Pearson BTEC

Pearson BTEC
International Level 3 in
Building Services Engineering, Civil Engineering, Construction and the Built Environment

L3

Specification

First teaching from April 2020

Issue 3

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Level 3 Qualifications in Building Services Engineering, Civil Engineering, Construction and the Built Environment

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About Pearson

We are the world's leading learning company operating in countries all around the world. We provide content, assessment and digital services to learners, educational institutions, employers, governments and other partners globally. We are committed to helping equip learners with the skills they need to enhance their employability prospects and to succeed in the changing world of work. We believe that wherever learning flourishes so do people.

This specification is Issue 3. We will inform centres of any changes to this issue. The latest issue can be found on our website.

References to third-party material made in this specification are made in good faith. Pearson does not endorse, approve or accept responsibility for the content of materials, which may be subject to change, or any opinions expressed therein. (Material may include textbooks, journals, magazines and other publications and websites.)

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

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Welcome

With a track record built over 40 years of learner success, our BTEC International Level 3 qualifications are recognised internationally by governments, industry and higher education. BTEC International Level 3 qualifications allow learners to progress to the workplace – either directly or via study at a higher level. Over 100,000 BTEC learners apply to university every year. Their Level 3 BTECs, either on their own or in combination with A Levels, are accepted by UK and international universities, and higher-education institutes for entry to relevant degree programmes.

Career-ready education

BTECs enable a learner-centred approach to education, with a flexible, unit-based structure and knowledge applied to project-based assessments. BTECs focus on the holistic development of the practical, interpersonal and thinking skills required to be successful in employment and higher education.

When creating the BTEC International Level 3 qualifications in this suite, we worked with many employers, higher-education providers, colleges and schools to ensure that we met their needs. Employers are looking for recruits who have a thorough grounding in the latest industry requirements and work-ready skills, for example teamwork. Learners who progress to higher education need experience of research, extended writing and meeting deadlines. BTEC qualifications provide the breadth and depth of learning to give learners this experience.

BTEC addresses these needs by offering:

- a range of BTEC qualification sizes, each with a clear purpose, so that there is something to suit each learner's choice of study programme and progression plans
- internationally relevant content, which is closely aligned with employer and higher-education needs
- assessments and projects chosen to help learners progress; this means that some assessments and projects are set by you to meet local needs, while others are set by Pearson, ensuring a core of skills and understanding common to all learners.

We provide a full range of support, both resources and people, to ensure that learners and teachers have the best possible experience during their course. See *Section 10 Resources and support*, for details of the support we offer.

Collaborative development

Learners who complete their BTEC International Level 3 qualifications in Building Services Engineering, Civil Engineering, Construction and the Built Environment aim to go on to employment, often via the stepping stone of higher education. It was, therefore, essential that we developed these qualifications in close collaboration with experts from professional bodies, businesses and universities, and with the providers who will be delivering the qualifications. We engaged experts in the development of these qualifications to ensure that the content meets providers' needs and gives learners quality preparation to help them progress. We are grateful to all the university and further-education lecturers, teachers, employers, professional body representatives and other individuals who have generously shared their time and expertise to help us develop these new qualifications.

Summary of Pearson BTEC International Level 3 Qualifications in Building Services, Civil Engineering, Construction and the Built Environment specification Issue 3 changes

Summary of changes made between the previous issue and this current issue	Page number
Suggestions of where ideas in sustainability could enhance teaching indicated in some unit content in Units 1, 2, 3 and 5.	Pages 37 to 83

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

Contents

Introduction to the BTEC International Level 3 qualifications in building services engineering, civil engineering, construction and the built environment sector

This specification contains all the information you need to deliver the Pearson BTEC International Level 3 Qualifications in Building Services Engineering, Civil Engineering, Construction and the Built Environment. We also refer you to other handbooks and policies. This specification includes all the units for these qualifications.

These qualifications are part of the suite of construction qualifications offered by Pearson. In this suite, there are qualifications that focus on different progression routes, allowing learners to choose the one best suited to their aspirations. These qualifications are not regulated in England.

All qualifications in the suite share some common units and assessments, which gives learners some flexibility in moving between sizes.

In the construction sector these qualifications are:

Pearson BTEC International Level 3 Certificate in Construction and the Built Environment

Pearson BTEC International Level 3 Subsidiary Diploma in Construction and the Built Environment

Pearson BTEC International Level 3 Foundation Diploma in Construction and the Built Environment

Pearson BTEC International Level 3 Diploma in Construction and the Built Environment

Pearson BTEC International Level 3 Diploma in Civil Engineering

Pearson BTEC International Level 3 Diploma in Building Services Engineering

Pearson BTEC International Level 3 Extended Diploma in Construction and the Built Environment

Pearson BTEC International Level 3 Extended Diploma in Civil Engineering

Pearson BTEC International Level 3 Extended Diploma in Building Services Engineering.

This specification signposts the other essential documents and support that you need as a centre in order to deliver, assess and administer the qualifications, including the staff development required. A summary of all essential documents is given in *Section 7 Administrative arrangements*. Information on how we can support you with these qualifications is given in *Section 10 Resources and support*.

The information in this specification is correct at the time of publication.

Qualifications, sizes and purposes at a glance

Title	Size and structure	Summary purpose
Pearson BTEC International Level 3 Certificate in Construction and the Built Environment	180 GLH Equivalent in size to 0.5 of an International A Level. Three mandatory units that are assessed by Pearson Set Assignment. Mandatory content (100 %). External set assignment (100%).	An introduction to a vocational sector through applied learning. This qualification is intended for post-16 learners who want to continue their education through applied learning and who aim to progress to higher education and/or employment. It aims to provide a coherent introduction to the study of the Construction and Built Environment sector.
Pearson BTEC International Level 3 Subsidiary Diploma in Construction and the Built Environment	360 GLH Equivalent in size to one International A Level. Three mandatory units that are assessed by Pearson Set Assignment. Mandatory content (50%). External set assignment (50%). Learners complete remaining optional units to the value of 180 GLH.	This qualification provides a broad basis of study for the Construction and Built Environment sector. It has been designed to support progression to higher education when taken as part of a programme of study that includes other appropriate Level 3 qualifications.
Pearson BTEC International Level 3 Foundation Diploma in Construction and the Built Environment	540 GLH Equivalent in size to 1.5 International A Levels. Three mandatory units that are assessed by Pearson Set Assignment. Mandatory content (33.33%). External set assignment (33.3%). Learners complete remaining optional units to the value of 360 GLH.	Designed as a one-year, full-time course, covering the fundamentals in Construction and the Built Environment that supports progression to a work-based learning qualification in construction sectors, to a further year of study at Level 3. It supports progression to higher education if taken as part of a programme of study that includes other BTEC International Level 3 qualifications or International A Levels.

Title	Size and structure	Summary purpose
Pearson BTEC International Level 3 Diploma in Construction and the Built Environment	720 GLH Equivalent in size to two International A Levels. There are seven mandatory units, of which five are assessed by Pearson Set Assignment. Mandatory content (58.33%). External set assignment (41.67%). Learners will complete remaining optional units to the value of 300 GLH.	This qualification is designed to support learners who want to study Construction and the Built Environment as the main element alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to higher education if taken as part of a programme of study that includes other BTEC International Level 3 qualifications or International A Levels.
Pearson BTEC International Level 3 Diploma in Civil Engineering	720 GLH Equivalent in size to two International A Levels. There are six mandatory units, of which four are assessed by Pearson Set Assignment. Mandatory content (50%). External set assignment (33.33 %). Learners will complete remaining optional units to the value of 360 GLH.	This qualification is designed to support learners who want to study Civil Engineering as the main element alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to higher education if taken as part of a programme of study that includes other BTEC International Level 3 qualifications or International A Levels.
Pearson BTEC International Level 3 Diploma in Building Services Engineering	720 GLH Equivalent in size to two International A Levels. There are six mandatory units, of which four are assessed by Pearson Set Assignment. Mandatory content (50%). External set assignment (33.33%). Learners will complete remaining optional units to the value of 360 GLH.	This qualification is designed to support learners who want to study Building Services Engineering as the main element alongside another area of complementary or contrasting study as part of a two-year, full-time study programme. The qualification would support progression to higher education if taken as part of a programme of study that includes other BTEC International Level 3 qualifications or International A Levels.

Title	Size and structure	Summary purpose
Pearson BTEC International Level 3 Extended Diploma in Construction and the Built Environment	1080 GLH Equivalent in size to three International A Levels. There are seven mandatory units, of which five are assessed by Pearson Set Assignment. Mandatory content (38.89%). External set assignment (27.78%). Learners will complete remaining optional units to the value of 660GLH.	This qualification is designed as a full-time course to support learners who want to study Construction and the Built Environment as the main focus of a two-year, full-time study programme. The qualification would support progression to higher education in its own right.
Pearson BTEC International Level 3 Extended Diploma in Civil Engineering	1080 GLH Equivalent in size to three International A Levels. There are six mandatory units, of which four are assessed by Pearson Set Assignment. Mandatory content (33.33%). External set assignment (22.2%). Learners will complete optional units to the value of 720 GLH.	This qualification is designed as a full-time course to support learners who want to study Civil Engineering as the main focus of a two-year, full-time study programme. The qualification would support progression to higher education in its own right.
Pearson BTEC International Level 3 Extended Diploma in Building Services Engineering	1080 GLH Equivalent in size to three International A Levels. There are six mandatory units, of which four are assessed by Pearson Set Assignment. Mandatory content (33.33%). External set assignment (22.2%) Learners will complete optional units to the value of 720 GLH.	This qualification is designed as a full-time course to support learners who want to study Building Services Engineering as the main focus of a two-year, full-time study programme. The qualification would support progression to higher education in its own right.

Structures of the qualifications at a glance

This table shows all the units and the qualifications to which they contribute. The full structure for these Pearson BTEC International Level 3 Qualifications in Building Services Engineering, Civil Engineering, Construction and the Built Environment is shown in *Section 2 Structure*. **You must refer to the full structure to select units and plan your programme.**

Key

Pearson Set Assignment units are shown in bold		M	**Mandatory units**	O	**Optional units**
CBE	**Construction and the Built Environment**	CE	**Civil Engineering**	BS	**Building Services Engineering**

Unit (number and title)	Unit size (GLH)	Certificate (180 GLH)	Subsidiary Diploma (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
		CBE	CBE	CBE	CBE	CE	BS	CBE	CE	BSE
1 Construction Technology	60	M	M	M	M	M	M	M	M	M
2 Construction Design	60	M	M	M	M	M	M	M	M	M
3 Construction Science	60	M	M	M	M	M	M	M	M	M
4 Safe Working Practice	60				M	M	M	M	M	M
5 Management of Commercial Risk	60				M			M		
6 Construction Mathematics	60				M	M	M	M	M	M
7 Graphical Detailing	60		O	O	O	O	O	O	O	O
8 Sustainability in Construction	60		O	O	M			M		
9 Building Information Modelling and Artificial Intelligence	60		O	O	O	O	O	O	O	O
10 Surveying in Construction	60		O	O		M			M	
11 Management of a Construction Project	60		O	O	O	O	O	O	O	O
12 Building Surveying in Construction	60		O	O			M			M
13 Site Engineering for Construction	60		O	O	O	O		O	O	

Unit (number and title)	Unit size (GLH)	Certificate (180 GLH)	Subsidiary Diploma (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
		CBE	CBE	CBE	CBE	CE	BS	CBE	CE	BSE
14 Low Temperature Hot Water Systems in Building Services	60		O	O	O	O	O	O	O	O
15 Measurement Techniques in Construction	60		O	O	O	O	O	O	O	O
16 Provision of Primary Services in Buildings	60		O	O	O		O	O		O
17 Further Mathematics for Construction	60				O	O	O	O	O	O
18 Work Experience	60		O	O	O	O	O	O	O	O
19 Projects in Construction	60		O	O	O			O		
20 Quantity Surveying	60		O	O	O		O	O		O
21 Building Services Science	60						O			O
22 Economics and Finance in Construction	60		O	O	O	O		O	O	
23 Construction in Civil Engineering	60				O	O		O	O	
24 Conversion, Adaptation and Maintenance of Buildings	60				O			O		
25 Building Services Control Systems	60						O			O
26 Heating Ventilation and Air Conditioning Design	60						O			O
27 Plumbing and Fluid Behaviour in Building Services Engineering	60						O			O
28 Electrical Principles and Installation Standards in Building Services Engineering	60						O			O

Unit (number and title)	Unit size (GLH)	Certificate (180 GLH)	Subsidiary Diploma (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
		CBE	CBE	CBE	CBE	CE	BS	CBE	CE	BSE
29 Principles and Applications of Structural Mechanics	**60**					**O**			**O**	
30 Public Health Engineering	**60**				**O**	**O**		**O**	**O**	
31 Specialist Civil Engineering Techniques	**60**					**O**			**O**	
32 Highway Construction and Maintenance in Civil Engineering	**60**					**O**			**O**	
33 Offsite and Onsite Construction Methods	**60**				**O**	**O**	**O**	**O**	**O**	**O**
34 Planning the Built Environment	**60**				**O**	**O**		**O**	**O**	

Qualification and unit content

Pearson has developed the content of the new BTEC International Level 3 qualifications in collaboration with employers and representatives from higher education, and relevant professional bodies. In this way, we have ensured that content is up to date and that it includes the knowledge, understanding, skills and personal attributes required in the sector.

The mandatory content ensures that all learners are following a coherent programme of study and that they acquire knowledge, understanding and skills that will be recognised and valued by higher education and employers. Learners are expected to show achievement across mandatory units as detailed in *Section 2 Structure*.

BTEC qualifications encompass applied learning that brings together knowledge and understanding with practical and technical skills. This applied learning is achieved through learners performing vocational tasks that encourage the development of appropriate vocational behaviours and transferable skills. Transferable skills are those such as communication, teamwork and research and analysis, which are valued in both higher education and the workplace. Opportunities to develop these skills are signposted in the units.

Our approach provides rigour and balance, and promotes the ability to apply learning immediately in new contexts.

Centres should ensure that content, for example content that references regulation, legislation, policies and regulatory/standards organisations, is kept up to date. The units include guidance on approaches to breadth and depth of coverage, which can be modified to ensure that content is current and reflects international variations.

Teachers, assessors and learners are encouraged to contextualise the detail of unit content in order to make sure that this is both locally relevant and meaningful to learners. Unit content cannot be changed but delivered appropriately to the local area/region where learning takes place. For example, regional planning legislation linked to construction can be used. Local building regulations and building codes need to be applied to relevant case studies that take account of current or best practice in the locale in which the qualification is delivered. Where possible and practicable, health and safety must be applied in context to the area/region and current best practice and can be referenced, but not necessarily compared to UK legislation, for instance the Health and Safety At Work Act 1974 which operates in the UK.

Where units use anything other than the decimal system of weights and measures found in the Système Internationale d'Unités (SI), learners are encouraged to convert to units that are used locally. Examples of this are units used to measure heat (Celsius/Fahrenheit), weight (kilogrammes or tonnes/pounds, hundredweights or tons), length or distance (metres/feet or inches) and such like.

Assessment

Assessment is designed to fit the purpose and objective of the qualification. It includes a range of assessment types and styles suited to vocational qualifications in the sector. All assessment is internal, but some mandatory units have extra controls on assessment and are assessed using Pearson Set Assignments

Pearson Set Assignment (PSA) units

Some units in the qualifications are assessed using a Pearson Set Assignment. Each assessment is set by Pearson and is marked by teachers.

Set assignment units are subject to external standards verification processes common to all BTEC units. By setting an assignment for some units, we can ensure that all learners take the same assessment for a specific unit. Learners are permitted to resit set assignment units during their programme. Please see *Section 6 Internal assessment* for further information.

Set assignments are available from September each year and are valid for one year only. For detailed information on the Pearson Set Assignment, please see the table in *Section 2 Structure*. For further information on preparing for assessment, see *Section 5 Assessment structure*.

Internal assessment

All units in the sector are internally assessed and subject to external standards verification. Before you assess you will need to become an approved centre, if you are not one already. You will need to prepare to assess using the guidance in *Section 6 Internal assessment*.

For units where there is no Pearson Set Assignment, you select the most appropriate assessment styles according to the learning set out in the unit. This ensures that learners are assessed using a variety of styles to help them develop a broad range of transferable skills. Learners could be given opportunities to:

- write up the findings of their own research
- use case studies to explore complex or unfamiliar situations
- carry out projects for which they have choice over the direction and outcomes
- demonstrate practical and technical skills using appropriate processes, etc.

For these units, Pearson will provide an Authorised Assignment brief that you can use. You will make grading decisions based on the requirements and supporting guidance given in the units. Learners may not make repeated submissions of assignment evidence. For further information, please see *Section 6 Internal assessment*.

Language of assessment

Assessment of the units for these qualifications is available in English but can be translated as necessary.

A learner taking the qualifications may be assessed in sign language where it is permitted for the purpose of reasonable adjustment for learners of determination. For information on reasonable adjustments for learners of determination, see *Section 7 Administrative arrangements*.

Grading for units and qualifications

Achievement of the qualification requires demonstration of depth of study in each unit, assured acquisition of a range of practical skills required for employment or for progression to higher education, and successful development of transferable skills. Learners who achieve a qualification will have achieved across mandatory units.

Units are assessed using a grading scale of Distinction (D), Merit (M), Pass (P) and Unclassified (U). All mandatory and optional units contribute proportionately to the overall qualification grade.

Qualifications in the suite are graded using a scale of P to D*, **or** PP to D*D*, **or** PPP to D*D*D*. Please see *Section 9 Understanding the qualification grade*, for more details. The relationship between qualification grading scales and unit grades will be subject to regular review as part of Pearson's standards monitoring processes, on the basis of learner performance and in consultation with key users of the qualifications.

1 Qualification purpose and progression

Pearson BTEC International Level 3 Qualifications in Building Services Engineering, Civil Engineering, Construction and the Built Environment

Who are these qualifications for?

The Pearson BTEC International Level 3 Qualifications in Construction and the Built Environment are designed either for learners in the 16-19 age group, who wish to pursue a career in the construction and the built environment industry via higher education to access graduate entry employment within the sector, or alternatively through a junior employment role.

The Pearson BTEC International Level 3 qualifications in Civil Engineering are designed either for learners in the 16-19 age group, who wish to pursue a career in the civil engineering industry via higher education to access graduate entry employment within the sector, or alternatively through a junior employment role.

The Pearson BTEC International Level 3 qualifications in Building Services Engineering are designed either for learners in the 16-19 age group, who wish to pursue a career in the building services industry via higher education to access graduate entry employment within the sector, or alternatively through a junior employment role.

Which size qualification to choose?

Choosing the most suitable size of qualification will depend on the learner's broader programme of study. For example, a learner who wishes to focus solely on Construction and the Built Environment or Civil Engineering may take the Diploma or Extended Diploma, while a learner who selects a smaller qualification, such as the Certificate or Subsidiary Diploma, may choose to combine it with qualifications from other sectors in order to support their desired progression. Smaller qualifications are also suitable for learners who are in employment and studying part-time.

Qualification structures have been designed to enable a learner who starts with the smallest qualification to progress easily to the larger qualifications.

What do these qualifications cover?

