the actions should now be justified, for example explaining why a particular course of action was chosen in preference to another.

For 2B.M3 and 2B.D2, learners should consider in a more generic way why the collection of data and keeping good control of a manufacturing operation are important factors. They will be basing some of their evidence on what they have been doing for the Pass criteria but they will need to consider the bigger picture. Evidence for these two criteria could be usefully sourced from a visit to a local engineering company.

For 1B.3, learners are only required to identify operating procedures and to make adjustments to parameters which are given to them, for example changing the sequence of machining operations so that the product can be made more efficiently.

For 1B.4, learners are only required to identify data requirements.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.D1	Preparing the Work Area	You look after production control for a small, sub-contract engineering company. The workshop has four CNC lathes and two small machining centres. An order comes in for a batch of 5000 components, to be machined from aluminium and in a very short timeframe. You must organise the work area.	To meet the Pass criteria evidence of practical demonstration is required e.g. observation records, annotated photographs, checklists, notes. To meet the Merit and Distinction criteria a written report should be presented.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M2, 2B.M3, 2B.D2	Controlling Manufacturing Operations	Production of the 5000 components has started alongside other jobs going through the workshop. You must make sure that all the components coming off the machines are correctly manufactured and that completion targets are being met.	To meet the Pass criteria evidence of practical demonstration is required e.g. observation records, annotated photographs, checklists, notes. Evidence of the data collected along with annotated job and tooling/equipment operating instructions. To meet the Merit and Distinction criteria a written report should be presented.

Unit 34: PC Software and Hardware in Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered how your PC (personal computer) is able to perform so many complex functions and yet how easily problems can occur when doing simple tasks? These are the concerns of the computer engineer who has an advanced knowledge of all the hardware within the system, and who can carry out tests to diagnose faults or problems. The PC is a complex system at first glance, with all its different components and parts. It is also modular in construction to allow for upgrading of hardware, component failures and installation of new devices, thus prolonging the computer's life. The hardware and software must work in harmony to operate efficiently.

This unit will give you the knowledge and skills needed to install, configure and test computer hardware and software and assemble a complete PC system. Learning aim A will give you the opportunity to discover the basic operation of a standard PC system, including a range of input and output devices and their main features. Learning aim B will give you the opportunity to delve deeper into the PC and look at the various standard hardware components that make up a complete system, such as system power supply, motherboards, microprocessors and memory types. You will also develop the knowledge and skills to install and configure such hardware. Finally, for Learning aim C you will learn how to install operating systems and standard software packages. You will also learn how to commission, configure and test these systems to meet customer requirements.

Learning aims

In this unit you will:

A know the basic operation of standard PC systems

B be able to safely install and configure standard PC hardware components

C be able to safely install standard software packages and operating systems, configure and test complete PC systems.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know the basic operation of standard PC systems
Topic A.1: Basic operations of a PC system Features and operation of PC systems, advantages/disadvantages of coding systems, including: ● block diagram to identify the main system components, e.g. input/output, central processing unit (CPU), arithmetic logic unit (ALU), control unit, storage, bus system, system clock ● analogue and digital signals ● binary system ● coding of American standard code for information interchange (ASCII) ● UNICODE ● system unit, e.g. types, cooling system, power supply. **Topic A.2: Input devices** Features and applications of a range of input devices, including: ● image processing, e.g. digital cameras, wand scanner, flatbed scanners, video camera ● hand devices, e.g. keyboards, touchscreens, mouse, joystick, trackball, digitiser tablet and crosshair, touchpad, microphones, sensing devices. **Topic A.3: Output devices** Features and applications of a range of output devices, including: ● monitors, e.g. flatscreen, touchscreen, tablets, projectors ● printers, e.g. bi-directional, impact, character, dot matrix, inkjet, laser, thermal, graph plotter ● sound systems ● storage devices, e.g. memory sticks, portable hard drives, virtual storage (Dropbox and iCloud) ● modems.

What needs to be learnt
Learning aim B: Be able to safely install and configure standard PC hardware components
Topic B.1: Hardware components – motherboards Knowing about formats, e.g. pico ITX, mini ITX, micro ATX, ATX, extended ATX, NLX; industry standard architecture (ISA). Features and operation, applications, advantages/disadvantages of components, including: ● power supply types ● voltage regulator, e.g. linear, switched ● peripheral component interconnection (PCI) ● memory slots ● onboard adapters. **Topic B.2: Hardware components – microprocessors** Features and operation, applications, advantages/disadvantages of components, including: ● microprocessor types, e.g. Dual core, Quad core, Pentium 4, Celeron, Centrino, AMD-Sempron, Core i7, AMD-Ryzen ● CPU, e.g. sockets, cooling systems, processor speed, over-clocking. **Topic B.3: Hardware components – memory types** Knowing about defragmentation. Features and operation, applications, advantages/disadvantages of components including: ● volatile ● permanent ● hard disk, e.g. tracks, sectors and clusters, virtual file allocation table (VFAT) ● cache ● semiconductor, e.g. random access memory (RAM), DRAM (EDO, SDRAM), ROM, PRAM, EPROM, EEPROM (flash PROM) ● chip types, e.g. single and dual in-line memory module (SIMM/DIMM) ● optical laser discs, e.g. CD, CD ROM, CD-R, CD-RW, DVD, DVD-ROM, DVD-R, DVD RAM, DVD+RW, DVD-RW, FMD-ROM, Blu-ray ● external, e.g. universal serial bus (USB) flash memory, tape backups (quarter-inch cartridge, digital audio tape (DAT)). **Topic B.4: Hardware components – display systems** Knowing about monitor size, resolution, refresher rate, standards, health and safety requirements. Features and operation, applications, advantages/disadvantages of components, including: ● liquid crystal display (LCD) projectors ● thin film transistor liquid crystal display (TFT-LCD) ● graphic adapters ● power supply. *continued*