The content of this qualification has been designed to support progression to particular roles in construction, civil engineering and building services industries, either directly into entry-level roles linked to these occupational areas or, more likely, via particular higher-education routes in the particular areas. The qualification content has been designed in consultation with employers, professional bodies and higher-education providers to ensure that the content is appropriate for the progression routes identified.

All learners will be required to take mandatory content that is directly relevant to progression routes in all of the identified areas.

In addition, learners take optional units that support the progression route identified in the qualification title. For example, learners taking the qualification as part of a work-based learning qualification for Construction and the Built Environment could take units such as:

- Unit 8: Sustainability in Construction
- Unit 10: Surveying in Construction
- Unit 11: Management of a Construction Project
- Unit 13: Site Engineering for Construction.

Or for example, learners taking the qualification as part of a work-based learning qualification in Civil Engineering could take units such as:

- Unit 23: Construction in Civil Engineering
- Unit 29: Principles and Applications of Structural Mechanics
- Unit 31: Specialist Civil Engineering Techniques
- Unit 32: Highway Construction and Maintenance in Civil Engineering.

Or, for example, learners taking the qualification as part of a work-based learning qualification in Building Services Engineering could take units such as:

- Unit 9: Building Information Modelling and Artificial Intelligence
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 16: Provision of Primary Services in Buildings
- Unit 25: Building Services Control Systems.

What could these qualifications lead to?

These qualifications support progression to job opportunities in the construction and built environment industry at a variety of levels. Jobs available include:

- construction project manager
- calibration technician
- project administration assistant.

These qualifications support progression to job opportunities in the civil engineering industry at a variety of levels. Jobs available include:

- entry-level civil engineer
- apprentice civil engineer.

These qualifications support progression to job opportunities in the building services engineering industry at a variety of levels. Jobs available in these areas include:

- entry level maintenance engineer
- office and facilities manager.

How do these qualifications provide transferable employability skills?

In the BTEC International Level 3 units, there are opportunities during the teaching and learning phase to give learners practice in developing employability skills. Where we refer to employability skills in this specification, we are generally referring to skills in the following three main categories:

- **cognitive and problem-solving skills** – using critical thinking, approaching non-routine problems, applying expert and creative solutions, using systems and technology
- **interpersonal skills** – communicating, working collaboratively, negotiating and influencing, self-presentation
- **intrapersonal skills** – self-management, adaptability and resilience, self-monitoring and development.

There are also specific requirements in some units for assessment of these skills where relevant, for example where learners are required to undertake real or simulated activities. These skills are indicated in the units and in *Appendix 2: Transferable employability skills*.

How do the qualifications provide transferable knowledge and skills for higher education?

All BTEC International Level 3 qualifications provide transferable knowledge and skills that prepare learners for progression to university. The transferable skills that universities value include:

- the ability to learn independently
- the ability to research actively and methodically
- the ability to give presentations and be active group members.

BTEC learners can also benefit from opportunities for deep learning, where they are able to make connections across units and select areas of interest for detailed study. BTEC International Level 3 qualifications provide a vocational context in which learners can develop the knowledge and skills required for particular degree courses, including:

- reading technical texts
- research skills
- effective writing
- selection of appropriate tools and processes used in building services engineering, civil engineering and construction
- analytical skills
- creative development
- ability to work in a legal, ethical and moral manner
- preparation for assessment methods used in a degree.

2 Structure

Qualification structures

The structures for the qualifications in this specification are:

- Pearson BTEC International Level 3 Certificate in Construction and the Built Environment (180 GLH)
- Pearson BTEC International Level 3 Subsidiary Diploma in Construction and the Built Environment (360 GLH)
- Pearson BTEC International Level 3 Foundation Diploma in Construction and the Built Environment (540 GLH)
- Pearson BTEC International Level 3 Diploma in Construction and the Built Environment (720 GLH)
- Pearson BTEC International Level 3 Diploma in Civil Engineering (720 GLH)
- Pearson BTEC International Level 3 Diploma in Building Services Engineering (720 GLH)
- Pearson BTEC International Level 3 Extended Diploma in Construction and the Built Environment (1080 GLH)
- Pearson BTEC International Level 3 Extended Diploma in Civil Engineering (1080 GLH)
- Pearson BTEC International Level 3 Extended Diploma in Building Services Engineering (1080 GLH)

Pearson BTEC International Level 3 Certificate in Construction and the Built Environment

Mandatory units

There are 3 mandatory units, all of which are set assignment units. Learners must complete and achieve a Pass or above in all mandatory units.

Pearson BTEC International Level 3 Certificate in Construction and the Built Environment (180 GLH)				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment

Pearson BTEC International Level 3 Subsidiary Diploma in Construction and the Built Environment

Mandatory units

There are 3 mandatory units, all of which are set assignment units. Learners must complete and achieve a Pass or above in all mandatory units.

Optional units

Learners must complete at least 3 optional units.

Pearson BTEC International Level 3 Subsidiary Diploma in Construction and the Built Environment (360 GLH)				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
Optional units – learners complete at least 3 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
8	Sustainability in Construction	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
12	Building Surveying in Construction	**60**	**Optional**	Internal
13	Site Engineering for Construction	**60**	**Optional**	Internal
14	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
16	Provision of Primary Services in Buildings	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
19	Projects in Construction	**60**	**Optional**	Internal
20	Quantity Surveying	**60**	**Optional**	Internal
22	Economics and Finance in Construction	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Foundation Diploma in Construction and the Built Environment

Mandatory units

There are 3 mandatory units, all of which are set assignment units. Learners must complete and achieve a Pass or above in all mandatory units.

Optional units

Learners must complete at least 6 optional units.

Pearson BTEC International Level 3 Foundation Diploma in Construction and the Built Environment (540 GLH)				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
Optional units – learners complete at least 6 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
8	Sustainability in Construction	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
12	Building Surveying in Construction	**60**	**Optional**	Internal
13	Site Engineering for Construction	**60**	**Optional**	Internal
14	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
16	Provision of Primary Services in Buildings	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
19	Projects in Construction	**60**	**Optional**	Internal
20	Quantity Surveying	**60**	**Optional**	Internal
22	Economics and Finance in Construction	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Diploma in Construction and the Built Environment

Mandatory units

There are 7 mandatory units, of which 5 are set assignment units and 2 assessed internally.

Optional units

Learners must complete at least 5 optional units.

Pearson BTEC International Level 3 Diploma in Construction and the Built Environment (720 GLH)				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
4	Safe Working Practice	**60**	**Mandatory**	Set assignment
5	Management of Commercial Risk	**60**	**Mandatory**	Set assignment
6	Construction Mathematics	**60**	**Mandatory**	Internal
8	Sustainability in Construction	**60**	**Mandatory**	Internal
Optional units – learners complete at least 5 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
13	Site Engineering for Construction	**60**	**Optional**	Internal
14	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
16	Provision of Primary Services in Buildings	**60**	**Optional**	Internal
17	Further Mathematics in Construction	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
19	Projects in Construction	**60**	**Optional**	Internal
20	Quantity Surveying	**60**	**Optional**	Internal
22	Economics and Finance in Construction	**60**	**Optional**	Internal

Optional units – learners complete at least 5 optional units *(continued)*				
23	Construction in Civil Engineering	**60**	**Optional**	Internal
24	Conversion, Adaptation and Maintenance of Buildings	**60**	**Optional**	Internal
30	Public Health Engineering	**60**	**Optional**	Internal
33	Offsite and Onsite Construction Methods	**60**	**Optional**	Internal
34	Planning the Built Environment	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Diploma in Civil Engineering

Mandatory units

There are 6 mandatory units, of which 4 are set assignment units and 2 assessed internally.

Optional units

Learners must complete at least 6 optional units.

Pearson BTEC International Level 3 Diploma in Civil Engineering				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
4	Safe Working Practice	**60**	**Mandatory**	Set assignment
6	Construction Mathematics	**60**	**Mandatory**	Internal
10	Surveying in Construction	**60**	**Mandatory**	Internal
Optional units – learners complete at least 6 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
13	Site Engineering for Construction	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
17	Further Mathematics for Construction	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
23	Construction in Civil Engineering	**60**	**Optional**	Internal
29	Principles and Applications of Structural Mechanics	**60**	**Optional**	Internal
30	Public Health Engineering	**60**	**Optional**	Internal
31	Specialist Civil Engineering Techniques	**60**	**Optional**	Internal
33	Offsite and Onsite Construction Methods	**60**	**Optional**	Internal
34	Planning the Built Environment	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Diploma in Building Services Engineering

Mandatory units

There are 6 mandatory units, of which 4 will are set assignment units and 2 assessed internally.

Optional units

Learners must complete at least 6 optional units.

Pearson BTEC International Level 3 Diploma in Building Services Engineering				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
4	Safe Working Practice	**60**	**Mandatory**	Set assignment
6	Construction Mathematics	**60**	**Mandatory**	Internal
12	Building Surveying in Construction	**60**	**Mandatory**	Internal
Optional units – learners complete at least 6 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
14	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
16	Provision of Primary Services in Buildings	**60**	**Optional**	Internal
17	Further Mathematics in Construction	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
20	Quantity Surveying	**60**	**Optional**	Internal
21	Building Services Science	**60**	**Optional**	Internal
22	Economics and Finance in Construction	**60**	**Optional**	Internal
25	Building Services Control Systems	**60**	**Optional**	Internal

Optional units – learners complete at least 6 optional units *(continued)*				
26	Heating Ventilation and Air Conditioning Design	**60**	**Optional**	Internal
27	Plumbing and Fluid Behaviour in Building Services Engineering	**60**	**Optional**	Internal
28	Electrical Principles and Installations Standards in Building Services Engineering	**60**	**Optional**	Internal
33	Offsite and Onsite Construction Methods	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Extended Diploma in Construction and the Built Environment

Mandatory units

There are 7 mandatory units, of which 5 are set assignment units and 2 assessed internally

Optional units

Learners must complete at least 11 optional units.

Pearson BTEC International Level 3 Extended Diploma in Construction and the Built Environment				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
4	Safe Working Practice	**60**	**Mandatory**	Set assignment
5	Management of Commercial Risk	**60**	**Mandatory**	Set assignment
6	Construction Mathematics	**60**	**Mandatory**	Internal
8	Sustainability in Construction	**60**	**Mandatory**	Internal
Optional units – learners complete at least 11 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
13	Site Engineering for Construction	**60**	**Optional**	Internal
14	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
16	Provision of Primary Services in Buildings	**60**	**Optional**	Internal
17	Further Mathematics in Construction	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
19	Projects in Construction	**60**	**Optional**	Internal
20	Quantity Surveying	**60**	**Optional**	Internal

Optional units – learners complete at least 11 optional units *(continued)*				
22	Economics and Finance in Construction	**60**	**Optional**	Internal
23	Construction in Civil Engineering	**60**	**Optional**	Internal
24	Conversion, Adaptation and Maintenance of Buildings	**60**	**Optional**	Internal
30	Public Health Engineering	**60**	**Optional**	Internal
33	Offsite and Onsite Construction Methods	**60**	**Optional**	Internal
34	Planning the Built Environment	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Extended Diploma in Civil Engineering

Mandatory units

There are 6 mandatory units, of which 4 are set assignment units and 2 assessed internally.

Optional units

Learners must complete at least 12 optional units.

Pearson BTEC International Level 3 Extended Diploma in Civil Engineering				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
4	Safe Working Practice	**60**	**Mandatory**	Set assignment
6	Construction Mathematics	**60**	**Mandatory**	Internal
10	Surveying in Construction	**60**	**Mandatory**	Internal
Optional units – learners complete at least 12 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
13	Site Engineering for Construction	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
17	Further Mathematics for Construction	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
22	Economics and Finance in Construction	**60**	**Optional**	Internal
23	Construction in Civil Engineering	**60**	**Optional**	Internal
29	Principles and Applications of Structural Mechanics	**60**	**Optional**	Internal
30	Public Health Engineering	**60**	**Optional**	Internal
31	Specialist Civil Engineering Techniques	**60**	**Optional**	Internal
33	Offsite and Onsite Construction Methods	**60**	**Optional**	Internal
34	Planning the Built Environment	**60**	**Optional**	Internal

Pearson BTEC International Level 3 Extended Diploma in Building Services Engineering

Mandatory units

There are 6 mandatory units, of which 4 are set assignment units and 2 assessed internally.

Optional units

Learners must complete at least 12 optional units

Pearson BTEC International Level 3 Extended Diploma in Building Services Engineering				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
Mandatory units – learners complete and achieve all units				
1	Construction Technology	**60**	**Mandatory**	Set assignment
2	Construction Design	**60**	**Mandatory**	Set assignment
3	Construction Science	**60**	**Mandatory**	Set assignment
4	Safe Working Practice	**60**	**Mandatory**	Set assignment
6	Construction Mathematics	**60**	**Mandatory**	Internal
12	Building Surveying in Construction	**60**	**Mandatory**	Internal
Optional units – learners complete at least 12 optional units				
7	Graphical Detailing	**60**	**Optional**	Internal
9	Building Information Modelling and Artificial Intelligence	**60**	**Optional**	Internal
11	Management of a Construction Project	**60**	**Optional**	Internal
14	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Measurement Techniques in Construction	**60**	**Optional**	Internal
16	Provision of Primary Services in Buildings	**60**	**Optional**	Internal
17	Further Mathematics for Construction	**60**	**Optional**	Internal
18	Work Experience	**60**	**Optional**	Internal
20	Quantity Surveying	**60**	**Optional**	Internal
21	Building Services Science	**60**	**Optional**	Internal
25	Building Services Control Systems	**60**	**Optional**	Internal

Optional units – learners complete at least 12 optional units *(continued)*				
26	Heating Ventilation and Air Conditioning Design	**60**	**Optional**	Internal
27	Plumbing and Fluid Behaviour in Building Services Engineering	**60**	**Optional**	Internal
28	Electrical Principles and Installations Standards in Building Services Engineering	**60**	**Optional**	Internal

Set assignment units

This is a summary of the type and availability of set assignment units. For more information, see *Section 5 Assessment structure*, and the units and sample assessment materials.

Unit	Type	Availability
Unit 1 Construction Technology	· An assignment set by Pearson and marked by the centre. · The advised period is 6 hours. · Completed using a computer.	**Two available for each series.**
Unit 2 Construction Design	· An assignment set by Pearson and marked by the centre. · The advised period is 11 hours. · Completed using a computer.	**Two available for each series.**
Unit 3 Construction Science	· An assignment set by Pearson and marked by the centre. · The advised period is 4 hours. · Completed using a computer.	**Two available for each series.**
Unit 4 Safe Working Practice	· An assignment set by Pearson and marked by the centre. · The advised period is 6 hours. · Completed using a computer.	**Two available for each series.**
Unit 5 Management of Commercial Risk	· An assignment set by Pearson and marked by the centre. · The advised period is 6 hours. · Completed using a computer.	**Two available for each series.**

Employer involvement in assessment and delivery

You are encouraged to give learners opportunities to be involved with employers. For more information, please see *Section 4 Planning your programme*.

3 Units

Understanding your units

The units in this specification set out our expectations of assessment in a way that helps you to prepare your learners for assessment. The units help you to undertake assessment and quality assurance effectively.

Each unit in the specification is set out in a similar way. This section explains how the units work. It is important that all teachers, assessors, internal verifiers and other staff responsible for the programme review this section.

Section	Explanation
Unit number	The number is in a sequence in the sector. Numbers may not be sequential for an individual qualification.
Unit title	This is the formal title that we always use, it appears on certificates.
Level	All units are at Level 3.
Unit type	This shows if the unit is internal or assessed using a Pearson Set Assignment. See structure information in *Section 2 Structure* for details.
Guided Learning Hours (GLH)	All of the units have a GLH of 60. This indicates the numbers of hours of teaching, directed activity and assessment expected. It also shows the weighting of the unit in the final qualification grade.
Unit in brief	This is a brief formal statement on the content of the unit that is helpful in understanding its role in the qualification. You can use this in summary documents, brochures, etc.
Unit introduction	This is written with learners in mind. It indicates why the unit is important, how learning is structured and how it might be applied when they progress to employment or higher education.
Assessment	For internal set assignment units, this section states whether set assignments are required to be completed.
Learning aims	These help to define the scope, style and depth of learning of the unit. You can see where learners should be learning standard requirements ('understand') or where they should be actively researching ('investigate'). You can find out more about the verbs we use in learning aims in *Appendix 4: Glossary of terms used*.
Summary of unit	This section helps teachers to see at a glance the main content areas given against the learning aims and the structure of the assessment. The content areas and structure of assessment must be covered. The forms of evidence given are suitable to fulfil the requirement.

Section	Explanation
Content	This section sets out the required teaching content of the unit. Content is compulsory except when shown as 'e.g.'. Learners should be asked to complete summative assessment only after the teaching content for the unit or learning aim(s) has been covered.
Assessment criteria	Each learning aim has Pass and Merit criteria. Each assignment has at least one Distinction criterion. A full glossary of terms used is given in *Appendix 4: Glossary of terms used.* All assessors need to understand our expectations of the terms used. Distinction criteria represent outstanding performance in the unit. Some criteria require learners to draw together learning from across the learning aims.
Essential information for assignments	This shows the maximum number of assignments that may be used for the unit to allow for effective summative assessment and how the assessment criteria should be used to assess performance. For set assignment units, this section will include any conditions for taking the assignment.
Further information for teachers and assessors	This section gives you information to support the implementation of assessment. It is important that this is read carefully alongside the assessment criteria, as the information will help with interpretation of the requirements.
Resource requirements	Any specific resources that you need to be able to teach and assess are listed in this section. For information on support resources, see *Section 10 Resources and support*.
Essential information for assessment decisions	This section gives guidance on and examples for each learning aim or assignment of the expectations for Pass, Merit and Distinction standard.
Assessment controls	This section gives details of the rules that learners need to abide by when taking the assessment.
Links to other units	This section shows you the main relationships between different units. This helps you to structure your programme and make best use of available materials and resources.
Employer involvement	This section gives you information on the units, which can be used to involve learners with employers. This will help you to identify the kind of involvement that is likely to be most successful.
Opportunities to develop transferable employability skills	This section gives you guidance on how transferable employability skills might be developed in teaching and assessment of the unit.

Index of units

This section contains all the units developed for these qualifications. Please refer to *pages 5–7* to check which units are available in all qualifications in the construction and the built environment sector.

Unit 1: Construction Technology

Level: **3**

Unit type: **Internal set assignment**

Guided learning hours: **60**

Unit in brief

Learners examine the underlying principles and construction methods used in the construction of new buildings and their associated external works.

Unit introduction

The construction industry provides the population of the world with the built environment needed to sustain all aspects of life as we know it. Today's buildings can use combinations of modern and traditional techniques and materials in their construction, and this unit will give you an understanding of the technology used in the design and construction of low-rise domestic and commercial buildings.

In this unit, you will examine various forms of low-rise construction and consider the most appropriate forms for differing site conditions and client requirements. You will gain an understanding of the different types of foundation that could be used on a project and the factors that influence its selection. You will investigate superstructure, external works design and construction, considering the most appropriate specifications and details for given scenarios.