What needs to be learnt
Topic B.5: Hardware components – standard interfaces and bus systems Features and operation, applications, advantages/disadvantages of components, including: ● internal, e.g. industry standard architecture (ISA), extended ISA (EISA), local bus peripheral component interconnection (PCI), video electronic standards association (VESA) ● external, e.g. serial and parallel ports (computer output on microfilm (COM) and line printer terminal (LPT)), small computer systems interface (SCSI), universal serial bus (USB) ● video ● mouse and keyboard connectors.
Topic B.6: Hardware components – power supply units Knowing about voltage levels, regulation, noise levels, cooling, requirements, dust considerations. Features and operation, applications, advantages/disadvantages of components, including: ● ATX power supply ● ATX12 power supply.
Topic B.7: Representing hardware components Diagrammatic representation of the system: ● block diagrams.
Topic B.8: Install and configure hardware Be able to install and configure hardware, including: ● Internal, e.g. system power supply, hard disk, RAM, adaptor adapter ● cards, hard drives, sound cards, graphic cards ● Peripherals, e.g. printers, scanners, cameras, monitors, keyboard, mouse ● configure for system ● interrupt request (IRQ) considerations ● use safe working practices, e.g. manual handling/lifting, general electrical mains safety, electrostatic strap, loose clothing, tidy work area.

What needs to be learnt
Learning aim C: Be able to safely install standard software packages and operating systems, configure and test complete PC systems
Topic C.1: Install and set up software applications Installing and configuring applications, including: ● software applications, e.g. word processing, spreadsheet, databases, CAD/CAM, desktop publishing, process control, mathematical and scientific software ● features, e.g. utilities, testing, virus protection, device drivers, applications, file system structure, file types ● installation, e.g. standard, custom ● copyright and licensing considerations ● setting operating characteristics ● uninstall. **Topic C.2: Install and set up an operating system** Planning, installing operating systems, features, advantages/disadvantages of set-up options, including: ● types, e.g. disk operating system (DOS), Windows family, UNIX, network operating system (NOS) ● OS types and relationships ● operating system, e.g. install, upgrade ● basic input/output system/complementary metal oxide semiconductor (BIOS/CMOS) set-up ● bootstrap and startup/shutdown procedures ● recovery procedures. **Topic C.3: Assemble, configure and test PCs to requirements** ● using pre-defined specifications, e.g. customer requirements ● testing hardware components ● operating conditions, e.g. determine, set up optimum ● documentation, e.g. system, configuration procedures ● safe working practices, e.g. manual handling/lifting, general electrical mains safety, electrostatic strap, loose clothing, tidy work area.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know the basic operation of standard PC systems			
1A.1 Identify the basic operation of a PC system.	2A.P1 Describe the features and basic operation of a PC system.	2A.M1 Compare the range of coding systems used for a range of PCs.	
1A.2 Identify input and output devices to meet a given need.	2A.P2 Describe input and output devices to meet two different given needs.	2A.M2 Explain the advantages and disadvantages of different devices to meet two different given applications.	2A.D1 Justify the appropriate use of input and output devices for given applications.
Learning aim B: Be able to safely install and configure standard PC hardware components			
1B.3 Create a block diagram, identifying the main components found in a PC system.	2B.P3 Describe, with the aid of a block diagram, the main hardware components found in a PC system.	2B.M3 Compare the features and operation of different standard bus systems, interfaces and their connectors.	2B.D2 Justify hardware, software and peripheral requirements for a PC system to meet user requirements.
1B.4 Carry out an installation and configuration of a given peripheral hardware component, using safe working practices.	2B.P4 Carry out an installation and configuration of three hardware components, including at least one peripheral and one internal hardware device, using safe working practices.		

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Be able to safely install standard software packages and operating systems, configure and test complete PC systems			
1C.5 Safely install and configure one given software application.	2C.P5 Safely install and configure two different software applications, customising one of them.		
1C.6 Safely install an operating system.	2C.P6 Safely install an operating system and confirm hardware is functioning correctly.	2C.M4 Plan and safely carry out the installation of an operating system selecting appropriate options during the set-up to meet operating requirements.	2C.D3 Evaluate the various set-up options for a PC system.
1C.7 Test a range of hardware components for a PC system using safe working practices. *	2C.P7 Assemble, configure and test a PC to a given specification using safe working practices. *	2C.M5 Design documentation for system details, configuration procedures and test results.	

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a workshop environment and the range of tools required to assemble and maintain PCs (essential)
- a range of PCs, components and documentation (as required).

Assessment guidance

This unit is assessed internally by the centre, and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

An important aspect of this unit is the consideration of safe working practices in a computer test laboratory or workshop, delivered, where possible, in a practical context.

Summative assessment will be carried out on an individual basis, but, during teaching, the sharing of tools, equipment and group work is acceptable. The making of a complete computer-based system, with its various types of units, cables, hardware components, peripherals and software configuration, should make for an enjoyable and rewarding learning experience.

A proportion of the summative assessment for this unit will be through teacher observation and questioning. Learners should provide supporting evidence such as a logbook record of installation and/or software configuration carried out. The log could contain a description of the task, the instructions provided (annotated to record progress or difficulties), a list of tools/equipment provided and their condition, photographs that have been annotated to explain procedures and problems encountered etc. Such supporting activity evidence would then validate the teacher or witness observation/ oral questioning records and vice versa.

Learning aim A at level 2 provides an introduction to PC systems. 2A.P1 and 2A.P2 could be assessed using a written task, allowing for the exploration of a range of computers, system components, input and output devices and PC hardware features.

For 2A.M1, learners need to understand the different codes used when programming PC systems, but not necessarily be able to write coded information. For 2A.M2 and 2A.D1, learners need to build on their knowledge and understanding of input and output devices and include within their evidence a written report on the suitability of such devices for at least two different activities.

Learning aim B requires a more practical approach to produce evidence for 2B.P3 and 2B.P4. This may be best achieved through teacher observation and subsequent questioning of underpinning knowledge. Learners will have the opportunity to physically handle hardware components, in a safe manner, and install a range of these components within a PC system.

For 2B.M3, learners will need to build on their knowledge of hardware components gained through practical activities carried out for 2B.P3 and 2B.P4. Evidence of the comparison of the features and operation of different standard interfaces, bus systems and their interfaces should be included. To achieve 2B.D2, learners must produce an appropriate workstation specification with reasons for hardware, software and peripheral selection against determined user requirements, perhaps supplied through a scenario.