This unit will give you the underlying knowledge and understanding of construction technology that supports a wide range of other units in this qualification. A sound knowledge of construction technology is an essential aspect of many roles, including architect, site manager, quantity surveyor, planner, buyer, estimator, etc.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Understand common forms of low-rise construction

B Examine foundation design and construction

C Examine superstructure design and construction

D Examine external works associated with construction projects.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand common forms of low-rise construction	**A1** Forms of low-rise construction	This unit is assessed through a Pearson Set Assignment.
B Examine foundation design and construction	**B1** Subsoil investigation **B2** Subsoil improvement **B3** Design principles **B4** Types of foundation	
C Examine superstructure design and construction	**C1** Walls **C2** Floors **C3** Roofs **C4** Internal finishes	
D Examine external works associated with construction projects	**D1** Foul and surface water drainage **D2** Utility services **D3** Roads and footpaths **D4** Sustainable urban drainage systems	

Content

Learning aim A: Understand common forms of low-rise construction

A1 Forms of low-rise construction

The application, characteristics, use, methods of load transfer, differences in construction methods, advantages and limitations of the following forms of low-rise construction.

- Framed structures:
  - skeleton, rectangular frame:
    - steel
    - in-situ reinforced concrete
    - prefabricated concrete
  - portal frame:
    - steel
    - laminated timber
    - prefabricated concrete
  - timber frame:
    - prefabricated platform frames
    - open panel systems
    - closed panel systems
  - structural insulated panels (SIPs).
- Traditional construction:
  - cavity wall
  - masonry wall
  - cut rafter roofing
  - timber floors
  - in-situ methods.
- Modular construction:
  - four-sided modules
  - open-sided modules
    - partially open sided
    - corner supported modules
  - stair modules
  - lift modules
  - non-loadbearing modules.

Learning aim B: Examine foundation design and construction

B1 Subsoil investigation

Subsoil investigation methods to obtain data and information for foundation design and their advantages and disadvantages.

- Investigation methods:
  - desk study
  - walkover survey
  - trial pits
  - auger holes
  - percussion drilling and window sampling
  - plate bearing test.

- Information used for foundation design:
  - bearing capacity
  - subsoil classification
  - groundwater levels
  - chemical analysis of soil samples and presence of sulphates
  - presence of obstructions – naturally occurring and from previous development.

B2 Subsoil improvement

Awareness of techniques of how to improve the bearing capacity of the ground before construction work commencing on site:

- vibroflotation, including vibro replacement
- grouting
- land drainage.

B3 Design principles

Foundation design considerations, including the relationship between building load and ground bearing capacity, the foundation footprint and transfer of loads to a suitable bearing strata.

- Factors used during design to minimise settlement:
  - building load
  - soil bearing capacity and type
  - foundation depth
  - groundwater.
- Design to minimise other movement:
  - soil shrinkage
  - ground heave
  - differential settlement
  - effects of tree growth and tree removal.
- The Building Regulations in the host nation – use to determine the minimum:
  - width of strip foundations
  - thickness of strip foundations
  - overlap where foundations are stepped.

B4 Types of foundation

The application, characteristics, substructure detailing, advantages and disadvantages and factors affecting choice of the following foundation types for different loadings and ground bearing capacities.

- Strip.
- Trench fill.
- Raft.
- Pad.
- Pile:
  - replacement piles
  - displacement piles
  - pile caps
  - ground beams.

Learning aim C: Examine superstructure design and construction

C1 Walls

Construction methods and techniques, materials used, stability, detailing, external finishes, performance requirements, sustainability considerations, advantages and disadvantages of the following wall elements.

- External cavity walls:
  - traditional brickwork and blockwork
  - blockwork with external skin rendered.
- Solid wall with rainscreen cladding.
- Internal walls and partitions:
  - blockwork partitions
  - timber stud partitions
  - metal stud partitions
  - demountable partitions.
- Prefabricated timber frame construction:
  - external wall details
  - cladding options, including brickwork
  - internal wall details.
- Openings in walls:
  - head detailing, including methods of supporting the wall above the opening
  - jamb detailing
  - sill and threshold detailing
  - windows
  - doors.

C2 Floors

Construction methods and techniques, materials used, support, detailing, finishes, performance requirements, sustainability considerations, advantages and disadvantages of the following floor types and elements.

- Ground floors:
  - solid concrete
  - beam and block
  - prestressed concrete
  - suspended timber.
- Intermediate floors:
  - beam and block
  - prestressed concrete
  - timber
  - platform floors in timber frame construction.
- Openings and stairs:
  - forming openings
  - timber stairs
  - precast concrete stairs.

C3 Roofs

Construction methods and techniques, materials and components used, support (including bracing and lateral restraint), detailing (at eaves, verge, abutments and ridge), finishes, performance requirements, sustainability considerations, advantages and disadvantages of the following roof types.

- Pitched, including mono pitch, double pitch, gable ended and hipped:
  - trussed rafter construction
  - timber roofing.
- Flat:
  - warm deck
  - cold deck
  - method of achieving required falls:
    - firrings
    - laser-cut tapered insulation
    - screed.

C4 Internal finishes

Application, characteristics, properties, advantages and disadvantages of the following finishes.

- Wall finishes:
  - two-coat plasterwork
  - dry lining
  - ceramic tiling
  - wood panelling
  - decorating:
    - paint
    - wallpaper.
- Ceiling finishes:
  - plasterboard and skim
  - suspended ceilings
  - UPVC ceiling cladding
  - timber-boarded ceilings.
- Floor finishes:
  - natural timber
  - laminates
  - carpets
  - ceramic tiling
  - sheet materials.

Learning aim D: Examine external works associated with construction projects

D1 Foul and surface water drainage

The layout, falls, access, advantages and disadvantages of the following methods of disposal for foul and surface water.

- Combined drainage.
- Separate drainage.

D2 Utility services

The depth, colour coding of ducts, positioning, typical layout and building entry of the following utility services.

- Water.
- Gas.
- Electricity.
- Telecommunications.

D3 Roads and footpaths

Construction methods and techniques, materials used, edge details, performance requirements, specifications, finishes, environmental impact, advantages and disadvantages of the following paving types.

- Tarmacadam to footpaths.
- Tarmacadam to vehicular areas and roads.
- Block paving.
- In-situ concrete.
- Precast concrete paving.

D4 Sustainable urban drainage systems

The methods, use, characteristics, advantages and disadvantages of sustainable urban drainage systems.

- Methods of temporary storage of excess surface water:
  - swales
  - infiltration basins
  - extended detention basins
  - wet ponds
  - infiltration systems.
- Methods allowing natural percolation to groundwater:
  - filter strips
  - porous surfaces:
    - porous block paving
    - permeable tarmacadam
    - porous concrete
    - gravel.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Understand common forms of low-rise construction</td><td rowspan="2">A.D1 Evaluate the effectiveness of different structural forms for use with a given low-rise buildings project scenario.</td></tr>
<tr><td>A.P1 Explain the different structural forms used in the construction of low-rise buildings.</td><td>A.M1 Discuss the use of different structural forms for use with a given low-rise buildings project scenario.</td></tr>
<tr><td colspan="2">Learning aim B: Examine foundation design and construction</td><td rowspan="4">BC.D2 Evaluate the construction of new low-rise buildings.</td></tr>
<tr><td>B.P2 Explain the different types of investigation used to provide information required for the design of foundations for low-rise buildings.
B.P3 Explain the different types of foundation used for low-rise buildings.
B.P4 Describe the principles of foundation design and how they impact on the choice of foundation type for low-rise buildings.</td><td>B.M2 Discuss the principles of foundation design and how they impact on the choice of foundation type for low-rise buildings.</td></tr>
<tr><td colspan="2">Learning aim C: Examine superstructure design and construction</td></tr>
<tr><td>C.P5 Explain the construction details used in the construction of walls, floors and roofs on new construction projects.
C.P6 Summarise the use of internal finishes for floors, walls and ceilings on new construction projects.</td><td>C.M3 Analyse the different details and finishes used in the construction of new construction projects.</td></tr>
</table>

Pass	Merit	Distinction
Learning aim D: Examine external works associated with construction projects		
D.P7 Summarise the design and construction of external works on new construction projects. **D.P8** Explain the use of sustainable urban drainage systems in new construction projects.	**D.M4** Discuss the design and construction of external works for new construction projects, including the incorporation of a sustainable urban drainage system.	**D.D3** Analyse the design and construction of external works for new construction projects, including the incorporation of a sustainable urban drainage system.

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess learners.

Further information for teachers and assessors

Resource requirements

There are no specific additional resource requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will demonstrate sound knowledge and understanding of the specific advantages and disadvantages of framed structures, traditional construction and modular construction methods when considered for use in the given project scenario. Learners will critically review the different forms of construction in the context of the scenario and will bring together key considerations to form a supported conclusion, drawing on information relevant to the given scenario.

For merit standard, learners will provide a coherent, logical and mostly balanced discussion that considers the application, characteristics, use, methods of load transfer, advantages and limitations of the different structural forms that could be considered for the given project scenario. They will demonstrate some understanding of the specific advantages and limitations of framed structures, traditional construction and modular construction methods when considered for use in the given project scenario.

For pass standard, learners will provide a clear explanation of different structural forms that are used in the construction of low-rise buildings. They will cover a minimum of two structural forms. Learners' work will demonstrate some knowledge of how the application, characteristics, advantages and limitations of each type of structural form affects the selection. Illustrations and/or sketches with annotations may be used, alongside written submissions, to help convey knowledge and understanding of the different structural forms.

Learning aims B and C

For distinction standard, learners will evaluate the effectiveness of the different foundation types, potential superstructure construction details and finishes to cover the basic proposals and site information for a low-rise construction scenario. Learners will demonstrate sound knowledge and understanding of the specific application, advantages and disadvantages of different foundation types, including strip, trench fill, raft, pad and various types of pile foundation, and the methods and performance requirements for the various elements of superstructure when considered for use in the given project scenario. Learners will review the different methods and details in the context of the scenario and will bring together key considerations to form a supported conclusion, including alternative specifications where appropriate, drawing on information relevant to the given scenario.

For merit standard, learners will provide a coherent, logical and mostly balanced discussion that considers the relationship between building load, ground bearing capacity, the foundation footprint, transfer of loads to a suitable bearing strata and the appropriate foundation types to cover the basic proposals and site information for a low-rise construction scenario. They will demonstrate a sound approach and competent analysis of typical details and finishes used in the construction of walls, floors and roofs. Learners must cover two details for each of the identified elements.

For pass standard, learners will provide a clear explanation of methods for determining soil type and properties, foundation types and principles of foundation design used in the construction of low-rise domestic buildings. Their explanation will cover a minimum of three different site investigation methods and foundation types, although the explanation will be generic and may only have limited focus to cover the basic proposals and site information for a low-rise construction scenario. Learners' work will cover an explanation of superstructure construction details, including walls, floors and roofs but this will be generic and not focused on the scenario. Details of internal finishes will be outlined, covering walls, ceilings and floors. Illustrations and/or sketches with annotations may be used, alongside written submissions, to help convey knowledge and understanding of the different principles and details.

Learning aim D

For distinction standard, learners will evaluate the effectiveness of external works, including sustainable urban drainage systems, to cover the basic proposals and site information for a low-rise construction scenario. Learners will demonstrate sound knowledge and understanding of the specific application, advantages and disadvantages of external works and sustainable urban drainage systems, when considered for use in the given project scenario. Learners will review the different methods and details in the context of the scenario and will bring together key considerations to form a supported conclusion, including alternative specifications where appropriate, drawing on information relevant to the given scenario.

For merit standard, learners will provide a coherent, logical and mostly balanced discussion in their work that covers how the design and construction of external works is suitable for the new construction project, including how external works are affected by the incorporation of a sustainable urban drainage system. This should include consideration of methods that delay and/or minimise the discharge of excess surface water, methods that provide for localised infiltration to groundwater and how all three approaches can be combined into a single effective system.

For pass standard, learners will demonstrate knowledge and understanding in their work of external works that incorporate sustainable drainage systems, including methods of temporary storage and methods allowing percolation to groundwater. Learners will demonstrate an awareness of the various external works requirements to cover the basic proposals and site information for a low-rise scenario. Illustrations and/or sketches with annotations may be used, alongside written submissions, to help convey knowledge and understanding of the different principles and details.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units

This unit links to:

- Unit 2: Construction Design
- Unit 4: Safe Working Practice
- Unit 7: Graphical Detailing
- Unit 12: Building Surveying in Construction
- Unit 13: Site Engineering for Construction
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction
- Unit 16: Provision of Primary Services in Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- participation in audience assessment of presentations
- design/ideas to contribute to unit assignment/case study/project materials
- work experience
- employer's business materials as exemplars
- support from local business staff as mentors.

Opportunities to develop transferable employability skills

Learners will have the opportunity to develop the following transferable skills in the completion and assessment of this unit.

- Decision making when comparing information.
- Presentation and interpersonal skills when working with others.
- Analytical and evaluative practices when considering use of construction materials.
- Mathematical skills and knowledge when calculating costs.

Unit 2: Construction Design

Level: **3**
Unit type: **Internal set assignment**
Guided learning hours: **60**

Unit in brief

Learners will apply the principles and practice of design and construction for low- and medium-rise buildings and structures.

Unit introduction

Almost all human activity takes place in and around buildings and structures that are, for example, places of shelter, work, worship, culture and sport, and these places have a strong influence on our quality of life. Buildings are deceptively complex and expensive to build and maintain, so their design requires careful consideration to ensure that they are fit for purpose and meet user requirements. Creating buildings and structures is a unique process that requires input from a team of built environment professionals, who take into consideration a wide variety of factors to resolve problems and meet client requirements.

In this unit, you will learn the principles and practice involved in the design and construction of low- and medium-rise buildings and structures, and gain an understanding of how design is influenced by client requirements and external constraints. You will consider the stages involved in the design and construction process and gain an understanding of the use of design techniques, including sketching and computer-aided design (CAD) to provide efficient methods of designing, constructing and maintaining structures over their life cycle. To complete the assessment task within this unit, you will need to draw on your learning from across your programme.

The content of this unit will give you the knowledge and understanding of design and construction that will support your progression to employment as a trainee construction professional, or entry to a construction-related higher education programme including degree-level.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Understand the construction design and build concepts and processes

B Project information and building design production

C Construction methods and techniques.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the construction design and build concepts and processes	**A1** Stages and tasks involved in the design process **A2** Factors that influence the design process	This unit is assessed through a Pearson Set Assignment.
B Project information and building design production	**B1** Project information **B2** Initial project brief **B3** Design production **B4** Computer-aided design	
C Construction methods and techniques	**C1** Forms of low- and medium-rise structures **C2** Sub-structure construction **C3** Superstructure construction **C4** Sustainability	

Content

Learning Aim A: Understand the construction design and build concepts and processes

A1 Stages and tasks involved in the design process

The application of stages related to the tasks associated with the design of low- and medium-rise domestic, commercial and industrial buildings.

- Preparation and brief.
- Concept design.
- Developed design.
- Technical design.

A2 Factors that influence the design process

Requirements and constraints, and their impact on the initial project brief and design process for combinations of rural, urban, greenfield and brownfield settings.

- Client requirements for the project outcomes:
  - building use:
    - to include domestic, industrial, commercial, retail, health, diversity and recreation
    - how the building operates within its defined use
  - the project spatial requirements – building size, layout, circulation space, number of floors, number and use of rooms
  - flexibility and remodelling potential
  - future extension potential to meet residential needs and business expansion
  - external and internal aesthetics, types and use of materials
  - sustainability, energy efficiency, alternate types of energy sources
  - age demographic of the building user(s)
  - target market sector
  - needs of different building users
  - security requirements for the building and client operations
  - corporate image and branding requirements.
- Site information and constraints:
  - site features – location, size, configuration, orientation, access, topography
  - borehole report used to provide information on geotechnical and ground conditions
  - ground contamination
  - building services availability
  - existing buildings, structures
  - neighboring structures and the need for temporary and permanent support
  - existing underground services
  - trees
  - rights of way
  - underground transport.

- Planning constraints:
  - planning consent/approval
  - local plan requirements
  - design sympathetic to local environment
  - planning objections and pressure groups
  - listed building consent
  - protection of greenbelt land
  - conservation areas
  - tree preservation orders (TPO), contaminated land, flood risk areas.
- Statutory constraints and their requirements, including subsequent updates:
  - construction design/management law/regulations
  - building regulations approval
  - disability laws/regulations
  - restrictive covenants on land and property.
- Environmental constraints:
  - avoidance of air, water and noise pollution
  - national planning requirements relevant to the local vernacular
  - wildlife and countryside protection with reference to protected species and habitat conservation.
- Social constraints:
  - neighbours' rights
  - local community objections
  - green space requirements
  - environmental and sustainability requirements
  - mixed and balanced development.
- Project budget and economic constraints:
  - cost planning
  - available funds
  - source of additional funding for business premises – grants, government incentives, regional funding, subsidies
  - local land prices
  - first-time buyer residential accommodation – borrowing potential, shared-ownership schemes, government incentives for developers
  - life cycle costs.

Learning Aim B: Project information and building design production

B1 Project information

Information used in the production of building designs.

- Client requirements.
- Site constraints.
- Planning constraints.
- Statutory constraints.
- Environmental and sustainability considerations.
- Social constraints.
- Economic constraints.

B2 Initial project brief

The initial project brief's purpose and its application.

- Content of an initial project brief:
  - spatial requirements
  - desired project outcomes
  - site information
  - budget requirements.
- Use of an initial project brief to generate and develop design ideas and specifications.
- Completion of an initial project brief: use of appropriate tone and technical language for target audience.

B3 Design production

Production of creative and innovative outline solutions and designs to meet initial project brief requirements and their presentation requirements for client and design team use.

- Production of designs for low- and medium-rise domestic, commercial and industrial buildings.
- Outline solution – to communicate use of space and appropriate form of construction.
- 2D and 3D sketches of initial ideas, to include internal and external views, plans and elevations:
  - freehand sketched
  - single-point perspective
  - two-point perspective
  - planometric views
  - isometric views
  - use of line thickness to convey a 3D effect
  - use of shade and light direction
  - freehand rendering techniques.
- Clear communication using technical annotations.
- Clear communication of key features, to include external fabric, roof type, service access, circulation space, windows, doors, etc.

B4 Computer-aided design

Use of computer-aided design (CAD) to produce virtual models and interiors.

- Setting up CAD projects:
  - number of floors
  - floor levels
  - linking elements, to include top and bottom anchors
  - building footprint
  - component libraries
  - saving in an appropriate format.

- Use of basic CAD methodologies:
  - dimensional control, sizing and scale
  - detail levels, to include appropriate level for drawing use and audience:
    - fine
    - medium
    - coarse
  - use of 'hidden element' features
  - setting up and drawing composite elements:
    - walls
    - floors
    - roofs
  - standard opening components, placing and positioning:
    - doors, to include external, internal, garage and industrial
    - windows
  - inclusion and placing of fixtures and fittings:
    - stairs
    - fitted units and fitted furniture
    - plumbing and sanitary ware fixtures
    - light fittings
  - furnishing and lighting for selected internal area.
- External site area:
  - setting up ground area
  - surface effects, to balance natural and built environment
  - contours, relief and topography
  - inclusion of features, to include street furniture, cars, etc.
  - inclusion of landscaping and planting features.
- Use and manipulation of CAD software to produce virtual models:
  - 3D digital project information:
    - 3D views
    - 3D perspective effects
    - surface detailing and effects
  - 2D digital project information, to include appropriate scale and level of detail:
    - plans
    - elevations
    - sections
- 3D manipulation:
  - orientation and rotation of images
  - zooming
  - detail level.