A practical approach should be continued for Learning aim C, again with evidence through teacher observations and records of questioning within learners' logbooks to meet 2C.P5, 2C.P6 and 2C.P7. Learners will have the opportunity to install software and operating systems and configure them to meet customer requirements. Learners will also need to display safe working practices while assembling, configuring and testing a PC.

For 2C.M4, learners must demonstrate a higher order of understanding of installing and setting up software, for which witness observation records of the procedures followed when installing the operating system could provide evidence. 2C.D3 leads on from 2C.M5 in asking learners to evaluate set-up options in the wider aspects related to a PC system. Evidence could contain appropriate screenshots and supporting research material.

Level 1 learners will show evidence that they can identify the basic operation of PCs, input and output devices, and can draw a block diagram identifying the main components in a PC. They will still be able to do the practical activities of building a PC system, although the teacher may test it as a demonstration. Knowledge and understanding could be tested through summative assessment questioning whilst observing or completing activities. Learners should, however, be able to test at least three hardware components of a PC system.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 2A.P1, 2A.P2, 2A.M1, 2A.M2, 2A.D1	PC Systems	Your manager has asked you to deliver a presentation focusing on the main types of PC systems and showing the uses of a range of input and output devices.	A presentation including research gathered from magazines, journals and manufacturers' information.
1B.3, 1B.4, 2B.P3, 2B.P4, 2B.M3, 2B.D2	Hardware Installation	Your manager has also requested that you carry out the installation of hardware components for your company.	Practical assignment, supported by observation/witness statements and a written report or logbook, including a block diagram of the tasks undertaken.
1C.5, 1C.6, 1C.7, 2C.P5, 2C.P6, 2C.P7, 2C.M4, 2C.M5, 2C.D3	Software Installation and PC Assembly	The company wishes to build its own PC systems and your manager has asked you to build, install appropriate software and operating systems, and then to fully configure and test each PC.	Practical assignment, supported by observation/witness statements and a written report or logbook of the tasks undertaken.

Unit 35: Application of Quality Control and Measurement in Engineering

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

Have you ever wondered why so many complex engineering products are so reliable and work so well? Think about a modern car – it contains thousands of engineered components that have to be manufactured to fit an array of other parts and assemblies. If they didn't fit together properly, the reliability of the car would be compromised and it could result in safety issues and hugely expensive product recalls.

Engineering companies operate quality assurance programmes to ensure that all parts of their organisation work towards supplying a quality product. Quality control is an essential part of these programmes. This involves inspection at the key stages of manufacture for dimensional and geometric accuracy and for characteristics such as surface texture and roughness. Automated equipment is sometimes used but manual inspection is still essential for a great many products and engineers use a large range of measuring and comparator equipment to inspect the many features that make up an engineered component or assembly.

This unit aims to provide you with knowledge of quality and quality control in engineering. You will consider what quality is and when, how and what quality control procedures need to be carried out for simple engineered products. You will also learn about quality documentation, standards and calibration, and will be introduced to the concept of tolerance and types of fit.

The unit also aims to provide you with the knowledge and skills needed to inspect simple engineered products, using appropriate techniques and equipment, in order to be able to measure and make judgements on the accuracy of dimensional and geometric features and surface finish.

Learning aims

In this unit you will:

A know about quality and quality control in engineering

B know about dimensional tolerances and types of fit for simple components

C use quality control equipment to monitor the quality of simple engineered products.

Learning aims and unit content

What needs to be learnt
Learning aim A: Know about quality and quality control in engineering
Topic A.1: Quality Meanings for the term 'quality' in engineering, including: ● fitness for purpose ● safe to use ● meeting customer requirements ● quality standards – ISO9000. Types and impact of quality costs when manufacturing engineered products, including: ● internal failure ● external failure ● appraisal ● prevention. **Topic A.2: Quality control** Essential parameters of quality control when manufacturing engineered products, including: ● types of inspection, e.g. pre-processing, in-process, completed products ● frequency of inspection, e.g. sampling, full batch ● documentation used, e.g. statistical charts, non-compliance reports ● provision for traceability, e.g. production records, batch labelling ● calibration, e.g. instrumentation (measuring equipment, comparator equipment, gauges), standards.
Learning aim B: Know about dimensional tolerances and types of fit for simple components
Topic B.1: Tolerances and components Principles of tolerances, including: ● use of standards – BS 4500 ● hole and shaft basis system ● ISO system of limits and fits ● types of fit used in assembled components – clearance, transition, interference ● implications of non-compliance ● impact of applying types of fit. Simple components, including: ● components with both male and female parts.

What needs to be learnt
Learning aim C: Use quality control equipment to monitor the quality of simple engineered products
Topic C.1: Features to be measured or compared Component features to include: ● dimensional – length, diameter, depth, flatness, parallelism, angle ● geometrical – profiles, roundness, concentricity, accuracy of form ● surface texture/roughness. **Topic C.2: Simple engineered products and engineering drawings** Components and assembled components with their engineering drawings that are suitable for measuring and comparing for fitness for purpose: ● dimensional features, including tolerances ● geometric features ● surface texture/roughness. **Topic C.3: Using measuring equipment** As applicable to the component feature to be measured, including: ● micrometers – internal, external, depth ● steel rules ● vernier callipers ● vernier height gauge ● surface plate ● straight edge ● engineers try-square ● bevel protractors ● combination sets ● roughness comparison specimens (Rubert gauges). **Topic C.4: Using comparator equipment** As applicable to the component feature to be compared, including: ● dial test indicators – plunger type, lever type ● simple mechanical comparators – inside calliper, outside calliper ● gauges – slip gauges, length bars, radius gauges, profile templates, go and no go gauges, e.g. plug gauges, gap gauges, taper plugs, ring gauges. **Topic C.5: Simple engineered products:** ● e.g. turned shaft, connecting rod, angled pin, threaded bush, stepped milled block, drilled plate, clamp strap, bearing cover etc.

Assessment criteria

Level 1		Level 2 Pass		Level 2 Merit		Level 2 Distinction	
Learning aim A: Know about quality and quality control in engineering							
1A.1	State two meanings of the term 'quality' in engineering.	2A.P1	Describe, using examples, three meanings of the term 'quality' in engineering.				
1A.2	State, using examples, two types of quality costs when manufacturing engineered products.	2A.P2	Describe, using examples, three types of quality costs when manufacturing engineered products.	2A.M1	Explain the impact of quality costs when manufacturing engineered products.	2A.D1	Compare and contrast undesirable and constructive quality costs when manufacturing engineered products.
1A.3	State the essential parameters of quality control when manufacturing engineered products.	2A.P3	Describe the essential parameters of quality control when manufacturing engineered products.	2A.M2	Explain, using examples, the essential parameters of quality control when manufacturing engineered products.		
Learning aim B: Know about dimensional tolerances and types of fit for simple components							
1B.4	Identify the reasons for tolerances.	2B.P4	Describe, using an example, the principles of tolerances and types of fit.	2B.M3	Justify, using an example, why tolerances and types of fit are necessary.	2B.D2	Evaluate, using a different example, how tolerances and types of fit impact on component compliance.
1B.5	Identify a type of fit between assembled components from given tolerance information. *	2B.P5	Describe the three different types of fit between assembled components from given tolerance information. *				

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Use quality control equipment to monitor the quality of simple engineered products			
1C.6 Identify a type of measuring equipment and a type of comparator equipment to be used when inspecting a simple given engineered product.	2C.P6 Describe the types of measuring and comparator equipment to be used when inspecting a simple given engineered product.	2C.M4 Justify the specific types of measuring and comparator equipment to be used when inspecting a simple given engineered product.	
1C.7 Use measuring and comparator equipment to inspect the dimensional and geometric features of a simple engineered product. *	2C.P7 Use measuring and comparator equipment with accuracy to inspect the dimensional, geometric and surface texture features of three simple engineered products. *	2C.M5 Use measuring and comparator equipment to assess the compliance of three simple engineered products when referenced to their engineering drawings. *	2C.D3 Using measuring and comparator equipment, evaluate the quality of three simple engineered products with reference to their engineering drawings and fitness for purpose. *

*Opportunity to assess mathematical skills

#Opportunity to assess English skills

Teacher guidance

Resources

The special resources required for this unit are:

- access to a variety of simple engineered products with the full range of features (components and assembled components)
- access to a workshop environment and the full range of measuring and comparator equipment.

The above are essential to enable learners to complete the practical aspects of this unit as defined by the learning aims, unit content and assessment criteria, and should be available in sufficient quantities to support the cohort size undertaking the unit.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Pearson.

Please read this guidance in conjunction with *Section 8 Internal assessment*.

Evidence of the achievement of the learning aims and assessment criteria may be obtained from well-planned investigative assignments and practical activities. It is anticipated that integrative assignments may be used to link this unit with other practical units in a coherent programme (such as *Unit 7: Machining Techniques*). If this approach is adopted the evidence for the specific learning aims and associated assessment criteria will need to be clearly and separately identified. In addition, centres should consider whether to deliver the mandatory *Unit 9: Interpreting and Using Engineering Information* prior to this unit so learners can readily extract the important quality control information from engineering drawings (see Learning aim C).

For 2A.P1, centres could provide example scenarios when requiring learners to describe three meanings of the term ‘quality’ in engineering. One of these descriptions must cover fitness for purpose, and the example scenario could be a component part that is ‘over engineered’.

For 2A.P2, centres could again provide example scenarios so that learners can demonstrate their understanding of three types of quality costs. Learners should consider engineered products made in quantity rather than one-offs, and must cover both failure and prevention costs in their response. More able learners will be able to explain the impact of quality costs for 2A.M1, and compare and contrast undesirable and constructive quality costs for 2A.D1.

For 2A.P3, learners must cover all five of the essential parameters of quality control.

For 2A.M2, learners will use examples to explain the essential quality control parameters when manufacturing engineered products, such as why sampling inspection is acceptable when making large quantities of standard nuts and bolts or why full batch inspection is necessary for small quantities of bespoke components.

For Learning aim A at level 1, learners must state: two meanings of the term ‘quality’ in engineering; two types of quality costs, with examples, when manufacturing engineered products; and the essential parameters of quality control when manufacturing engineered products.

Evidence for Learning aim A could be in the form of a report or presentation.

For Learning aim B at level 2, learners should use an example when providing evidence of their knowledge of dimensional tolerances and types of fit. This example could be a simple component assembly with both male and female parts. Learners must make reference to the three different types of fit, how they relate to manufacturing tolerances and the use of standards in their response to 2B.P4. To achieve 2B.P5, they must use given information on the tolerances for mating parts to describe the three different types of fit they have referred to in 2B.P4. More able learners will use the example to justify why tolerances and types of fit are necessary, with reference to the implications of non-compliance for 2B.M3. The most able learners will use a different example to evaluate how tolerances and types of fit impact on component compliance for 2B.D2, with particular focus on both the advantages and disadvantages of applying the different types of fit.

Level 1 learners will identify the reasons for tolerances for 1B.4 and one type of fit from the tolerance information given for 1B.5.

Evidence for Learning aim B could be in the form of a report containing annotated drawings, a presentation or an information leaflet.

For the first part of Learning aim C at level 2, learners should be given a simple engineered product and an engineering drawing of the product so they can choose and describe suitable types of measuring and comparator equipment that would enable a full inspection of all the product features. This product should have a range of both dimensional and geometric features that have been produced to defined levels of accuracy, so learners have the opportunity to choose the most appropriate equipment for 2C.P6. Centres should consider providing learners with a range of appropriate engineered products from which learners choose one. More able learners will justify the different types of measuring and comparator equipment chosen for 2C.M4.