- Rendered images:
  - camera views, to include camera position, angle of coverage, shadow effects
  - setting up rendered views:
    - internal lighting effects
    - external lighting effects
    - weather effects
    - seasonal effects
    - sun position
    - lighting/sun on or off
    - detail level
  - processing, saving and printing of rendered images.
- Extraction of 2D and 3D drawings:
  - plans
  - elevations
  - cross sections
  - 3D models.
- Drawing output:
  - setting up borders and title block
  - orthographic drawing conventions, to include third angle
  - scale and placement of images
  - printer and screen outputs.

Learning aim C: Construction methods and techniques

Construction methods and techniques used in the design and construction of low- and medium-rise domestic, commercial and industrial buildings.

C1 Forms of low- and medium-rise structures

- Functional requirements of key primary and secondary elements.
- Types, characteristics and application of construction techniques and methods for:
  - traditional construction
  - timber frame construction
  - steel frame construction
  - light steel frame construction
  - concrete frame construction
  - modern methods of construction (MMC)
  - structural insulated panels (SIPs)
  - Passivhaus construction.

C2 Sub-structure construction

- Types, purpose and use of methods of site investigation and analysis:
  - site surveys – desk, walk-over, measured, survey reports
  - soil investigation – bore holes, trial pits, auger, test data/results/reports
  - soil assessment – classification, particle size distribution, compressive/tensile/ shear strength
  - groundwater – water table, contaminates, dewatering techniques/control.

- Factors and principles affecting foundation design:
  - structural requirements – building type, loading types, load transmission
  - ground load bearing capacity – soil type/condition
  - differential settlement and ground heave – made up ground, subsidence, underground features/mining, shrinkable clay, frost, trees, hard standings.
- Purpose, types, sizing, construction methods/techniques and details of foundations:
  - strip – traditional, deep, narrow, wide, stepped, reinforced
  - raft – edge thickening, edge beam, reinforced
  - pad – isolated, combined, reinforced
  - pile – replacement, displacement, end bearing, friction, pile caps, edge beams, reinforced.

C3 Superstructure construction

The construction requirements and detailing of the superstructure and external envelope, and their suitability for use in different scenarios.

- External walls:
  - solid masonry, cavity walls, curtain walls, infill walling, rain screen, panel, cladding, profiled sheets, rammed earth, straw bale
  - formation of openings, heads, sills, jambs/reveals, thresholds
  - weather tightness
  - thermal and acoustic insulation
  - finishes.
- Internal walls:
  - separating/party, partition/compartment
  - loadbearing, non-loadbearing
  - finishes.
- Structural frames:
  - steel, reinforced concrete, timber, structural insulated panels, light gauge steel
  - fire protection.
- Ground floors:
  - solid and suspended
  - in-situ concrete, beam and block, timber
  - thermal insulation
  - damp proofing
  - finishes
  - upper floors – composite concrete/profiled steel, pre-cast concrete slabs, in-situ concrete, beam and block, timber/engineered timber
  - fire protection.
- Roofs:
  - flat/pitched forms and terminology
  - traditional, trussed rafter, profiled decking, lattice frame, portal frame
  - weather protection, coverings.
- Stairs and landings:
  - stair and landing terminology/regulations
  - timber, in-situ concrete, precast concrete, steel.

- Doors and windows:
  - types, construction
  - uses in fire compartmentalization and escape.

C4 Sustainability

Sustainability methods and techniques used in the design of modern construction projects and in the refurbishment, remodelling and extension of existing buildings to reduce pollution, the impact on the environment and the carbon footprint of the building.

- Passive solar gain.
- Passive stack ventilation.
- Water use reduction methods:
  - grey water systems
  - rainwater harvesting
  - water efficiency measures and fittings.
- Waste reduction measures:
  - segregation of waste
  - recycling.
- Use of alternative energy sources:
  - ground source – ground source heat pump (horizontal and vertical)
  - air source – air source heat pump (indoor heat exchanger, outdoor heat exchanger, air to air, air to water)
  - wind – micro wind generator (horizontal axis; vertical axis)
  - solar – solar photovoltaic (PV) panels, solar panel (thermal).
- Energy-efficient electrical and mechanical services installations.
- Sustainable and low embodied energy materials.
- Insulation methods:
  - floors
  - walls
  - roofs.
- Sustainable urban drainage systems.
- Sustainable landscape design.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the construction design and build concepts and processes		**A.D1** Evaluate the stages, tasks and factors involved in the design process.
A.P1 Explain the stages and tasks involved in the design process. **A.P2** Explain the factors that influence the design process.	**A.M1** Discuss the stages, tasks and factors that are involved in the design process.	
Learning aim B: Project information and building design production		**B.D2** Evaluate the requirements of the project brief when designing a building for a project scenario.
B.P3 Explain how information is used when developing a building design. **B.P4** Demonstrate the use of CAD to produce a design proposal.	**B.M2** Discuss the information when preparing a design for a building for a given scenario.	
Learning aim C: Construction methods and techniques		**C.D3** Justify the choice of all forms of construction for the building design for a given project scenario.
C.P5 Explain the form of construction, sub-structure and superstructure for building design for a given scenario. **C.P6** Comment on sustainability of methods and techniques used in building design for a given scenario.	**C.M3** Analyse a given scenario to provide a recommended form of construction associated with the design of a building in a given scenario.	

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess learners.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

This unit is assessed internally by the centre and externally verified by Pearson. Please read this guidance in conjunction with Section (TBC) Internal Assessment.

Learning aim A

For Distinction standard, learners will demonstrate a comprehensive knowledge and understanding of the factors that influence design and development, and consider in depth how these impact on construction details. They will make use of developed technical vocabulary in their work.

For Merit standard, learners will demonstrate some knowledge and understanding of the factors that influence design and development, with some consideration of how these impact on construction details. They will make some use of appropriate technical vocabulary in their work.

For Pass standard, learners will demonstrate limited knowledge and understanding of the factors that influence design and development, with little consideration of how they impact on construction design. They will show limited use of technical vocabulary in their work.

Learning aim B and C

For Distinction standard, learners will be able to use and interpret most of the relevant information in the context of a scenario, showing a balanced consideration of this information with minimal errors or omissions. They will be able to analyse the spatial requirements of a project and provide detailed justifications of suitable forms of construction to produce a design that communicates design intentions with clarity and comprehensively addresses the initial project brief. Learners use annotations that clearly explain the key features and operation of the design. They can produce an accurate and complete virtual model that appropriately addresses the scenario requirements and provide printouts of 3D rendered views.

For Merit standard, learners will be able to select, use and interpret relevant information in the context of a scenario. They will be able to consider the spatial requirements of a project and consider suitable forms of construction to produce a design that communicates design intentions with clarity and addresses aspects of the initial project brief, with some use of annotations. They can produce a virtual model that addresses some aspects of the scenario requirements and provide printouts of 3D rendered views.

For Pass standard, learners will show limited ability in selecting and interpreting relevant information in the context of the scenario. They will demonstrate limited awareness of the spatial requirements and suitable forms of construction when producing a design. They will produce a limited virtual model which will have omissions and be lacking in detail.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units

The assessment for this unit should draw on knowledge, understanding and skills developed from:

- Unit 1: Construction Technology
- Unit 7: Graphical Detailing
- Unit 11: Management of a Construction Project
- Unit 15: Measurement Techniques in Construction
- Unit 20: Quantity Surveying
- Unit 21: Building Services Science

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 3: Construction Science

Level: **3**
Unit type: **Internal set assignment**
Guided learning hours: **60**

Unit in brief

Learners demonstrate an understanding of the underlying scientific principles used in the design, construction and refurbishments of buildings and infrastructure.

Unit introduction

Roles in the construction and built environment industry require the application of knowledge and understanding related to the design of structures and infrastructure, the selection and use of construction materials, and the provision of human comfort in buildings. Whether you want to become a site manager, designer, engineer or surveyor, you will apply the knowledge and skills to ensure that materials are fit for purpose and that specified quantities are ordered and used on a construction project.

In this unit, you will develop the skills needed to solve a variety of practical construction problems by applying knowledge of materials and scientific principles. You will learn about the science that underpins the manufacture, properties and degradation of construction materials. You will apply mathematical principles and techniques to carry out calculations that determine how materials behave under the action of forces or loads when used as structural members, and draw conclusions regarding whether a material is fit for purpose. You will understand scientific principles and apply them to heat loss, sound reduction and lighting levels to provide human comfort during structure design, build and refurbishment.

This unit gives a foundation to help you progress to a wide range of construction-related higher education qualifications and will support you in a variety of construction roles, such as a technician, or as a trainee.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Explore construction materials and their properties

B Examine the behaviour of construction materials

C Examine thermal comfort in the built environment

D Examine how acoustics and lighting affect human comfort in the built environment.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore construction materials and their properties	**A1** Material properties **A2** Properties of construction materials	This unit is assessed through a Pearson Set Assignment.
B Examine the behaviour of construction materials	**B1** Degradation of construction materials **B2** Effects of temperature changes on construction materials **B3** Behaviour of structural members under load	
C Examine thermal comfort in the built environment	**C1** Scientific principles and their application in the built environment **C2** Heat losses and gains in buildings **C3** Condensation	
D Examine how acoustics and lighting affect human comfort in the built environment	**D1** Acoustic comfort **D2** Lighting	

Content

Learning aim A: Explore construction materials and their properties

A1 Material properties

Material properties, characteristics, terminology and use in construction:

- mass and density
- strength
  - tensile
  - compressive
  - shear
  - bending
- hardness
- toughness
- malleability
- workability
- stiffness
- fatigue and creep
- fire resistance
- electrical conductivity and conductance
- thermal conductivity and conductance
- resistance to moisture penetration
- resistance to vapour penetration
- resistance to degradation
- embedded energy
- recycling potential.

A2 Properties of construction materials

Key properties of construction materials, how they work together to provide composite performance and properties, how they impact on performance in use, and the specification of materials for different scenarios and levels of exposure to the elements.

- Bricks – facings, Class A engineering, Class B engineering, commons.
- Concrete – prescribed mixes, design mixes, mixes by ratio of volume, mixes by ratio of weight, screed mixes.
- Concrete blocks – aerated, high density, insulated.
- Mortar mixes – cement mortar, lime mortar, cement lime mortar, coloured mortar.
- Sand – building, sharp, silver.
- Plasterboard.
- Glass and glass finishes – smart, laminated, tempered, float, clear, obscured.
- Insulation materials – fibreglass, expanded polystyrene, Celotex, mineral wool, cellulose, straw, polyurethane.
- Plastics used for polythene damp-proof membranes (DPM), damp-proof courses (DPC).
- Plastics used for doors and window frames, soffits, bargeboards, fascia, guttering, Polyvinylchloride (PVC), unplasticised Polyvinylchloride (uPVC).

- Timber and manufactured boards – hardwoods, softwoods, plywood, chipboard, particle board, medium-density fibreboard (MDF).
- Roofing materials – slate, concrete, pantile, roofing felt, thatch, ridge, lead flashing, corrugated metal sheet.
- Engineered timber – glulam beams, engineered joists.
- Steel – mild, stainless, high strength.
- Aluminium alloys.
- Natural materials – stone, bamboo, clay, straw, wattle and daub, mud, grass.

Learning aim B: Examine the behaviour of construction materials

B1 Degradation of construction materials

The impact of the climate and environment on building materials for various scenarios, degradation methods and types, preventive and reduction measures, and impact of failure of a single material in a composite element.

- Sources of degradation and their cause:
  - natural agents – ageing, ultraviolet (UV) radiation
  - timber infestation – insect attack, fungal
  - timber decay – wet rot, dry rot, lichens and mosses
  - moisture movement – capillary action, shrinkage
  - exposure conditions – weathering, freeze-thaw, thermal ageing, creep, humidity, loadings
  - chemical degradation – acid rain, sulphate, alkalis, leaching
  - corrosion in metals – oxidation.
- Remedial measures to prevent and reduce degradation and their benefits and drawbacks:
  - use of special paints
  - protective coatings.

B2 Effects of temperature changes on construction materials

- Types of heat:
  - latent
  - sensible.
- The effect of temperature change on the properties of materials:
  - changes of state
  - evaporation
  - expansion and contraction.

B3 Behaviour of structural members under load

- Types of structural members:
  - beams, lintels
  - columns, walls and frames
  - struts and ties.
- The effect of different loading conditions and potential failure of beams, lintels, columns, walls, frames, struts and ties in the following materials:
  - concrete
  - reinforced concrete
  - timber
  - steel.

- Types, configuration and effect of loads:
  - dead and live load
  - imposed and wind loads
  - point and distributed loads.
- Characteristics, properties and use of types of supports:
  - pinned
  - roller
  - hinged
  - fixed.
- Effects of structural failure on structural members.

Learning aim C: Examine thermal comfort in the built environment

C1 Scientific principles and their application in the built environment

- Air temperature.
- Mean radiant temperature.
- Relative humidity.
- Air movement.
- Dry and wet bulb temperatures.
- Mechanisms of heat transfer:
  - conduction
  - convection
  - radiation.
- Measurement instruments and their application in heat in determining human comfort conditions:
  - thermometer
  - globe thermometer
  - hygrometer
  - anemometer
  - electronic control systems
  - thermostats
  - remote monitoring systems, e.g. smartphone applications to monitor and control temperature, reduce energy usage and costs.
- Acceptable thermal comfort parameters according to a combination of personal factors and thermal comfort requirements:
  - age
  - gender
  - clothing
  - state of health
  - level of activity
  - metabolic rate.

C2 Heat losses and gains in buildings

- How heat is lost in a building:
  - fabric heat losses
  - ventilation heat losses
  - thermal bridges and their impact on heat losses.
  - contribution of air changes to heat losses

- Factors contributing to heat gains and losses:
  - insulation of building
  - surface area of the external shell
  - exposure and impact of local and changing climatic conditions on a building
  - temperature difference between inside and outside
  - air change rate
  - building use.
- Thermal conductivity and thermal resistance.
- Significance of the insulating material and its thickness.
- Determination of fabric and ventilation heat losses.
- Heat loss control methods (alternative methods for controlling heat loss from buildings):
  - roof, wall and floor insulation
  - double/triple glazing, low emissivity glass
  - secondary glazing
  - draught reduction
  - insulated building materials
  - location and type of heating installations in a building.

C3 Condensation

- Sources of water vapour in buildings.
- Causes and effects of condensation in buildings.
- Impact of structural temperature profiles.
- Impact of dew-point temperature profiles.
- Prediction and prevention of condensation.
- Interstitial condensation.
- Methods for controlling condensation in buildings:
  - air conditioning
  - heating and ventilation
  - dehumidification
  - extractor fans.

Learning aim D: Examine how acoustics and lighting affect human comfort in the built environment

D1 Acoustic comfort

Scientific principles of sound, its relation to human comfort and the acoustic fitness for purpose of the area relative to its intended use.

- Scientific principles:
  - difference between sound and noise
  - frequency of sound
  - standard units
  - addition and averaging of decibel levels
  - sound reduction indices
  - reverberation times.

- Acceptable acoustic comfort parameters of an area relative to its intended use:
  - current building regulations
  - noise criteria indices
  - personal factors: age; previous exposure to noise; state of health; type of activity.
- Measurement of sound levels.
- Difference between sound insulation and sound absorption.
- Difference between airborne and impact sound.
- Issues associated with flanking transmission.
- Reasons why sound insulation and sound reduction is required.
- Understanding and application of sound insulation approaches:
  - source-path-receiver approach
  - improving structural elements
  - controlling flanking sound
  - use of appropriate materials to reduce sound.

D2 Lighting

Scientific principles and the provision of appropriate lighting levels and type for various activities in the built environment.

- Scientific principles:
  - differences between natural and artificial light
  - illuminance levels
  - daylight factors
  - glare indices
  - direct and reflected light
  - power of a light source
  - flow of light energy
  - illumination of surface.
- Standard units of measurement:
  - candela – power of a light source
  - lumen – flow of light energy
  - lux – illumination on surface.
- Acceptable illuminance levels for different activities and building use.
- Variation of daylight factors in a room.
- Principal components of daylight factor:
  - sky component (SC)
  - externally reflected component (ERC)
  - internally reflected component (IRC).
- Artificial lighting sources:
  - incandescent lamps
  - compact fluorescent lamps (CFLs)
  - fluorescent tubes
  - discharge lamps
  - halogen lamps
  - ballast lamps
  - light-emitting diodes (LEDs).

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Explore construction materials and their properties</td><td rowspan="4">AB.D1 Evaluate the suitability of the combined use of given construction materials to meet performance requirements.</td></tr>
<tr><td>A.P1 Explain, with reference to material properties, why materials are suitable for given situations.</td><td>A.M1 Discuss why specific materials are appropriate for given situations.</td></tr>
<tr><td colspan="2">Learning aim B: Examine behaviour of construction materials</td></tr>
<tr><td>B.P2 Explain how construction materials can deteriorate in use and the methods used to prevent this.
B.P3 Explain the underpinning concepts related to structures under load.</td><td>B.M2 Assess the effects of external conditions on construction materials and structures and how the effects can be reduced.</td></tr>
<tr><td colspan="2">Learning aim C: Examine thermal comfort in the built environment</td><td rowspan="4">CD.D2 Evaluate factors that impact on human comfort for a given context in the built environment.</td></tr>
<tr><td>C.P4 Explain factors that can affect thermal comfort.
C.P5 Explain how heat losses, heat gains and condensation occur in buildings.</td><td>C.M3 Assess how thermal comfort can be affected by internal and external factors.</td></tr>
<tr><td colspan="2">Learning aim D: Examine how acoustics and lighting affect human comfort in the built environment</td></tr>
<tr><td>D.P6 Explain the principles of acoustic comfort.
D.P7 Explain how lighting levels affect comfort levels inside buildings.</td><td>D.M4 Discuss how human comfort can be affected by sound and light.</td></tr>
</table>

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess learners.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, learners must show a full range of progressive steps when producing solutions to complex problems related to the science of construction materials. They will interpret the information provided and then demonstrate good use of methods, including demonstrating a clear understanding of how materials behave under loading conditions. Learners will recognise links between different aspects of materials, their properties and their applications, and will produce solutions that follow a logical structure when selecting materials for given construction problems.

Solutions to calculations will be provided to an appropriate degree of precision and be presented in their simplest form. Learners might make minor errors, however these would be unlikely to impact on design decisions for structural members.

For Merit standard, learners must produce solutions to a range of construction problems that involve a number of different materials and how they perform under given conditions. Learners should show they are able to interpret information in order to select appropriate methods to solve a number of problems linked to materials, their properties and also their applications and to suggest suitable materials for given applications.

The majority of calculations will be completed using an appropriate method, although there may be some minor errors, such as transposition errors or taking unconventional approaches to arrive at suitable solutions. Some arithmetic errors may be present, which are then likely to be carried through in subsequent working.