For the second part of Learning aim C at level 2, learners should be provided with a further three simple engineered products, and the engineering drawings of the products, that between them would allow learners to use the full range of measuring and comparator equipment when inspecting the full range of features to defined levels of accuracy/finish for 2C.P7. Centres should consider the strategy they use to ensure all learners are given the opportunity to do this. All the products should have non-compliance issues, some major and some minor, so the more able learners can make judgements about product compliance for 2C.M5 and quality for 2C.D3.

For Learning aim C at level 1, learners need to identify a type of measuring equipment and a type of comparator equipment to be used when inspecting a simple engineered product as provided, and use measuring and comparator equipment to inspect the dimensional and geometric features of another simple engineered product.

Evidence for Learning aim C could be in the form of a report, observation record/s, annotated photographs, diaries/logs and a quality control table.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment	Scenario	Assessment evidence
1A.1, 1A.2, 1A.3, 2A.P1, 2A.P2, 2A.P3, 2A.M1, 2A.M2, 2A.D1	Quality in Engineering	You have just started work as a quality engineer for a company that manufactures and assembles precision engineered components. The company is considering changing its whole approach to quality control and your team leader has asked you to investigate and report back on: a) the different meanings of 'quality'; b) types of quality costs; and c) the essential parameters of quality control.	A presentation with images and text that uses engineering examples to: describe meanings of the term 'quality'; describe/ compare the different types of quality costs and their impact; and explain the essential parameters of quality control when manufacturing engineered products.
1B.4, 1B.5, 2B.P4, 2B.P5, 2B.M3, 2B.D2	Tolerances and Grades of Fit	Your team leader is impressed with your 'Quality in engineering' presentation and would now like you to produce an information leaflet for the marketing department, which explains tolerances and grades of fit, so they can develop sales materials that focus on the precision nature of the components that company produces.	An information leaflet with images and text that uses engineering examples to describe/justify/evaluate: a) what tolerances and types of fit are; b) the three different types of fit; c) why they are necessary; and d) their impact on component compliance.

Criteria covered	Assignment	Scenario	Assessment evidence
1C.6, 1C.7, 2C.P6, 2C.P7, 2C.M4, 2C.M5, 2C.D3	Using Quality Control Equipment	As a quality engineer you are tasked with confirming the types of equipment to be used when inspecting the components the company produces. Your team leader needs you to continue doing this, but has also asked you to undertake some manual inspection activities as the company is temporarily understaffed on the shop floor.	A written report with images that describes/justifies types of measuring and comparator equipment that should/could be used when inspecting a simple engineered product as provided by the centre. Observation record/s, annotated photographs and diaries/logs recording practical activities when inspecting three further simple engineered products and a quality control table that: a) details product compliance when referenced to their engineering drawings; and b) evaluates the quality of each product with reference to their engineering drawings and fitness for purpose.

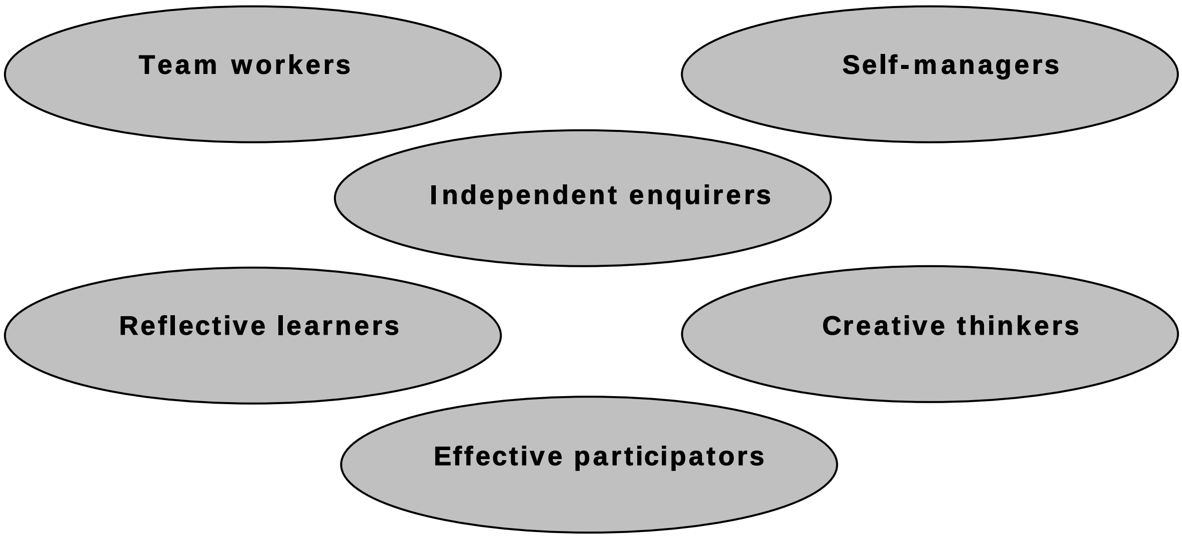
Annexe A

Personal, learning and thinking skills

A FRAMEWORK OF PERSONAL, LEARNING AND THINKING SKILLS 11–19 IN ENGLAND

The framework comprises six groups of skills that are essential to success in learning, life and work. In essence, the framework captures the essential skills of: managing self; managing relationships with others; and managing own learning, performance and work. It is these skills that will enable young people to enter work and adult life confident and capable.

The titles of the six groups of skills are set out below.



For each group, there is a focus statement that sums up the range of skills. This is followed by a set of outcome statements that is indicative of the skills, behaviours and personal qualities associated with each group.

Each group is distinctive and coherent. The groups are also interconnected. Young people are likely to encounter skills from several groups in any one learning experience. For example, an independent enquirer would set goals for their research with clear success criteria (reflective learner) and organise and manage their time and resources effectively to achieve these (self-manager). In order to acquire and develop fundamental concepts such as organising oneself, managing change, taking responsibility and perseverance, learners will need to apply skills from all six groups in a wide range of learning contexts.

The skills

Independent enquirers
Focus: Young people process and evaluate information in their investigations, planning what to do and how to go about it. They take informed and well-reasoned decisions, recognising that others have different beliefs and attitudes.
Young people: ● identify questions to answer and problems to resolve ● plan and carry out research, appreciating the consequences of decisions ● explore issues, events or problems from different perspectives ● analyse and evaluate information, judging its relevance and value ● consider the influence of circumstances, beliefs and feelings on decisions and events ● support conclusions, using reasoned arguments and evidence.

Creative thinkers
Focus: Young people think creatively by generating and exploring ideas, making original connections. They try different ways to tackle a problem, working with others to find imaginative solutions and outcomes that are of value.
Young people: ● generate ideas and explore possibilities ● ask questions to extend their thinking ● connect their own and others' ideas and experiences in inventive ways ● question their own and others' assumptions ● try out alternatives or new solutions and follow ideas through ● adapt ideas as circumstances change.

Reflective learners
Focus: Young people evaluate their strengths and limitations, setting themselves realistic goals with criteria for success. They monitor their own performance and progress, inviting feedback from others and making changes to further their learning.
Young people: ● assess themselves and others, identifying opportunities and achievements ● set goals with success criteria for their development and work ● review progress, acting on the outcomes ● invite feedback and deal positively with praise, setbacks and criticism ● evaluate experiences and learning to inform future progress ● communicate their learning in relevant ways for different audiences.

Team workers
Focus: Young people work confidently with others, adapting to different contexts and taking responsibility for their own part. They listen to and take account of different views. They form collaborative relationships, resolving issues to reach agreed outcomes.
Young people: ● collaborate with others to work towards common goals ● reach agreements, managing discussions to achieve results ● adapt behaviour to suit different roles and situations, including leadership roles ● show fairness and consideration to others ● take responsibility, showing confidence in themselves and their contribution ● provide constructive support and feedback to others.

Self-managers
Focus: Young people organise themselves, showing personal responsibility, initiative, creativity and enterprise with a commitment to learning and self-improvement. They actively embrace change, responding positively to new priorities, coping with challenges and looking for opportunities.
Young people: ● seek out challenges or new responsibilities and show flexibility when priorities change ● work towards goals, showing initiative, commitment and perseverance ● organise time and resources, prioritising actions ● anticipate, take and manage risks ● deal with competing pressures, including personal and work-related demands ● respond positively to change, seeking advice and support when needed.

Effective participators
Focus: Young people actively engage with issues that affect them and those around them. They play a full part in the life of their school, college, workplace or wider community by taking responsible action to bring improvements for others as well as themselves.
Young people: ● discuss issues of concern, seeking resolution where needed ● present a persuasive case for action ● propose practical ways forward, breaking these down into manageable steps ● identify improvements that would benefit others as well as themselves ● try to influence others, negotiating and balancing diverse views to reach workable solutions ● act as an advocate for views and beliefs that may differ from their own.

Summary of the PLTS coverage throughout the programme

This table shows where units support the development of personal, learning and thinking skills.

Key:

✓ indicates opportunities for development

a blank space indicates no opportunities for development

Unit	Personal, learning and thinking skills					
	Independent enquirers	Creative thinkers	Reflective learners	Team workers	Self-managers	Effective participators
1	✓					
2	✓	✓				✓
3	✓	✓			✓	✓
4	✓	✓			✓	
5	✓	✓				✓
6	✓	✓	✓		✓	
7	✓	✓	✓		✓	
8	✓	✓	✓		✓	
9	✓					
10	✓	✓				
11	✓	✓				
12	✓	✓	✓		✓	
13	✓	✓			✓	
14	✓					
15	✓	✓			✓	
16	✓				✓	
17	✓	✓	✓		✓	
18	✓	✓	✓		✓	
19	✓				✓	
20	✓	✓			✓	
21	✓					
22	✓	✓	✓	✓	✓	✓
23	✓	✓				✓
24	✓	✓			✓	
25	✓	✓			✓	

Unit	Personal, learning and thinking skills					
	Independent enquirers	Creative thinkers	Reflective learners	Team workers	Self-managers	Effective participators
26	✓	✓			✓	
27	✓	✓			✓	
28	✓	✓			✓	
29	✓	✓			✓	
30	✓	✓			✓	
31	✓	✓			✓	✓
32	✓	✓	✓		✓	
33	✓	✓	✓			✓
34	✓	✓				
35	✓	✓				

Annexe B

Level 2 Functional Skills

Functional Skills standards for English Level 2

Speaking, listening and communication
Make a range of contributions to discussions in a range of contexts, including those that are unfamiliar, and make effective presentations
Reading
Select, read, understand and compare texts and use them to gather information, ideas, arguments and opinions
Writing
Write a range of texts, including extended written documents, communicating information, ideas and opinions, effectively and persuasively

Functional Skills standards for mathematics Level 2

Representing
1. Understand routine and non-routine problems in familiar and unfamiliar contexts and situations 2. Identify the situation or problems and identify the mathematical methods needed to solve them 3. Select a range of mathematics to find solutions
Analysing
1. Apply a range of mathematics to find solutions 1. Use appropriate checking procedures and evaluate their effectiveness at each stage
Interpreting
2. Interpret and communicate solutions to multistage practical problems in familiar and unfamiliar contexts and situations 3. Draw conclusions and provide mathematical justifications

Functional Skills standards for ICT Level 2

Using ICT
1. Plan solutions to complex tasks by analysing the necessary stages 2. Select, interact with and use ICT systems safely and securely for a complex task in non-routine and unfamiliar contexts 3. Manage information storage to enable efficient retrieval
Finding and selecting information
1. Use appropriate search techniques to locate and select relevant information 2. Select information from a variety of sources to meet requirements of a complex task
Developing, presenting and communicating information
1. Enter, develop and refine information using appropriate software to meet requirements of a complex task 2. Use appropriate software to meet the requirements of a complex data-handling task 3. Use communications software to meet requirements of a complex task 4. Combine and present information in ways that are fit for purpose and audience 5. Evaluate the selection, use and effectiveness of ICT tools and facilities used to present information

Mapping to Level 2 Functional Skills

This table shows where a **learning aim** in a unit is of particular relevance for learners being prepared for assessment in Functional Skills in English, mathematics and/or ICT at Level 2. Centres may identify further opportunities arising in their own programmes in addition to those identified below, for example group work, research, employment-related activities and work experience.