For Pass standard, learners must show solutions to routine construction related problems that are logical in the choice of processes to be followed and demonstrate an understanding of the properties of materials and their behaviour in use. Solutions to single stage problems will be mostly accurate although minor arithmetic errors are acceptable, whilst explanations of concepts will be accurate and be sufficiently detailed to convey understanding to third party.

Learning aims C and D

For Distinction standard, learners will evaluate the effectiveness of the combination of acoustic, thermal and lighting factors on human comfort for a given low-rise construction scenario. Learners will demonstrate sound knowledge and understanding of specific human comfort parameters, the methods of achieving human comfort and performance requirements for the various elements of building structures and services to ensure human comfort is achieved. Learners will review the different methods and details in the context of the scenario and will bring together key considerations to form a supported conclusion, including alternative suggestions where appropriate, drawing on information relevant to the given scenario.

For Merit standard, learners will provide a coherent, logical and mostly balanced assessment that considers the relationship between thermal comfort and the internal and external factors that affect heat losses and gains within a low-rise construction scenario. They will present a logical discussion of how light and sound influence human comfort and consider the scientific principles that underpin human comfort within given construction contexts.

For Pass standard, learners will provide a clear explanation of factors that can influence thermal comfort in low-rise domestic dwellings, including the scientific principles that relate to heat transfer and ways in which heat losses and gains can occur in buildings. Their explanation will cover how heat transfer occurs through the fabric of a building, although the explanation may be generic and have limited focus on the scenario. Learners' work will cover an explanation of acoustic comfort, including ways in which noise and sound can be controlled, but this will be generic and not focused on the scenario. Details of how lighting levels affect comfort levels in a building will be outlined, covering both artificial and natural light, to help convey knowledge and understanding of the different scientific principles and types of illumination that may be available.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 12: Building Surveying in Construction.

Opportunities to develop transferable employability skills

This unit provides learners with the knowledge and understanding of the scientific principles that underpin all strands of construction. It provides an opportunity for learners to develop the analytical problem-solving skills required to complete projects independently. Learners will also have the opportunity to develop their skills in the interpretation of data and relevant information for a construction project.

Unit 4: Safe Working Practice

Level: **3**
Unit type: **Internal set assignment**
Guided learning hours: **60**

Unit in brief

Learners will carry out a safe system of work and investigate the significance of safety system reviews. They will understand the responsibilities of employees and employers with regard to health and safety in construction operations.

Unit introduction

Health and safety in construction operations is essential so that workers carry out practical activities safely. Safety means planning appropriate systems of work, assessing the risks in construction operations, and applying control measures to reduce risks to an acceptable level. Companies aim for a target of zero accidents in the workplace, promoting their reputation as safe constructors.

In this unit, you will examine the importance of planning to promote effective safe working practice. You will also examine the procedures used to control hazards and risks for construction operations across a range of activities. You will design a safe system of work that could be instigated and maintained in a typical on-site construction context.

This unit can help you progress to health and safety management and supervision in the construction sector as a contracts manager or site manager, or to specialist health and safety qualifications.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit, you will:

A Explore the principles of safe working practice

B Carry out the development of a safe system of work for construction operations

C Understand safe working practice for on-site construction operations.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore the principles of safe working practice	**A1** Importance of safe working practice **A2** Regulation of safe working practice **A3** Planning of effective safe working practice	This unit is assessed through a Pearson Set Assignment.
B Carry out the development of a safe system of work for construction operations	**B1** Risk assessment **B2** Principles of hazard prevention **B3** Preparation of method statement	
C Understand safe working practice for on-site construction operations	**C1** General on-site health and safety **C2** Working at height **C3** Controlling substances hazardous to health **C4** Manual handling **C5** Working with plant, machinery and equipment **C6** Working with excavation **C7** Training and education	

Content

Learning aim A: Explore the principles of safe working practice

A1 Importance of safe working practice

Reasons for promoting good standards of safe working on a construction site:

- avoiding worker fatalities and injuries
- reducing incidences of ill-health
- meeting society's expectations
- the need to provide a safe place to work
- the requirement for a safe plant and equipment
- safe systems of work
- competent workers.

A2 Regulation of safe working practice

Role of national government and international bodies in formulating best practice, legislation and regulations relating to safe working, covering:

- employer's responsibilities
- workers' rights and responsibilities
- the role of enforcement agencies
- legislation
- national and international standards
- the consequences of non-compliance with legislation, standards and enforcement agencies.

A3 Planning of effective safe working practice

The key elements of safe working management systems, including:

- policy
- organising
- planning and implementing
- evaluation – monitoring, review, measurement, investigation
- auditing
- actions for improvement – preventative/corrective actions.

Learning aim B: Carry out the development of a safe system of work for construction operations

Relevant administration and management tasks must be carried out to ensure that a construction site is a safe place of work.

B1 Risk assessment

- Definition of a hazard and a risk.
- Principles of risk assessment:
  - identifying hazards by various methods – direct observation, checklists, ‘toolbox talks’
  - identifying those at risk – workers, operators, maintenance staff, cleaners, contractors, visitors, public
  - evaluating risk and adequacy of current controls
    - likelihood of harm and probable severity
    - risk ratings
    - prioritisation or risk
    - applying controls to specific hazards
    - residual risks: acceptable/tolerable risk level.
- Writing risk assessments and evaluating control measures.
- Arrangements for controlling significant risk and safe systems of work.
- Requirements to review risk assessments – following an accident, change legislation, new equipment.

B2 Principles of hazard prevention

- Hierarchy of hazard prevention:
  - eliminate the hazard/risk
  - control the hazard/risk at source by modifying a construction solution
  - minimise the hazard/risk by introducing a safe system of work
  - where residual hazards/risks cannot be controlled by collective measures, provide personal protective equipment (PPE).

B3 Preparation of method statement

Distinction between a written method statement and a safe system of work.

Writing method statements, sequencing of statements, resources to be used.

- Content of a method statement:
  - a step-by-step description of the activities to be undertaken
  - plant and equipment requirements
  - training procedures
  - precautions necessary to protect workers and others
  - handling and storage of materials
  - temporary works requirements
  - emergency procedures.

Learning aim C: Understand safe working practice for on-site construction operations

C1 General on-site health and safety

General provisions for managing construction safety on site.

- Management and arrangement of the work, including:
  - site-specific health and safety goals
  - site security
  - site rules
  - fire and emergency procedures
  - accident/near-miss reporting
  - site welfare/first aid
  - waste disposal and good housekeeping
  - gate and entrance signage and notices
  - minimising noise and vibration.
- Use, isolation, inspection, maintenance and certification of plant and equipment.
- Issuing, care and maintenance of PPE.
- Safe stacking and storage of materials and flammable substances.
- Safe working procedures near overhead power lines.
- Management of open excavations.
- Precautions necessary to prevent falling materials.
- Precautions necessary when working in adverse weather conditions.
- Checks for buried services.

C2 Working at height

The approach to working safely at height:

- organisation and planning required before working at height commences
- avoiding risks from working at height by establishing if an alternative safer method can be used
- work equipment requirements for operatives
- requirements for any working platform used to gain access for working at height
- requirements for personal fall protection to be provided for employees
- the use of ladders.

C3 Controlling substances hazardous to health

Aspects of the use of substances and chemicals during construction activities on site:

- main classification of substances hazardous to health – irritant, corrosive, harmful, toxic or carcinogenic
- forms of substances hazardous to health, including dusts, fibres, fumes, gases, mists, vapours and liquids
- health effects of substances hazardous to health, both acute and chronic
- risk assessment of all substances used in the workplace – highlighting precautionary methods to be employed before and during use

- control measures, use, maintenance, examination and testing – reducing the risk to an acceptable level
- exposure limits in the long and short term
- monitoring and health surveillance of employees using substances at work.

C4 Manual handling

Explore methods of handling manual loads to avoid personal injuries:

- typical manual handling injury, including chronic and acute
- safe manual load
- assessment of manual handling risk by considering the task, load, individual and work environment
- means of eliminating or mitigating manual handling risk, including design, automation and mechanisation
- methods of carrying manual load to mitigate injury owing to lifting, poor posture, repetitive or awkward movement.

C5 Working with plant, machinery and equipment

Explore methods of working safely with plant and machinery:

- types of plant, machinery and equipment, including handheld tools, vehicles and heavy plant such as excavators
- hazards presented by using plant, machinery and equipment, including electrocution, vibration and noise
- assessment of risk for using plant, machinery and equipment
- method of eliminating or mitigating risk associated with using plant, machinery or equipment such as guards or emergency stop controls.

C6 Working with excavation

Explore methods of working safely with open excavations:

- hazards presented by working near or in open excavations, including buried services, falls, excavation collapse, water ingress, contaminated ground
- method of eliminating or mitigating risk associated with excavations such as excavation supports, barriers, dewatering, positioning of spoil, and routing of vehicles and plant.

C7 Training and education

- Induction and on-site safety training, e.g. toolbox talks.
- Fire safety training.
- Off-site training requirements and links to control measures, e.g. for working at height, noise, confined spaces.
- Training associated with equipment.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Explore the principles of safe working practice		
A.P1 Explain the benefits of promoting good standards of safe working practice. **A.P2** Explain how regulation controls health and safety in construction. **A.P3** Explain how effective planning improves standards of health and safety.	**A.M1** Discuss the impact of health and safety working practice principles, regulation and planning in controlling health and safety in construction.	**A.D1** Evaluate the effectiveness of health and safety working practice principles, regulation and planning in controlling health and safety in construction.
Learning aim B: Carry out the development of a safe system of work for construction operations		
B.P4 Explain methods used to identify hazards and assess risks. **B.P5** Produce a safe system of work for a given construction operation and a risk assessment, to include a method statement giving effective control measures.	**B.M2** Optimise the safe system of work for a construction operation.	**B.D2** Justify the optimised safe system of work for a construction operation.
Learning aim C: Understand safe working practice for on-site construction operations		
C.P6 Explain how the application of safe working practice controls health and safety for on-site construction operations. **C.P7** Explain how education and training improve standards of health and safety.	**C.M3** Discuss the impact of health and safety working practice principles, and education and training in controlling health and safety for on-site construction.	**C.D3** Evaluate the effectiveness of health and safety working practice principles, education and training in controlling health and safety for on-site construction.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.D1)

Learning aim: B (B.P4, B.P5, B.M2, B.D2)

Learning aim: C (C.P6, C.P7, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must consider an accident report and then thoroughly evaluate how safe systems of work can be improved by using effective planning and regulation. They must consider both the strengths and potential weaknesses of the safe systems of work in relation to the scenario and arrive at a logical conclusion, with accurate justifications supporting the effectiveness of the safe system of work. Learners must demonstrate that they have developed a robust, in-depth understanding of how regulative and planning principles impact on safe systems of work.

For Merit standard, learners will adopt a balanced approach in considering an accident report and in discussing how safe systems of work can be improved by effective planning and regulation. Learners will comment on the how the regulative and planning principles of safe systems of work interrelate, in relation to the scenario.

For Pass standard, learners need to explain the benefits of promoting good standards of safe working practice. They will use mostly relevant examples to explain how regulation and effective planning improve standards of health and safety in a construction working environment.

Learning aim B

For Distinction standard, learners must thoroughly evaluate how hazard identification, risk assessment and method statements support a safe system of work for a given construction operation. They must consider the strengths and potential weaknesses of the safe system of work while examining risk assessments, method statements and control measures. This will result in a reasoned conclusion, with justifications supporting the effectiveness of the optimised safe system of work. Learners must demonstrate that they have developed a robust, comprehensive understanding of the methods used to ensure that construction operations can be carried out safely with minimal risk of accident, injury or near miss.

For Merit standard, learners must produce an optimised safe system of work. They must analyse how hazard identification; risk assessment and method statements support a safe system of work for a given construction operation. They must conduct a methodical and detailed examination that considers the various facets of the safe system of work, while examining risk assessments, method statements and control measures, and how they can be improved. Learners must demonstrate that they fully understand the methods used to ensure that construction operations can be carried out safely with minimal risk of accident, injury or near miss.

For Pass standard, learners must produce a realistic, appropriate explanation of the methods used to identify hazards and assess risks. They will produce a realistic risk assessment and method statement, with effective control measures that support a safe system of work for a given construction operation. Learners must demonstrate that they have a good understanding of the methods used to ensure that construction operations can be carried out safely with minimal risk of accident, injury or near miss.

Learning aim C

For Distinction standard, learners must thoroughly evaluate, in terms of advantages and disadvantages, the effectiveness of the principles of safe working practice in controlling risks on a construction site. Learners will make specific, relevant references to the role of safety education and training in order to produce a logical, coherent response. Learners' research must lead to a supported, convincing judgement of the impact of risk reduction, perhaps considering fatalities and major and minor accidents to come to a robust conclusion. This can include making reasoned judgements where the principles of safe working practice have not been effective, perhaps failing to reduce accident rates or incidents on construction sites.

For Merit standard, learners must discuss the principles of safe working practice, and associated training and education, in controlling safety on a construction site. They should consider what needs to be provided, for example safety information and welfare facilities, and how they are provided, depending on the principles of safe working practice. Learners will consider the impact in terms of relevant preliminary items and temporary features provided on site, for example mobile, elevated platforms for gaining access at height, and training operatives to use harnesses to restrain falls from height.

For Pass standard, learners will explain, using examples of on-site requirements, how safe working principles control health and safety for on-site construction operations. Learners will cover all the different site contexts outlined in the content for learning aim C, considering, for example, working at height. Learners will give an accurate explanation of how education and training improve standards of health and safety.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 13: Site Engineering for Construction
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction
- Unit 16: Provision of Primary Services in Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of:

- technical workshops involving staff with expertise in a range of specialist areas from local construction organisations
- contribution of ideas to unit assignments for individual learner projects
- contribution of project materials
- guest speakers from a related health and safety background
- work experience on a construction site
- business materials to be used as exemplars
- support from local business staff as mentors
- health and safety policies and procedural documentation.

Unit 5: Management of Commercial Risk

Level: **3**
Unit type: **Internal set assignment**
Guided learning hours: **60**

Unit in brief

Learners carry out an assessment of commercial risk as part of the procurement process and then consider how external factors and risks impact on a tender a firm tender offer.

Unit introduction

Construction, Civil Engineering and Building Services Engineering companies obtain work via the tendering and estimating process. Commercial managers are present at a tender settlement or adjudication meeting to decide upon the tender sums that balances the conflicting factors that impact on the potential success of the tender bid. Commercial managers consider the potential commercial risk, current workload, company growth aspirations, the need to maintain turnover and level of competition in order to arrive at a tender sum that is considered a correct and appropriate offer.

In this unit, you will learn how to consider a project scenario, together with relevant tender information, in order to produce a commercial risk assessment for use in a tender settlement meeting. You will use an estimate of the total cost of construction and an associated commercial risk assessment for a given scenario to produce an appropriate tender for a project.

The content of this unit can be directly applied to the role of the estimator and to aspects of other roles such as quantity surveyors, commercial managers, and contracts manager, who make the final decision relating to the tender sum. The unit gives a good foundation for studying management of construction projects at a higher level, including degree-level programmes.

Assessment

This unit has a set assignment. Learners must complete a Pearson Set Assignment Brief.

Learning aims

In this unit you will:

A Understand the risks associated with construction projects

B Review information used when making commercial tender decisions

C Undertake commercial decisions to support the procurement process

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the risks associated with construction projects	**A1** Tender strategies **A2** Contractual arrangements **A3** Supply chain **A4** Commercial risk analysis	This unit is assessed through a Pearson Set Assignment.
B Review information used when making commercial tender decisions	**B1** Commercial intelligence **B2** Company aspirations and needs **B3** Site visit report **B4** Business analysis **B5** Market structure	
C Undertake commercial decisions to support the procurement process	**C1** Application of risk analysis to make commercial decisions **C2** Analysis of the estimated project cost **C3** Use of commercial intelligence **C4** Tender adjudication and settlement meetings	

Content

Learning aim A: Understand the risks associated with construction projects

A1 Tender strategies

The level of potential tender importance for a company, commitment of resources and resource requirements, company attitude to commercial risk, and the need to procure further contracts to maintain company turnover or meet planned expansion, resulting in tendering strategies that are effective and appropriate.

- Decision to accept or decline the invitation to tender and level of commitment:
  - reviewing available information
  - regular tender
  - priority tender (fully committed).
- Tender decision programme:
  - visit to the site and locality
  - review of estimated project cost
  - finalisation of the tender works programme
  - internal co-ordination and review meetings
  - tender adjudication, settlement meeting.
- Allocation of resources:
  - tendering budget
  - availability of appropriate estimating team
  - supply chain tendering response times.
- Site and location.

A2 Contractual arrangements

How the project's contractual arrangements, including terms and conditions, impact on the level of risk, the decision to tender and potential financial returns.

- Conventional lump sum form of procurement:
  - with quantities
  - without quantities
- Design and build.
- Term contracts.
- Serial contracts.
- International contracts.
- Host nation standard forms of contract.

A3 Supply chain

Supply chain factors and their impact on the commercial risks associated with tender estimates.

- Quotations from suppliers and subcontractors:
  - fixed or fluctuating prices
  - variant bids
  - incomplete quotation and prices.

- Suppliers of materials:
  - number of alternative suppliers
  - capacity to supply
  - named manufacturer or generic specification
  - previous experience of supplier performance and credentials.
- Subcontractors:
  - previous experience of working relationship
  - experience of similar projects
  - number of available subcontractors in the specialist area
  - geographical area of operations
  - supervision requirements
  - references
  - insurances
  - quality assurance (QA) registration
  - health and safety record
  - collateral warranties
  - considerate contractor policies and credentials.
- Nominated suppliers and subcontractors:
  - appointment by third party
  - design elements that may be included in their package of works
  - appointment unknown at time of tender
  - value indicated via prime cost (PC) sum.

A4 Commercial risk analysis

Factors that impact on the assessment of commercial risk and the final tender decision.

- Current workload and the need to maintain turnover.
- Market conditions and economic climate.
- Political stability of the country or region.
- Currency value, fluctuations and exchange rate.
- Project considerations:
  - buildability
  - previous experience of construction methods.
- Site and location factors:
  - ground contamination
  - soil types and ground conditions
  - existing site features
  - availability of tipping facilities
  - security requirements:
    - risk of theft and vandalism
    - proximity of schools and children’s playgrounds
    - community attitude to crime reporting
    - community reputation
  - availability of skilled workforce
  - industrial relations and local labour agreements

  - o geographical location in relation to contractor's office and depot
  - o requirement for temporary roads and services
  - o presence of protected species
  - o existing trees:
    - – preservation orders
  - o delaying tactics of local pressure groups
  - o local and changing climatic conditions
  - o availability of space for contractor's accommodation, storage and distribution
  - o health and safety and environmental protection laws and/or regulations in the country or region.
- Programme factors:
  - o commencement date:
    - – weather and climate considerations
    - – in relation to completion of other projects
  - o specific contract conditions that:
    - – affect the intended method of working
    - – impose restrictions
    - – affect access to the site
    - – interrupt the regular flow of trades
    - – affect the duration of the project
    - – affect the sequencing of the project
    - – are of major cost significance or difficult to quantify in terms of cost.
- Financial issues:
  - o cash flow forecasting for the project and own company
  - o impact of inflation
  - o available finance
  - o contract bond
  - o retention percentage
  - o payment period and frequency of payments
  - o financial checks on the client:
    - – company accounts
    - – credit reference agencies
    - – confirmation of financing.