Key: a letter, e.g. A, indicates the learning aim where there are opportunities for development; a blank space indicates no opportunities for development

Unit	English			Mathematics			ICT		
	Speaking, listening and communication	Reading	Writing	Representing	Analysing	Interpreting	Using ICT	Finding and selecting information	Developing, presenting and communicating information
1	A, B, C	A, B, C	A, B, C	N/A	N/A	N/A	A, B, C	A, B, C	A, B, C
2	B, C, D	A, B, C, D	A, B, C, D	N/A	N/A	N/A	N/A	A, B, C, D	A, B, C, D
3	A, B	A, B	A, B	N/A	N/A	N/A	N/A	A, B	A, B
4	A, B	A, B, C	A, B, C	C	C	N/A	C	A	A
5	A, B	A, B	A, B	A, B	A, B	A	A	A, B	A, B
6	A, B	A, B	A, B	N/A	N/A	N/A	A, B	A, B	A, B
7	A, B	A, B	A, B	B	B	N/A	N/A	A, B	A, B
8	A, B, C	A, B, C	A, B, C	A, D	A, D	A, D	A	A, B, C	A, B, C
9	A, B	A, B	A, B	A, B	A, B	N/A	A, B	A, B	A, B
10	N/A	N/A	N/A	A, B	A, B	A, B	N/A		
11	N/A	A, B	A, B	A, B	A, B	A, B	N/A	A, B	A,B
12	A, B, C	A, B, C	A, B, C	N/A	N/A	N/A	N/A	A, B, C	A, B, C

Unit	English			Mathematics			ICT		
	Speaking, listening and communication	Reading	Writing	Representing	Analysing	Interpreting	Using ICT	Finding and selecting information	Developing, presenting and communicating information
13	A, B	A, B	A, B	A, B	A, B	N/A	B	A, B	A, B
14	A, B	A, B	A, B	N/A	N/A	N/A	A, B	A, B	A, B
15	A, B, C, D	A, B, C, D	A, B, C, D	C	N/A	N/A	C, D	A, B, C, D	A, B, C, D
16	A, B	A, B	A, B	A, B	A, B	A, B		A, B	A, B
17	A, B, C	A, B	A, B, C	N/A	N/A	N/A	N/A	A, B, C	N/A
18	A, B, C, D	A, B, C, D	A, B, C, D	D	D	N/A	B, C, D	A, B, C, D	A, B, C, D
19	A, B	A, B	A	N/A	N/A	N/A	N/A	A	A
20	A, B, C, D	A, B, D	A, B, C, D	N/A	N/A	A, B, D	N/A	A, B, C, D	A, B, D
21	A, B, C, D	A, B, C, D	A, B, C, D	N/A	N/A	B	D	A, B, C, D	A, B, C, D
22	A, B, C	A, B, C	A, B, C	N/A	N/A	N/A	N/A	A, B, C	A, B, C
23	B, C, D	A, B, C, D	A, B, C, D	A, C	C	C	B, D	A, B, C, D	A, B, C, D
24	A, B, C, D	A, B, C, D	A, B, C, D	N/A	N/A	N/A	A, B, C	A, B, C, D	A, B, C, D
25	A, B, C, D	A, B, C, D	A, B, C, D	N/A	N/A	N/A	A, B, C	A, B, C, D	A, B, C, D
26	A, B, C, D	A, B, C, D	A, B, C, D	N/A	N/A	N/A	A, B, C	A, B, C, D	A, B, C, D
27	A, B, C, D	A, B, C, D	A, B, C, D	N/A	N/A	N/A	A, B, C	A, B, C, D	A, B, C, D
28	A, B, C	A, B, C	A, B, C	A, C	A, C	N/A	N/A	A, B, C	A, B, C
29	A, B, C	A, B, C	A, B, C	N/A	N/A	N/A	N/A	A, B, C	A, B, C
30	A, B, C	A, B, C	A, B, C	N/A	N/A	N/A	A, B, C	A, B, C	A, B, C

Unit	English			Mathematics			ICT		
	Speaking, listening and communication	Reading	Writing	Representing	Analysing	Interpreting	Using ICT	Finding and selecting information	Developing, presenting and communicating information
31	A, B	A, B	A, B	B	B	N/A	A, B	A, B	A, B
32	A, B	A, B	A, B	B	B	N/A	N/A	A, B	A, B
33	A, B	A, B	A, B	N/A	N/A	N/A	B	A, B	A, B
34	A, B	A, B, C	A, B, C	C	C	N/A	C	A, B, C	A, B, C
35	A	A, B, C	A, B, C	C	C	N/A	N/A	A, B, C	A, B, C

Annexe C

Synoptic assessment

Synoptic assessment in these qualifications is embedded throughout the assessment criteria across the units of study. The mandatory units provide the essential knowledge, understanding and skills required in the engineering sector and underpin the content of the optional specialist units.

In addition, there are further mandatory units mandatory *Unit 3: Health and Safety in Engineering*, *Unit 5: Engineering Materials*, *Unit 9: Interpreting and Using Information in Engineering* and *Unit 10: Mathematics for Engineering*, provide the essential knowledge, understanding and skills required in Engineering and underpin the content of the optional specialist units.

Learners studying the Pearson BTEC Level 1/Level 2 First Certificate, Extended Certificate and Diploma in Engineering are able to demonstrate a number of synoptic approaches towards meeting the assessment criteria, including:

- showing links and holistic understanding/approaches to several units of study from the specification
- being able to interrelate overarching concepts and issues, bringing together their engineering knowledge
- drawing together and integrating knowledge, understanding and skills across different units, in order to develop an appreciation of how topics relate to one another, how each may contribute to different engineering situations and to the world of engineering
- demonstrating their ability to use and apply a range of different methods and/or techniques in engineering
- synthesising information gained from studying a number of different engineering related activities
- applying knowledge, understanding and skills from across different units to a particular engineering situation
- evaluating and justifying their decisions, choices and recommendations.

Synoptic assessment in engineering enables learners to demonstrate their ability to integrate and apply knowledge, understanding and skills with breadth and depth. The assessment will show learners' ability to make connections between, and integrate, different topics of the unit content.

Examples

Unit 2: Investigating an Engineered Product

Unit content:

- performance requirements (what are the technical considerations that must be achieved within the product?)
- material and component requirements (how should materials and components perform within the product?)

Topics from the unit content underpin knowledge, understanding and skills across the mandatory and several of the optional specialist units.

Centres have the flexibility to assess a number of the criteria across more than one unit using integrated themes and assignment tasks which emphasise the links between the world of engineering, drawing the unit content together.

Annexe D

Summary of units in the BTEC Level 1/Level 2 First in Engineering

The BTEC First suite in Engineering contains four qualifications:
Award (120 GLH), **Certificate (240 GLH)**, **Extended Certificate (360 GLH)** and **Diploma (480 GLH)**.

The smaller qualifications are 'nested' within the larger qualifications, which means that learners may take a smaller-sized qualification, then top up to a larger size without repeating the units already achieved in the smaller size.

This table lists each unit in the suite and how it is used within individual qualifications, i.e. is the unit mandatory (Mand), optional specialist (Opt) or not included (—).

Key: Mand – Mandatory; Opt – Optional specialist; — indicates where the unit does not appear in the qualification

Unit	Unit title	GLH	Qualifications			
			Award	Certificate	Extended Certificate	Diploma
1	The Engineered World **(externally assessed)**	30	Mand	Mand	Mand	Mand
2	Investigating an Engineered Product	30	Mand	Mand	Mand	Mand
3	Health and Safety in Engineering	30	Opt	Opt	Opt	Mand
4	Engineering Maintenance	30	Opt	Opt	Opt	Mand (M) Opt (U), (Me)
5	Engineering Materials	30	Opt	Opt	Opt	Mand
6	Computer-aided Engineering	30	Opt	Opt	Opt	Opt (U), (T), (Ma), (Me)
7	Machining Techniques	60	Opt	Opt	Opt	Opt (U), (Ma), (Me)
8	Electronic Circuit Design and Construction	60	Opt	Opt	Opt	Opt (U), (T) (M) (Ma)

Unit	Unit title	GLH	Qualifications			
			Award	Certificate	Extended Certificate	Diploma
9	Interpreting and Using Engineering Information **(externally assessed)**	30	—	Mand	Mand	Mand
10	Mathematics for Engineering	30	—	Mand	Mand	Mand
11	Electrical and Mechanical Science for Engineering	30	—	Opt	Opt	Opt (U), (T), (M), (Me)
12	Engineering Design	60	—	Opt	Opt	Opt (U), (T), (Ma), (Me)
13	Engineering Assembly	30	—	Opt	Opt	Opt (U), (M), (Ma), (Me)
14	Vehicle Electrical Systems	30	—	Opt	Opt	Opt (U), (M), (Me)
15	Operating an Efficient Workplace	60	—	—	Opt	Opt (U), (Ma)
16	Vehicle Electrical Systems	30	—	—	Opt	Opt (U)
17	Welding	60	—	—	Opt	Opt (U), (Ma), (Me)
18	Computer Numerical Control Programming	60	—	—	Opt	Opt (U), (T), (Ma), (Me)
19	Bicycle Servicing and Maintenance	30	—	—	Opt	Opt (U), (T), (M)
20	Sustainable Vehicle Power and Structure Design	60	—	—	Opt	Opt (U), (T)
21	Introduction to Communications for Engineering	60	—	—	—	Mand
22	Continuous Improvement and Problem Solving	60	—	—	—	Opt (U), (Ma)

Unit	Unit title	GLH	Qualifications			
			Award	Certificate	Extended Certificate	Diploma
23	Electronic Devices and communication Applications	60	—	—	—	Opt (U), (T), (M), (Ma)
24	Operation and Maintenance of Mechanical Systems and Components	60	—	—	—	Opt (U), (M)
25	Operation and Maintenance of Electronic Systems and Components	60	—	—	—	Opt (U), (M)
26	Operation and Maintenance of Electrical Systems and Components	60	—	—	—	Opt (U), (M)
27	Operation and Maintenance of Fluid Power Systems and Components	60	—	—	—	Opt (U), (M)
28	Fabrication Techniques	60	—	—	—	Opt (U), (Ma), (Me)
29	Casting Techniques	60	—	—	—	Opt (U), (Ma), (Me)
30	Vehicle Maintenance Techniques	60	—	—	—	Opt (U), (M)
31	Production Planning for Engineering	30	—	—	—	Opt (U), (Ma), (Me)
32	Engineering Marking Out	30	—	—	—	Opt (U), (Me)
33	Preparing and Controlling Engineering Manufacturing Operations	30	—	—	—	Opt (U)
34	PC Software and Hardware in Engineering	60	—	—	—	Opt (U), (T)
35	Application of Quality Control and Measurement in Engineering	60	—	—	—	Opt (U), (Ma), (Me)

Annexe E

Structure: Pearson BTEC Level 1 / Level 2 First Award in Engineering

- The Pearson BTEC Level 1/Level 2 First Award in Engineering is taught over 120 guided learning hours (GLH). It has mandatory and optional specialist units.
- Learners must complete the two mandatory units, and a choice of optional units to reach a total of 120 GLH.

This BTEC First Award has units that your centre assesses (internal) and a paper-based exam that Pearson sets and marks (external).

Pearson BTEC Level 1 / Level 2 First Diploma in Engineering			
Unit	**Mandatory units**	**Assessment method**	**GLH**
1	The Engineered World	External	30
2	Investigating an Engineered Product	Internal	30
	Optional specialist units		
3	Health and Safety in Engineering	Internal	30
4	Engineering Maintenance	Internal	30
5	Engineering Materials	Internal	30
6	Computer-aided Engineering	Internal	30
7	Machining Techniques	Internal	30
8	Electronic Circuit Design and Construction	Internal	60

Specification

BTEC FIRST ENGINEERING

Certificate
Extended Certificate
Diploma

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