Learning aim B: Review information used when making commercial tender decisions

B1 Commercial intelligence

Information gathering and its impact on the final tender decision relating to assessing the level of competition, including number of competitors and likelihood of fully committed tenders.

- The advantages and disadvantages of gathering commercial intelligence methods to support the final tender decision:
  - o speaking to suppliers and subcontractors
  - o networking
  - o press releases
  - o subscribing to intelligence services or journals that publish information on successful bids.

- Competitive tendering:
  - number of competing bids
  - other tenderers:
    - recent tendering success
    - recent pricing levels
    - capacity to take on new contracts
    - current tendering workloads.

B2 Company aspirations and needs

How tender decisions can be impacted by internal attitudes and long term planning.

- Attitude to risk.
- Expansion plans.
- Consolidation plans.
- Specialisation.
- Preparation for business sale or share issue.
- Increase in company skill base.
- Retention of specialist staff or skilled works.
- Potential acquisitions.
- Diversity into new markets.
- Change of focus of operation.
- Contribution to head office overheads.
- Profit needs or requirements.

B3 Site visit report

Assessment of site visit information to assist with the pricing of preliminary items, repairs and alterations, and the assessment of commercial risk.

- Information obtained from the site visit and locality:
  - review of site location issues and impacts
  - assessment of structures requiring demolition
  - repairs and alterations required and their cost
  - site clearance requirements
  - identified security issues
  - site access restrictions
  - community issues assessment
  - available space for site establishment and circulation
  - appropriate methods for materials distribution on site.

B4 Business analysis

- Feasibility study methodology and approaches.
- Other feasibility and viability methods.

B5 Market structure

How the competitive environment and market structures influence supply of labour and materials and the demand for construction work, considering their impact on tender prices or the cost of construction work.

- Competitive environment:
  - competition – local, national and international
  - competitive advantage – differentiation, pricing policies, reputation, market share
  - level of commercial intelligence
  - market structures
  - perfect competition, imperfect competition, monopoly
  - features of markets – number of firms, freedom of entry, nature of product
  - barriers to entry – tariffs, quotas, contractor selection, other limiting factors
  - regional stability
  - political climate.

Learning aim C: Undertake commercial decisions to support the procurement process

Factors that influence the final tender decision and how they are considered when deciding the final tender sum.

C1 Application of risk analysis to make commercial decisions

Use of risk analysis in terms of time and potential cost, within the context of market, political and economic conditions, to determine tender adjustments:

- current workload and the need to maintain turnover
- market conditions and economic climate
- political stability of the country or region
- currency value, fluctuations and exchange rate
- site and location factors:
  - ground contamination
  - soil types and ground conditions
  - security requirements:
    - risk of theft and vandalism
    - proximity of schools and children's playgrounds
    - community attitude to crime reporting
    - community reputation
    - political activity
  - industrial relations and local, regional or national labour agreements
  - presence of protected species
  - existing trees:
    - preservation orders
    - delaying tactics of local pressure groups
  - local climatic conditions.

- programme factors:
  - commencement date:
    - weather and climate considerations
    - in relation to completion of other projects
  - duration
  - specific contract conditions that:
    - affect the intended method of working
    - impose restrictions
    - affect access to the site
    - interrupt the regular flow of trades
    - affect the duration of the project
    - affect the sequencing of the project
    - are of major cost significance or difficult to quantify in terms of cost.
- financial issues:
  - cash flow forecasting
  - impact of inflation
  - available finance
  - contract bond
  - retention percentage
  - payment period and frequency of payments
  - financial checks on the client:
    - company accounts
    - credit reference agencies
    - confirmation of financing
  - where there is the potential that the project cost exceeds the client's budget, opportunities to:
    - negotiate a bill of reductions
    - participate in value engineering workshops
    - propose contractor recommended changes.

C2 Analysis of the estimated project cost

Consideration of key cost centres:

- preliminaries
- labour cost
- materials cost
- plant cost
- overhead allowance
- total of PC sums
- total of PS and contingencies
- suggested alternative tenders or variant bids.

C3 Use of commercial intelligence

Commercial intelligence and its influence on the final tender decision.

- Competitive tendering:
  - number of competing bids
  - other tenderers:
    - recent tendering success
    - recent pricing levels
    - capacity to take on new contracts
    - current tendering workloads
    - proximity to base
    - known expertise
    - apparent attitude to risk
    - apparent attitude to contractual claims
    - relationship with client.

C4 Tender adjudication and settlement meetings

- Adjustments to the final sum to take into account:
  - company overheads
  - desired profit margin
  - potential for buyers to generate further margins
  - current market conditions and economic climate
  - need to maintain workload and turnover:
    - contribution to overhead costs
    - redundancy avoidance measures
    - continuity of cash flow
  - need to retain skills and experience:
    - managers, technicians and professionals
    - craft skills
  - previous experience of similar projects
  - company aspirations
  - planned expansion
  - acquisition of new expertise
  - commercial risk
  - considerations relevant to the host country or region
  - level of competition
    - number of competing tenderers
    - assessment of competitors' tendering intentions.
- Discounts (for the main contractor of a subcontract or package tender).
- Conversion of the estimate into a firm bid (tender).
- Director's adjustment.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the risks associated with construction projects		
A.P1 Explain the commercial risks associated with tendering for the project in a given scenario. **A.P2** Explain impact of commercial risk on the decision to tender and level of commitment.	**A.M1** Discuss the commercial risks and decision to tender associated with the project in a given scenario.	**A.D1** Evaluate the commercial risks and commitment to tender associated with the project in a given scenario.
Learning aim B: Review information used when making commercial tender decisions		
B.P3 Explain how company aspirations and needs and business analysis could influence tender decisions. **B.P4** Explain how external information and factors impact on tender outcomes.	**B.M2** Discuss the information used when making commercial tender decisions.	**B.D2** Evaluate the impact of information used when making commercial tender decisions for a given project scenario.
Learning aim C: Undertake commercial decisions to support the procurement process		**C.D3** Justify a tender submission for a given project scenario that considers risk analysis, and commercial intelligence and is a relevant submission in the context of the scenario.
C.P5 Demonstrate use of risk analysis to produce a final adjusted tender sum. **C.P6** Produce a report to recommend a tender submission for a given tender scenario.	**C.M3** Analyse a given tender scenario to provide a recommended tender submission.	

Essential information for assignments

This unit is assessed using a Pearson Set Assignment Brief. A set assignment must be used to assess learners.

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

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

Please read this guidance in conjunction with *Section 6 Internal assessment*.

Learning aim A

For Distinction standard, learners will consider the key commercial risks that are associated with the project in the scenario and will realise that some risks have a greater impact than others. They will also consider how some elements contained within the scenario may help to mitigate the identified risks and that some of the risks may impact more on the client than the contractor. They will have linked the project risk to the decision to tender and will have arrived at a conclusion relating to the use of a regular or fully committed tendering approach. Their work will be evaluative and consider the relative magnitude, importance and impact of each risk with consideration of how to mitigate the risk this will result in an evaluative conclusion related to the suggested approach to the tender.

For Merit standard, learners will consider commercial risks that are associated with the project in the scenario and may realise that some risks have a greater impact than others. They will have linked the project risk to the decision to tender and will have discussed the use of a regular or fully committed tendering approach. Their work will be discursive and consider the impact of some risks to provide a balanced recommendation.

For Pass standard, learners will consider some commercial risks that are associated with the project in the scenario but may not realise that other risks have greater impact and financial consequences, hence they may focus on some or the more minor elements of risk. They will have linked the project risk to the decision to tender and will have considered a tendering approach. Their work will be descriptive and will explain the identified risk and tendering strategy.

Learning aims B and C

For Distinction standard, learners will demonstrate a developed understanding of conflicting and complex tender price pressures that arise from; level of competition, commercial intelligence, current workload, risks present in the scenario, attitude to risk and organisational aspirations. They will identify an appropriate tender sum and fully justify their selection showing how they have considered the 'tender price pressures' to select a price that meets the needs of the company within the context of the provided scenario and market climate. Their work will be evaluative and consider the relative magnitude, importance and impact of each 'tender price pressure' with consideration of how to use monetary values to mitigate the risk this will result in an evaluative and justified conclusion confirming the proposed tender price.

For Merit standard, learners will demonstrate a good understanding of tender price pressures that arise from; commercial intelligence, current workload, risks present in the scenario, attitude to risk and organisational aspirations. They will identify an appropriate tender sum and discuss their selection showing how they have considered the 'tender price pressures' to select a price that meets the needs of the company within the context of the provided scenario and market climate. Their work will be discursive and consider the impact of each 'tender price pressure'.

For Pass standard, learners will demonstrate some understanding of tender price pressures that arise from; commercial intelligence, current workload, risks present in the scenario, attitude to risk and organisational aspirations. They will identify an appropriate tender sum and recommend its use. Their work will be mainly descriptive and consider the factors that are taken into account when deciding upon a tender submission.

Assessment controls

Time: this assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.

Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.

Resources: all learners should have access to the same types of resources to complete the assignment.

Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 11: Management of a Construction Project
- Unit 15: Measurement Techniques in Construction
- Unit 20: Quantity Surveying
- Unit 22: Economics and Finance in Construction.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Opportunities to develop transferable employability skills

This unit will help to develop analytical business skills that could be transferred to other contexts and sectors.

Unit 6: Construction Mathematics

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners will develop an understanding of a variety of mathematical methods and techniques relevant to construction and in the solving of practical construction problems.

Unit introduction

Construction, civil engineering and building services engineering are technical disciplines that require the collection, processing and use of numerical data. For example, in a simple construction project the dimensions of a structure are designed and specified by the architect or engineer, area and volume calculations are determined for cost purposes by the cost control surveyor, the quantity of materials to be ordered is determined by the buyer, and the setting out dimensions and angles may be calculated by the contractor.

It is therefore essential that learners develop an appropriate understanding of the mathematical methods and techniques required for these key activities and of how to apply them correctly.

This unit explores the rules for manipulating formulae and equations, calculating lengths, areas and volumes, determining trigonometric and geometric properties, and applying graphical and statistical techniques.

On completion of the unit, learners will be able to select and apply appropriate mathematical techniques to address a wide variety of standard, practical and industry-related problems. It will also enable learners to access more advanced mathematical-based units on their respective learning pathway.

Learning aims

In this unit you will:

A Understand basic underpinning mathematical techniques and methods to manipulate and/or solve formulae, equations and algebraic expressions

B Examine and apply mathematical techniques correctly to solve practical construction problems involving perimeters, areas and volumes

C Examine and apply geometric and trigonometric techniques correctly to solve practical construction problems

D Investigate the use of statistical and graphical methods correctly to solve construction problems.

Summary of unit

<table>
<tr><th>Learning aim</th><th>Key content areas</th><th>Assessment approach</th></tr>
<tr><td>A Understand basic underpinning mathematical techniques and methods to manipulate and/or solve formulae, equations and algebraic expressions</td><td>A1 Calculator functions
A2 Mathematical techniques including issues of rounding/ accuracy
A3 Algebraic techniques and expressions</td><td rowspan="2">A report containing:
· calculations and interpretation of results for a variety of standard, practical and industry constructed related problems.</td></tr>
<tr><td>B Examine and apply mathematical techniques correctly to solve practical construction problems involving perimeters, areas and volumes</td><td>B1 Basic techniques
B2 Practical construction problems
B3 Circular measures</td></tr>
<tr><td>C Examine and apply geometric and trigonometric techniques correctly to solve practical construction problems</td><td>C1 Trigonometric techniques
C2 Geometric techniques
C3 Practical construction problems</td><td rowspan="2">A report containing:
· calculations and interpretation of results for a variety of standard, practical and industry constructed related problems
· appropriate graphs, charts and analysis of statistical data for a series of construction related problems.</td></tr>
<tr><td>D Investigate the use of statistical and graphical methods correctly to solve construction problems</td><td>D1 Graphical techniques
D2 Statistical techniques
D3 Solving of practical construction problems</td></tr>
</table>

Content

Learning aim A: Understand basic underpinning mathematical techniques and methods to manipulate and/or solve formulae, equations and algebraic expressions

The application and understanding of the underpinning concepts of how to manipulate and/or solve formulae, equations and algebraic expressions.

A1 Calculator functions

- Be able to use the basic functions of a calculator from formula or data provided:
  - add; subtract; multiply; divide
  - sin; cos; tan
  - $\sin^{-1}$; $\cos^{-1}$; $\tan^{-1}$
  - x^2; x^3; $\sqrt{x}$
  - π; radians
  - standard form

A2 Mathematical techniques including issues of rounding/accuracy

Application of mathematical techniques and methods to manipulate and/or solve formulae, equations and expressions:

- Formulae, equations and expressions:
  - mathematical operators
  - factorization
  - expansion
  - transposition
  - substitution and elimination
  - decimal places
  - significant figures
  - use of approximation to check calculations
  - truncation errors and accuracy
  - calculator functions and use
  - rearranging formulae to change subject of formulae, complex formulae involving exponents, roots and trigonometric identities
  - substituting values into and evaluating formulae.

A3 Algebraic techniques and expressions

Application of mathematical techniques and methods to manipulate and/or solve algebra problems:

- Typical problems that involve algebraic equations or expressions:
  - linear equations of the form $y = mx + c$
  - pair of simultaneous linear equations in two unknowns
    - factorisation and quadratics
  - multiply expressions in brackets by a number, symbol or by another expression in a bracket
  - by extraction of a common factor $a(x + y)$, $a(x + 2) + b(x + 2)$
    - quadratic expressions

- roots of an equation, including quadratic equations with real roots by factorisation
- use of quadratic formula to solve quadratic expressions
- use of 'completing the square' method to solve quadratic expressions
- the application of binomial theorem to small errors.

Learning aim B: Examine and apply mathematical techniques correctly to solve practical construction problems involving perimeters, areas and volumes

Application of mensuration techniques, including the use of numerical integration method:

B1 Basic techniques

- Simple mensuration formulae.
- Numerical integration methods-application of mid-ordinate rule; trapezoidal rule; Simpson's rule.

B2 Practical construction problems

- Perimeters, areas and volumes.
- Calculations for simple and compound shapes e.g. rectangles, trapeziums, triangles, prisms, circles, spheres, pyramids, cones and regular and irregular surface areas and volumes.

B3 Circular measures

- Radian measure.
- Conversion of degree measure to radian measure and vice versa.
- Arc length $S = r\theta$
- Area of sector $A = \frac{1}{2}r^2$

Learning aim C: Examine and apply geometric and trigonometric techniques correctly to solve practical construction problems

C1 Trigonometric techniques

- Sine, cosine, tangent ratios.
- Sine rule; cosine rule.
- Area of triangle area rule $A = \frac{1}{2}ab\sin C$

C2 Geometric techniques

- Properties of points, lines, angles, curves and planes.
- Pythagoras' rule.
- Radians.
- Sectors-arc lengths and areas.

C3 Practical construction problems

- Geometric techniques to determine length, area and volume for shapes containing straight lines and curves.
- Use of trigonometry to determine dimensions in 2D and 3D e.g. surveying, setting out, dimensions of pitched roof and similar.

Learning aim D: Investigate the use of statistical and graphical methods correctly to solve construction problems

Application of statistical and graphical methods to solve practical construction problems

D1 Statistical techniques

- data types-discrete, continuous, grouped, ungrouped
- processing large groups of data to determine: mean, median, mode and standard deviation
- cumulative frequency, quartiles, quartile range
- methods of visual presentation of statistics and data, interpretation and production of: line graphs, bar charts, scatter diagrams, pie charts

D2 Graphical techniques

- Cartesian and polar co-ordinates
- intersections of graph lines with axes; gradients of straight lines and curves
- equations of straight-line graphs $y = mx + c$
- areas under straight line graphs
- solution of simultaneous equations
- solve quadratic equations

D3 Practical construction problems

- use of graphs to solve construction problems
- use of statistics to present data and make decisions based on statistical data

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand basic underpinning mathematical techniques and methods to manipulate and/or solve formulae, equations and algebraic expressions		**AB.D1** Independently carry out checks on calculations using relevant alternative mathematical methods, making appropriate judgements on the outcome.
A.P1 Demonstrate the use of the main functions of a scientific calculator to perform calculations, applying manual checks to results. **A.P2** Demonstrate the use of standard mathematical outcome techniques to simplify expressions and solve problems using linear formulae. **A.P3** Demonstrate the use of graphical methods to solve linear and quadratic equations.	**A.M1** Demonstrate the use of algebraic methods to solve linear, quadratic and simultaneous linear and quadratic equations.	
Learning aim B: Examine and apply mathematical techniques correctly to solve practical construction problems involving perimeters, areas and volumes		
B.P4 Demonstrate the use of mathematical techniques to solve construction problems associated with simple perimeters, areas and volume.	**B.M2** Demonstrate the use of appropriate algebraic methods to find lengths, angles, areas and volumes for one 2D complex construction industry-related problem.	

Pass	Merit	Distinction
Learning aim C: Examine and apply geometric and trigonometric techniques correctly to solve practical construction problems		**CD.D2** Apply the use of binomial theory to small errors problem and demonstrate an understanding of the limitations of certain solution in terms of accuracy, approximations and rounding errors.
C.P5 Demonstrate the use of trigonometric techniques to solve simple 2D construction problems. **C.P6** Demonstrate the use of geometric techniques to solve simple construction problems.	**C.M3** Demonstrate the use of appropriate trigonometric techniques to solve one complex 3D construction industry-related problem.	
Learning aim D: Investigate the use of statistical and graphical methods correctly to solve construction problems		
D.P7 Demonstrate the use of statistical techniques to solve practical construction problems. **D.P8** Demonstrate the use of graphical techniques to solve practical construction problems.	**D.M4** Demonstrate the use of standard deviation techniques to compare the quality of manufactured products used in the construction industry.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims, and criteria is:

Learning aims: A and B (A.P1, A.P2, A.P3, B.P4, A.M1, B.M2, AB.D1)

Learning aims: C and D (C.P5, C.P6, D.P7, D.P8, C.M3, C.M4, CD.D2)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to maths support websites, for example www.mathcentre.ac.uk, and spreadsheet software.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, learners should, independently, carry out alternative mathematical methods to check solutions, using appropriate and relevant techniques. This could include the use of estimating techniques to confirm that solutions 'made sense'. A high level of clarity and presentation should be displayed. Multi-stage calculations to confirm manually-generated results should be evident. Learners would also be expected to draw suitable conclusions from the resultant outcomes that relate to industrial situations.

For Merit standard, learners, with minimal tutor support, should demonstrate how to solve linear, quadratic, and simultaneous linear and quadratic equations, using solutions by formula, by factorisation and by the 'completing the square' method. The structure and layout of the solutions should show a correct and methodical progression through the various stages of the calculations. Learners should be able to extract data from one 2D complex industry-related problem. The solutions should be set out methodically and using the correct mathematical conventions clearly. The units should be clearly stated throughout.

For Pass standard, learners must be able to use the main functions of a scientific calculator with confidence and efficiency and produce rough mental and manual checks for their answers. They should give their answers in the appropriate form, taking into account truncation, rounding and standard form. Solutions should be set out using the correct mathematical conventions. All solutions to formulae should be re-substituted back to check answers. Minor oversights are acceptable when simplifying expressions, provided that the majority of the work and methods are correct. For simple linear solutions learners will be expected to plot graphs by appropriate selection of a range of x-variables. For more complex types, such as simultaneous equations or those including powers, the range of values can be provided. All graphs should be annotated and labelled correctly. Mensuration problems should clearly show appropriate use of labelled diagrams. The solutions should be set out methodically and using the correct mathematical conventions clearly. In all industry-related problems the correct units should be used.

Learning aims C and D

For Distinction standard, learners should, independently, demonstrate an understanding of the accuracy and rounding of data, and its effect on calculated outcomes. This includes the application of binomial theory to small errors. Suitable conclusions should be made on the resultant outcomes, in an industrial context.

For Merit standard, learners with minimal teacher support, should be able to extract data from complex industry-related problems: one 2D and one 3D. They should present and apply the data to suitable mathematical models and perform the necessary calculations. The solutions should be set out methodically and using the correct mathematical conventions clearly. The units should be clearly stated throughout.

Learners, with minimal teacher support, should be able to use standard deviation techniques to compare and comment on the material properties of manufactured products, for example, cube test strength and steel tensile strength. Access to secondary research data will be sufficient to cover this criterion.

For Pass standard, learners should provide solutions that clearly show how they have approached trigonometric and geometric problems and collated their data, this should also include the appropriate use of labelled diagrams. Solutions should be set out methodically and use correct mathematical conventions clearly. Units should be clearly stated for the problems involving physical properties. Learners must use graphical techniques to solve practical construction problems. This relates to the production, interpretation and use of graphs. Learners need to demonstrate how industry-related statistical data is calculated, presented and used to aid decision making. The calculation of values and their representation could be integrated within spreadsheet work. Learners should interpret their results and draw relevant conclusions.

Links to other units

This unit links to:

- Unit 10: Surveying in Construction
- Unit 12: Building Surveying in Construction
- Unit 13: Site Engineering for Construction
- Unit 15: Measurement Techniques in Construction
- Unit 17: Further Mathematics for Construction
- Unit 20: Quantity Surveying
- Unit 23: Construction in Civil Engineering.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Opportunities to develop transferable employability skills

Learners will have the opportunity to develop the following transferable skills in the completion and assessment of this unit.

- Decision making when comparing information.
- Analytical and evaluative practices when considering use of mathematical techniques and methods.
- Mathematical skills and knowledge when calculating costs.

Unit 7: Graphical Detailing

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop knowledge and apply skills to produce graphical information by manual and computer-aided design (CAD) methods.

Unit introduction

The construction industry is heavily reliant on communicating through the use of graphical information. Whether you are a designer, builder or planner, an understanding of drawn information and the ability to produce it yourself is an essential part of your work. Information can be produced using manual or CAD methods. Although the industry is fast moving towards CAD, skills in the use of manual methods remain very important, especially those to make freehand sketches.

In this unit, you will develop an understanding of the range of media, equipment and techniques required to produce drawings manually, and you will learn about CAD techniques and requirements.

You will produce a number of drawings using manual and CAD methods. This unit will help you develop the skills to produce freehand sketches.

The knowledge and skills gained in this unit are essential to prepare you for progression to various roles in architectural and landscape design. An understanding of graphical representation is essential in other roles too, such as site management, site engineering, planning and quantity surveying. It will also help you progress to a higher education programme in construction and related disciplines.

Learning aims

In this unit you will:

A Understand the resources required to produce construction drawings

B Develop construction drawing for a given construction brief

C Undertake production of two-dimensional and three dimensional freehand construction sketches.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the resources required to produce construction drawings	**A1** Manual methods **A2** Computer-aided design (CAD) **A3** Comparison of manual and CAD methods of drawing	An evaluative report or presentation supported with illustrations, images and sketches of the equipment and media that learners used in producing their construction drawings.
B Develop construction drawings for a given construction brief	**B1** Construction drawings	Learners' construction drawings produced using manual and CAD methods, following standard conventions and practices in response to a given brief.
C Undertake production of two-dimensional and three-dimensional freehand construction sketches	**C1** Principles, techniques and conventions **C2** Freehand sketches **C3** Skills, knowledge and behaviours	A portfolio of 2D and 3D freehand sketches. The portfolio should demonstrate the skills to use two- and three-point perspectives.

Content

Learning aim A: Understand the resources required to produce construction drawings

A1 Manual methods

Purpose, function, application and use of equipment and media for the production of construction drawings manually.

- Equipment required and its use in producing construction drawings manually:
  - hand drafting equipment, e.g. pens, pencils, scale rules, erasers, erasing shields, adjustable set squares, compasses, templates and flexible curves, stencils, parallel motion drawing boards, drafting tape.
- Media selection and use to produce fit-for-purpose graphical information, to include:
  - grades of pencil (HB, H, 2H)
  - ink pens, e.g. 0.2, 0.25, 0.4, 0.5 mm thick
  - paper (detail paper, cartridge paper, tracing paper, A1, A2, A3 and A4 sizes)
  - reprographics.
- Manual drawing techniques, application and use, to include:
  - drawing lines and shapes
  - drawing to a scale
  - lettering and dimensioning
  - use of graphic conventions and standard symbols.

A2 Computer-aided design (CAD)

Hardware and software specifications for a CAD system, CAD techniques and the comparison of the use of CAD with manual methods to produce construction drawings.

- Hardware requirements:
  - requirements to run the CAD software, e.g. graphics card, speed of processor, random-access memory (RAM) capacity, memory storage, e.g. hard disk, solid state drive (SSD), USB stick, network drives, cloud
  - input devices, to include keyboard, mouse, other input devices, e.g. light pen, digitiser, joystick, thumbwheel
  - output devices, e.g. monitor, printer, plotter.
- Software requirements, to include:
  - operating systems available and their suitability for use with the chosen software package
  - CAD software packages and their advantages and limitations in use
  - minimum computing system requirements for the selected software package, e.g. hard disk space, memory required, processor, video card.
- CAD techniques, such as:
  - use of common commands and their application to produce designs, to include set-up, drawing, editing, zoom
  - plotting methods, to include vector plotting, colour plotting, black and white printing, greyscale printing, colour printing
  - setting up floor and external levels
  - drawing with composite elements, e.g. cavity wall
  - inserting standard components
  - using and applying layers in drawing production
  - using and applying line weights and their interpretation

- selecting and applying appropriate drawing scale
- producing a 3D virtual building model
- producing 2D views, to include plan views, elevation views, cross sections and site layout
- producing camera views and rendered images.

A3 Comparison of manual and CAD methods of drawing

Comparison of manual and CAD methods to produce construction drawings, to include:

- equipment requirements and costs
- accuracy and ease of making changes
- time and cost to produce drawings
- training and support required
- conversion from 3d to 2d
- production of rendered views
- transfer of information.

Learning aim B: Develop construction drawings for a given construction brief

B1 Construction drawings

Types and production of construction drawings following standards and conventions using manual and CAD methods:

- standards and conventions requirements and their application to the different types of construction drawing
- site plan requirements
- two-storey building plans
- elevations
- cross-section drawing
- component or detail drawing
- structural drawing showing general arrangements
- preliminary sketch drawing.

Learning aim C: Undertake production of two-dimensional and three-dimensional freehand construction sketches

C1 Principles, techniques and conventions

Application of principles and techniques used to draw freehand sketches, to include:

- concept of proportionality
- oblique projection
- ‘draw what you see’ perspective drawings
- identifying the horizon line, perspective line and vanishing point
- sketching with vanishing points, to include two- and three-point perspective.

C2 Freehand sketches

Two-dimensional and three-dimensional freehand sketch techniques and their application to:

- the interior of a building, to include room or space showing location of doors, windows, features and fixings
- the exterior of a building, to include the showing of spatial layout and important features
- marking requirements to indicate the clear location of vanishing point(s) on sketches
- the use and appropriate application of annotations to communicate details of materials, finishes, condition or any other relevant information in sketches.

C3 Skills, knowledge and behaviours

Demonstrate behaviour and its impact on outcomes, to include professionalism, etiquette, working to deadlines, accountability and individual responsibility.

- Evaluating outcomes to help inform high-quality justified decisions.
- Media and communication skills, including:
  - the ability to convey intended meaning e.g. written (reports, visual aids for presentational use) and verbal (one-to-one and group, informal and formal situations)
  - use of tone and language for verbal and written communications to convey intended meaning and make a positive and constructive impact on the audience, e.g. positive and engaging tone, technical/vocational language suitable for intended audience.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the resources required to produce construction drawings		
A.P1 Explain the use of media and equipment to produce manual drawings for a given building. **A.P2** Describe the resources required to produce CAD drawings for a given building. **A.P3** Compare manual and CAD methods for the production of drawings in terms of their resource requirements, efficiency and cost.	**A.M1** Analyse the use of manual and CAD methods to produce drawings for a given building, in terms of their resource requirements, efficiency and cost.	**A.D1** Evaluate the use of manual and CAD methods to produce drawings for a given building in terms of their resource requirements, efficiency and cost.
Learning aim B: Develop construction drawings for a given construction brief		
B.P4 Produce construction drawings for a two-storey building drawn to an appropriate scale, containing some technical information following standards.	**B.M2** Produce good-quality construction drawings for a two-storey building drawn accurately to an appropriate scale, containing appropriate technical information following standards.	**B.D2** Produce high-quality, fully annotated construction drawings for a two-storey building drawn accurately to an appropriate scale, containing detailed technical information following standards.
Learning aim C: Undertake production of two-dimensional and three-dimensional freehand construction sketches		
C.P5 Produce annotated 2D and 3D freehand sketches, using appropriate conventions, for the interior of a building. **C.P6** Produce annotated 2D and 3D freehand sketches, using appropriate conventions, for the exterior of a building.	**C.M3** Produce good-quality, annotated 2D and 3D freehand sketches for the interior and exterior of a building with convergence to vanishing points.	**C.D3** Produce high-quality, fully annotated 2D and 3D freehand sketches for the interior and exterior of a building with accurate convergence to vanishing points.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, A.P3, B.P4, A.M1, B.M2, A.D1, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to CAD and manual equipment for drawing and sketching.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, learners evaluate manual and CAD methods to produce drawings. Learners will demonstrate a thorough understanding of the media and equipment required to produce manual and CAD drawings. They will produce a balanced evaluation of the methods used and take into account resource requirements, efficiency and cost.

Learners will produce a set of good-quality drawings using standards and conventions for a two-storey building. The drawings will contain correct technical information.

For Merit standard, learners analyse manual and CAD methods to produce drawings. Learners will produce an analysis of the comparison of methods, which may lack balance but will take into account resource requirements, efficiency and cost.

Learners will produce a set of good-quality drawings using standards and conventions for a two-storey building. The drawings will include the use of both CAD and traditional drafting techniques (only one technique needs to be applied to each drawing produced) and drawings will contain appropriate technical information.

For Pass standard, learners analyse manual and CAD methods to produce drawings. Learners will produce an analysis of the comparison of methods, which may lack balance but will take into account some elements of resource requirements, efficiency and cost.

Learners will produce a set of appropriately annotated drawings using standards and conventions for a two-storey building. This set of drawings must include the use of both CAD and traditional drafting techniques (only one technique needs to be applied to each drawing produced) and drawings will contain some technical information.

Learning aim C

For Distinction standard, learners produce high-quality, fully annotated 2D and 3D freehand sketches. These will be produced using two- or three-point perspective drawing techniques for the interior and exterior of a building. Learners will demonstrate a thorough understanding of the concept of proportionality and vanishing points, although these may be outside the boundaries of the media at this level. Sketches will be fully annotated, providing details of materials, finishes, condition or any other relevant information and will show location of doors, windows, features, fixings and spatial layout.

For Merit standard, learners produce good-quality, annotated 2D and 3D freehand sketches. These will be produced using two- or three-point perspective drawing techniques for the interior and exterior of a building. At this level, learners will show some understanding of proportionality and may have worked with vanishing points in the constraints of the media. Sketches will be annotated, providing details of most of the materials, finishes, condition or any other relevant information and will show location of doors, windows, features, fixings and spatial layout.

For Pass standard, learners produce annotated 2D and 3D freehand sketches.
At this level, learners will show some understanding of proportionality. Sketches will be annotated, providing details of some of the materials, finishes, condition or any other relevant information and will show location of doors, windows, features, fixings and spatial layout.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 13: Site Engineering for Construction
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction
- Unit 16: Provision of Primary Services in Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- technical workshops involving staff from local construction organisations
- contribution of ideas to unit assignment/project materials.

Opportunities to develop transferable employability skills

Learners will have the opportunity to develop the following transferable skills in the completion and assessment of this unit.

- Interpretation of graphical presentations.
- Evaluative and developmental skills.
- Innovation when using knowledge to create practical plans.

Unit 8: Sustainability in Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of the impact of construction on the natural environment and the techniques and methods used to minimise that impact.

Unit introduction

With global warming and declining natural resources becoming major issues, sustainable construction is increasingly important to protect the world for future generations. Emissions cause long-term health issues so there is pressure on all industries, including construction, to minimise these and ensure that where they are unavoidable, they are as clean as possible.

In this unit, you will learn about aspects of the environment that need to be protected, how construction design can minimise the long-term impact that buildings have on the natural environment, and how construction activities can be adapted to minimise their impact on the local natural environment and on communities.

This unit will support you in progressing to a higher-level construction programme, such as the Higher National in Construction, or to a general construction degree. It will also help you progress to the workplace as a technician, environmental officer or site manager with a construction company.

Learning aims

In this unit you will:

A Understand the impact of construction on the environment

B Explore the methods of sustainable building design

C Examine alternative energy sources.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the impact of construction on the environment	**A1** Features of the natural environment that need to be protected **A2** Impact of construction activities on the environment **A3** Impact of new development on the environment	A report, presentation or booklet that examines the features of the natural environment that need to be protected and which suggests appropriate methods and approaches to minimise the impact of construction activities and development.
B Explore the methods of sustainable building design	**B1** Energy-based techniques **B2** Materials-based techniques **B3** Waste-based techniques **B4** Methods of minimising the impact of development	
C Examine alternative energy sources	**C1** Renewable methods of electricity generation **C2** Sources of heating and cooling	A report that examines and recommends alternative sources of energy for a proposed development project.

Content

Learning aim A: Understand the impact of construction on the environment

A1 Features of the natural environment that need to be protected

The features of the natural environment that need to be protected and why their protection will benefit future generations:

- air quality
- ozone quality
- water quality
- land
  - landscape
  - soil quality
  - drainage
  - forests
  - biodiversity
  - ecology
- light
  - visibility
  - night sky
- finite resources
  - fossil fuels
  - ores and minerals
  - raw materials.

A2 Impact of construction activities on the environment

- Airborne emissions, their sources in construction activities and their impact on global and local environments, and the health of the population:
  - carbon dioxide emissions and their impact on global warming
  - carbon monoxide and its impact on public health and ecosystems
  - particulates and their impact on the health of individuals
  - chlorofluorocarbons (CFCs) and their impact on the ozone layer
  - nitrogen oxides (NOx) and the formation of acid rain.
- Water-based pollution associated with site activities, to include spillages, discharges, wastage, run-off, storage and mixing activities. The impact on soil quality, groundwater quality and potential pollution of drinking water:
  - oil-based fuels
  - cement products
  - gypsum products
  - chemical agents
  - temporary site facilities.

- Impacts on land and the landscape, to include visual amenity, soil quality, habitats and ecosystems:
  - landfill activities
  - fly tipping and litter
  - deforestation
  - acid rain
  - loss of greenbelt and green spaces
  - drainage and flooding.
- Light pollution and the impact on the population and wildlife:
  - loss of clarity, to include the night sky, impact of glare
  - impact on nocturnal animals
  - disturbance to human activities, to include impact on sleep patterns.
- Finite resources used during construction activities and the impact of their use on future generations:
  - oil-based products, to include fuels and polymers
  - ore- and mineral-based products
  - timbers and boards
  - stone, to include walling materials, fill materials and aggregates
  - clay-based products, to include bricks and tiles.

A3 Impact of new development on the environment

The impact on the natural environment of development of the built environment.

- Increased traffic density:
  - localised air pollution
  - congestion leading to lower speeds and increased emissions
  - waterborne contaminants from surface water run-off.
- Increased surface water run-off:
  - downstream flooding
  - pollution of watercourses
  - impact on natural irrigation and drainage.
- Loss of land and green space:
  - loss of natural visual amenity
  - deforestation
  - reduction in farmland and food production
  - loss of natural habitats
  - damage to ecosystems.
- Increased greenhouse gases and emissions:
  - pollution and emissions arising from the use of the built environment
  - loss of conversion of CO_2 to oxygen.

Learning aim B: Explore the methods of sustainable building design

B1 Energy-based techniques

How good design can produce buildings that have minimal impact on the environment, and which are considered zero carbon.

- Efficient heating and ventilation systems:
  - Modern, efficient plant
  - use of control systems
  - combined heat and power systems.
- High standards of insulation to walls, floors and roofs.
- Airtight buildings:
  - door and window openings
  - ventilation methods to include passive stack ventilation.
- Use of renewable and alternative sources of heat and power:
  - small-scale wind turbines
  - roof-mounted photovoltaic cells
  - biomass boilers
  - ground and air source heat pumps.

B2 Materials-based techniques

How appropriate specification, distribution, transportation and use of materials can contribute to sustainable buildings and sustainable techniques.

- Specification and use of renewable materials:
  - softwoods and associated timber products from sustainable forests
  - sustainable insulation, to include sheep's wool, cellulose and other recycled products
  - plant-based polymers
  - flax and associated products, to include flax panels and use in composites
  - hemp and associated products, to include insulation products and hempcrete
  - recycled and reclaimed materials.
- Consideration and minimisation of embodied energy and associated emissions at different stages of materials production:
  - extraction of raw materials
  - processing of materials
  - manufacture of products and components
  - distribution and delivery of materials, products and components.
- Use of durable, long-lasting materials and products:
  - minimisation of future maintenance
  - impact on initial cost and long-term savings
  - sustainable benefits over the life of the building.

B3 Waste-based techniques

How alternative methods of construction and site management can minimise the volume of waste produced during construction activities and how that waste can be used to further reduce the impact on the environment.

- Off-site prefabrication:
  - timber-frame construction
  - modular construction
  - structural insulated panels (SIPs)
  - engineered joists and eco joists
  - modular components
  - precast concrete floors and stairs
  - steel-framed construction.
- Modular materials:
  - minimisation of cutting
  - designed to suit modular dimensions.
- Modern methods of construction:
  - use of mechanical plant
  - installation of prefabricated elements
  - modern batching and silo facilities.
- Waste planning:
  - action taken to minimise damage on site, to include correct storage, handling and timing of deliveries
  - segregation and sorting of waste
  - use of recyclable materials.

B4 Methods of minimising the impact of development

- Traffic management:
  - cycle to work schemes
  - provision of cycle paths and networks
  - public transport systems
    - transport interchanges
    - bus and tram networks
    - prioritisation of public transport routes.
- Sustainable Urban Drainage Systems (SuDS).
- Methods that delay surface water run-off to reduce the risk of surface water flooding and how these methods protect and benefit the natural and built environment:
  - delayed dispersal
    - managing run-off volumes and flow rates
    - dispersal at source via permeable paving or filter strips
    - protecting natural flow regimes in water courses
    - use of soakaways
  - temporary surface water storage
    - swales
    - underground tanks
    - attenuation basins
    - retention ponds

- rainwater harvesting
  - methods and use within domestic buildings
  - methods and use in agriculture and industry.
- Carbon offsetting:
  - tree planting
  - ecological landscaping.

Learning aim C: Examine alternative energy sources

How alternative energy sources can be used for both micro-supplies locally and in national supply chains. The benefits and drawbacks of the different sources and how they contribute to sustainability and use in off-grid scenarios. The location and orientation requirements of each method of generation or sources of heat.

C1 Renewable methods of electricity generation

- Solar power generation:
  - photovoltaic cell installations providing power to individual buildings
  - solar farms providing power to communities and the National Grid.
- Wind power:
  - small-scale wind generation
  - onshore wind farms
  - offshore wind farms.
- Hydro-electric power generation:
  - mini hydro-electric power generation systems
  - large-scale hydro-electric power stations
  - energy storage and regeneration methods.
- Tidal and wave power generation:
  - tidal flow systems used in estuaries and rivers
  - wave power used in open water.
- Biomass power stations:
  - small-scale power generation
  - systems feeding into the national grid.

C2 Sources of heating and cooling

- Ground source heating.
- Air source heating.
- Geothermal heating.
- District heating schemes:
  - surplus heat from industry
  - heat from waste incineration.
- Biomass boilers.
- Combined heat and power (CHP) installations.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the impact of construction on the environment		**AB.D1** Evaluate the potential impact of construction activities and development on the features of the natural environment. **AB.D2** Review the effectiveness of methods adopted to minimise the impact of construction activities and development on the natural environment for a given scenario.
A.P1 Explain the features of the natural environment that need to be protected. **A.P2** Explain the impact of construction activities and development on the natural environment.	**A.M1** Discuss the potential impact of construction activities and development on the features of the natural environment.	
Learning aim B: Explore the methods of sustainable building design		
B.P3 Examine energy, materials and waste-based techniques of sustainable construction. **B.P4** Explain ways of minimising the impact of development on the natural environment.	**B.M2** Discuss the methods used to minimise the impact of construction activities and development on the natural environment for a given scenario.	
Learning aim C: Examine alternative energy sources		
C.P5 Explore renewable methods of electricity generation. **C.P6** Explain alternative sources of sustainable heating and cooling.	**C.M3** Analyse the effectiveness of alternative sources of energy for a given scenario.	**C.D3** Evaluate the effectiveness of alternative sources of energy for a given scenario.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment*, gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, A.D1, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aims A and B

For Distinction standard, learners will consider the potential impact of construction activities and development on the features of the natural environment, and the relative magnitude and importance of each impact. They will go on to investigate the effectiveness of methods that could be adopted to minimise the impact of construction activities and development on the natural environment, in the context of a given scenario. They will investigate energy, materials and waste-based techniques of sustainable construction in order to consider ways of minimising the impact of development on the natural environment. Learners will consider the benefits and drawbacks of any methods under consideration and reach conclusions that relate to the effectiveness and appropriateness of the methods.

For Merit standard, learners will consider the potential impact of construction activities and development on the features of the natural environment. They will analyse the relevance of each impact and will go on to investigate methods that could be adopted to minimise the impact of construction activities and development on the natural environment, in the context of a given scenario. They will examine energy, materials and waste-based techniques of sustainable construction in order to outline ways of minimising the impact of development on the natural environment. They may consider the benefits and drawbacks of any methods under consideration, but will be discursive and may not reach any conclusions relating to the effectiveness and appropriateness of the methods.

For Pass standard, learners will consider the features of the natural environment that need to be protected and how construction activities and development can impact on the natural environment. They will explore energy, materials and waste-based techniques of sustainable construction and look at ways of minimising the impact of development on the natural environment. Their work will be mostly descriptive and consider how and why protection is needed and provided.

Learning aim C

For Distinction standard, learners will consider the effectiveness of alternative sources of energy for a given scenario. They will include alternative forms of sustainable electricity generation, heating and cooling. They will consider the benefits and drawbacks of any methods under consideration. They will reach conclusions relating to the effectiveness and appropriateness of the methods considered.

For Merit standard, learners will consider the alternative sources of energy for a given scenario. They will include alternative forms of sustainable electricity generation, heating and cooling. Their work may consider the benefits and drawbacks of any methods under consideration, but will be discursive, and they may not have reached any conclusions relating to the effectiveness and appropriateness of the methods.

For Pass standard, learners will consider renewable methods of electricity generation and alternative sources of sustainable heating and cooling. Their work will be mostly descriptive and will consider how alternative energy can be provided.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 21: Building Services Science
- Unit 25: Building Services Control Systems
- Unit 26: Heating, Ventilation and Air-conditioning Design
- Unit 27: Plumbing and Fluid Behaviour in Building Services Engineering
- Unit 33: Offsite and Onsite Construction Methods
- Unit 34: Planning the Built Environment.

Opportunities to develop transferable employability skills

This unit will help learners to develop their use of language in a number of different document formats, including report writing. Sustainability is a key issue across all industry sectors and professions, so knowledge and understanding of sustainability can be considered relevant to many areas of employment.

Unit 9: Building Information Modelling and Artificial Intelligence

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners will develop knowledge and skills in the principles and use of building information modelling (BIM) technologies and artificial intelligence (AI) to streamline the design, construction and usage of building projects.

Unit introduction

Working in the construction industry today means that you need to know more about BIM and AI, and how to use them.

BIM aims to coordinate all aspects of a building project, covering a building's design, construction and operation, and its repurposing and recycling at the end of its useful life. AI involves the development of computer systems that are as capable as people at performing problem-solving, pattern recognition and learning tasks.

Through carrying out a BIM-enabled design and construct project, this unit introduces you to using a Digital Plan of Work (DPoW) and the Common Data Environment (CDE) in which the DpoW operates. You will understand the information management environment, learning how, for example, Construction Operations Building information exchange (COBie) is used to transfer information. You will study the benefits of adopting BIM as a modern method of construction and consider how it will support future advancements with AI. Finally, you will investigate the effect of policies, standards and legislation of a BIM-enabled environment on a design and construct project.

This unit gives you the knowledge and skills you need to work in a BIM-enabled workplace environment. The unit also introduces you to AI. You can further your knowledge and understanding of BIM and AI by progressing to a construction industry-related degree and then specialising in a BIM-specific role, or using BIM and AI in your chosen construction profession.

Learning aims

In this unit, you will:

A Examine the use of a Digital Plan of Work in an information management environment

B Examine the construction information management environment

C Investigate the contribution of information management technologies to a BIM-enabled design and construct project

D Investigate the effect of policy, standards and legislation on the BIM-enabled environment.

Summary of unit

<table>
<tr><th>Learning aim</th><th>Key content areas</th><th>Assessment approach</th></tr>
<tr><td>A Examine the use of a Digital Plan of Work in an information management environment</td><td>A1 Digital Plan of Work (DPoW)
A2 BIM and its implementation in the DPoW
A3 Common Data Environment (CDE) and the DPoW</td><td>A report showing the application of the DPoW and the support provided by the CDE in a BIM-enabled design and construct project.</td></tr>
<tr><td>B Examine the construction information management environment</td><td>B1 Construction Operations Building information exchange (COBie)
B2 BIM deployment strategies
B3 Security of data
B4 Controlling the flow of information in a CDE</td><td rowspan="2">A presentation or report, showing how information flows are kept secure and how information technologies contribute to the construction environment, including how they support sustainability, statutory control, AI and use of modern methods of construction in a BIM-enabled environment design and construct project.</td></tr>
<tr><td>C Investigate the contribution of information management technologies to a BIM-enabled design and construct project</td><td>C1 BIM and sustainability, and statutory control approval
C2 BIM, AI and modern methods of construction</td></tr>
<tr><td>D Investigate the effect of policy, standards and legislation on the BIM-enabled environment</td><td>D1 The DPoW and new working methods and practices
D2 BIM, buildability and working practices
D3 Industry, professional and government policies and legislation, and working practices
D4 Allocating roles and resources</td><td>A presentation or report showing the effect on a BIM-enabled design and construct project of policy and legislation application, to include roles and resources.</td></tr>
</table>

Content

Learning aim A: Examine the use of a Digital Plan of Work in an information management environment

A1 Digital Plan of Work (DPoW)

The typical stages of a DPoW and its application to the Employer's Information Requirements (EIR).

- The DPoW stages, their sequencing and who does what:
  1. Brief
  2. Concept
  3. Definition
  4. Design
  5. Build and commission
  6. Handover and close out
  7. Operation and end of life.
- Typical EIR:
  - definition of EIR – information required by employer from internal team, suppliers and for asset operation
  - technical information requirements, including software platforms, data-exchange formats and co-ordinates
  - management information requirements, including standards, stakeholders' roles and responsibilities, planning work and data segregation, security, co-ordination and class detection processes, collaboration processes, model review meetings, system performance constraints, compliance plan and delivery strategy for asset information
  - commercial information requirements, including timing of data drops and BIM/project deliverables.

A2 BIM and its implementation in the DPoW

The characteristics of BIM and its implementation.

- BIM protocol and how it:
  - enables digital technology design
  - embeds key product and asset data in all project stages
  - manages information throughout the project life cycle, using three-dimensional (3D) computer modelling
  - provides an information repository for digital data project information throughout a design and construct project, with the capability to manipulate to produce information and support information sharing
  - produces unified information output for the client at handover.
- BIM levels of maturity:
  - requirements of each level of maturity
  - BIM maturity requirement timescales and impact on design and construct projects.

A3 Common Data Environment (CDE) and the DPoW

How CDE supports the operation of a BIM-led design and construct project.

- How CDE functions, including the advantages and disadvantages of composite and federated information environments.
- Measures required to ensure that:
  - a construction project's CDE is up to date
  - the content is suitable and accurate.

Learning aim B: Examine the construction information management environment

B1 Construction Operations Building information exchange (COBie)

- The contribution of COBie to the ease and optimisation of the running, maintenance and repair of a building and its services, including:
  - facilities management benefits
  - repair and renewal scheduling.
- Source of manufacturer and supplier information, and specifications in a common format, including the coding of EIR.
- Holding of the project information model:
  - end-of-work stages
  - originator and sign-off
  - multiple and single shared data
  - embedding data
  - archive and published data
  - BIM levels.

B2 BIM deployment strategies

The contribution of smart and linked technologies to remotely locate, access and manage project information and activities.

- Digital technology considerations in a BIM environment:
  - hardware capacity
  - software suitability and compatibility
  - competences to effectively apply smart technologies.
- Use digital technology to:
  - plan and carry out routine maintenance and servicing
  - determine component replacement
  - define asset end of life.

B3 Security of data

Importance of and requirements to protect data, intellectual properties, sensitive designs, specifications and other project information, to include:

- setting and controlling protocols and access permissions
- version control.

B4 Controlling the flow of information in a CDE

- Work in progress – end of work stages.
- Shared published archive.
- Project information model.
- Originator and sign off.
- Multiple and single shared area.
- Embedding data.
- Archive and published data.

Learning aim C: Investigate the contribution of information management technologies to a BIM-enabled design and construct project

C1 BIM and sustainability, and statutory control approval

Contribution of BIM to sustainability and statutory control approval before construction starts.

- Sustainability requirements:
  - materials selection
  - service specifications, to include optimising renewable sources of heating and cooling, and the use of natural resources, including natural light and natural ventilation methods through the efficient orientation of the structure
  - lifestyle energy use and life-cycle analysis
  - adaptability and future-proofing.
- Use of BIM to obtain statutory approval, e.g. planning permission.

C2 BIM, AI and modern methods of construction

The contribution of the BIM 3D virtual environment and its support of modern methods of construction (MMC).

- Construction time and waste reduction, e.g. efficient factory production, delivery to installation, logistical planning.
- 3D printing and off-site component manufacture use, e.g. transport costs reduction, allowing for flexibility in requirements.
- Use of AI on construction projects, including:
  - artificial neural networks to predict project programmes and cost overrun
  - machine learning to
    - identify and mitigate clashes between different BIM models (architectural, engineering, mechanical, electrical and plumbing)
    - plan for the distribution of labour and machinery on site
    - monitor and priorities site risk
  - 3D site scans taken by robots to assess the progress of construction
  - autonomous and semi-autonomous construction plant
  - facial recognition to assess worker productivity
  - application of virtual reality, e.g. to plan safe systems of work for construction.
- Impact of AI on construction projects, including, reduction of errors, reduction of worksite injuries and improving operational efficiencies.

Learning aim D: Investigate the effect of policy, standards and legislation on the BIM-enabled environment

D1 The DPoW and new working methods and practices

The DPoW and BIM, and their influence on work methods and working practices.

- The DPoW stages:
  1. Brief
  2. Concept
  3. Definition
  4. Design
  5. Build and commission
  6. Handover and close out
  7. Operation and end of life.
- Effect on design, construction and maintenance roles owing to streamlined information flow and connected communications.
- Data security and permissions for appropriate parties.
- New responsibilities and accountability arising from the information left by BIM and its data trail:
  - traceability of roles, responsibilities and decision making during a design and construct project
  - ability to trace errors back to their source.

D2 BIM, buildability and working practices

The ability to model designs and construction processes in BIM virtually, and in advance of construction, to enable the main parties in a design and construct project to:

- identify design issues
- consider best building methods and practices
- overcome construction planning clashes and logistical problems
- enable safe systems of work to be agreed on and put in place before construction starts.

D3 Industry, professional and government policies and legislation, and working practices

The effect of industry bodies, government policy and legislation on BIM content, implementation and timelines on design and construct projects using information management technologies:

- national statutory instruments
- health and safety legislation and bodies
- building legislation
- International Organization for Standardization (ISO).

D4 Allocating roles and resources

Effect of the DPoW and BIM on the resources required, roles, teamwork and collaboration.

- Resources, e.g. hardware and software requirements to support BIM and personnel working in this environment.
- Dealing with information and communications in a real-time environment, how it looks and works, and its security.
- The roles and responsibilities of individuals given in DPoW, e.g. lead designer, BIM manager, BIM co-ordinator, CAD/IT technician, manufacturer, project manager, site manager.
- New responsibilities and accountability arising from the information left by BIM and its data trail.
- Building contract requirements and supporting industry guidelines.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Examine the use of a Digital Plan of Work in an information management environment</td><td rowspan="2">A.D1 Evaluate the application of the DPoW and CDE in a BIM-enabled design and construct project.</td></tr>
<tr><td>A.P1 Describe the application of the DPoW stages in a BIM-enabled design and construct project.
A.P2 Describe how the CDE supports a BIM-enabled design and construct project.</td><td>A.M1 Analyse the application of the DPoW and CDE in a BIM-enabled design and construct project.</td></tr>
<tr><td colspan="2">Learning aim B: Examine the construction information management environment</td><td rowspan="4">BC.D2 Evaluate the contribution of information management technologies, COBie and BIM deployment strategies for a design and construct project.</td></tr>
<tr><td>B.P3 Outline the contribution of COBie and BIM deployment strategies to support the secure flow of information for a design and construct project.</td><td>B.M2 Explain the contribution of COBie and BIM deployment strategies to support the secure flow of information for a design and construct project.</td></tr>
<tr><td colspan="2">Learning aim C: Investigate the contribution of information management technologies to a BIM-enabled design and construct project</td></tr>
<tr><td>C.P4 Describe the contribution of BIM use to sustainability for a specific design and construct project.
C.P5 Describe the contribution of BIM use to gain statutory control for a specific design and construct project.
C.P6 Describe the contribution of the 3D BIM environment and AI to modern methods of construction use for a specific design and construct project.</td><td>C.M3 Explain the contribution of BIM for a specific design and construct project.</td></tr>
</table>

Pass	Merit	Distinction
Learning aim D: Investigate the effect of policy, standards and legislation on the BIM-enabled environment		**D.D3** Evaluate the effect of industry, professional and government policies, and legislation on construction activities, roles and resources for a given BIM-enabled design and construct project.
D.P7 Outline the effect of industry, professional and government policies, and legislation on construction activities for a given BIM-enabled design and construct project. **D.P8** Outline the allocation of roles and resources for a given BIM-enabled design and construct project.	**D.M4** Discuss the effect of industry, professional and government policies and legislation on construction activities, roles and resources for a given BIM-enabled design and construct project.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, C.P4, C.P5, C.P6, B.M2, C.M3, BC.D2)

Learning aim: D (D.P7, D.P8, D.M4, D.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to suitable BIM-enabled design and construct project case studies. This may include employer engagement for the design and construct project information requirements.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will demonstrate a structured, coherent, logical and comprehensive evaluation of the application of the DPoW and the support offered by the CDE, associated with an information management environment in a BIM-enabled design and construct project. They will use technical terms and information consistently and correctly. They will use relevant graphical information, which will be clear and effective in supporting their evaluation.

Their evaluation will include a supported conclusion on the application of the DPoW and CDE in a BIM-enabled design and construct project.

For merit standard, learners will produce a structured and coherent analysis of the application of the DPoW and the support offered by the CDE, associated with an information management environment in a BIM-enabled design and construct project. They will demonstrate some consistency and use of technical terms and information. They will use some relevant graphical information, although this may not always be used effectively to support their statements. Learners may have some DPoW sequencing issues or miss out a stage. They are not required to draw a conclusion.

For pass standard, learners will describe the application of the DPoW and the support offered by the CDE associated with an information management environment in a BIM-enabled design and construct project. They will attempt to use technical terms, but they may not always be applied consistently and/or appropriately. Graphical information may contain some inaccuracies and may not support the BIM-enabled project.

Learning aims B and C

For distinction standard, learners will demonstrate a coherent, structured, comprehensive and wide-ranging evaluation of COBie's contribution to a design and construct project, and the BIM deployment strategies required to manage and convey information securely in a CDE. Their evaluation will show the contribution of IT and AI to current sustainability standards, including the incorporation of modern construction methods and obtaining statutory control approval. Where they use graphical information, this will be clear and effective in supporting their evaluation. The sources they quote must be widely recognised as authoritative in the construction industry.

For merit standard, learners will explain COBie's contribution to a design and construct project, but their explanation may be limited with respect to the importance and value of this contribution. They will explain the BIM deployment strategies required to manage and convey information securely in the design and construct project's CDE but this may show some imbalance. The explanation will show the contribution of IT and AI to support current sustainability standards, including the incorporation of modern construction methods and obtaining statutory control approval. Where they use graphical information, it may not always be clearly linked and/or relevant to the explanation.

For pass standard, learners will outline COBie's contribution to a design and construct project but there will be no indication of the importance and value of this contribution. They will describe the BIM deployment strategies required to manage and convey information securely in the design and construct project's CDE, but this will show some omissions or imbalance. The description will provide some details of the contribution that IT and AI provide to support current sustainability standards, including the incorporation of modern construction methods and obtaining statutory control approval.

Learning aim D

For distinction standard, learners will, for the given design and construct project, provide a coherent, structured, comprehensive and wide-ranging evaluation of the effect of BIM-related industry, professional and government policies and legislation on processes, practices, resource requirements, work roles and responsibilities. They will give a balanced consideration of the interrelationships between these items and their relative importance to fully support their conclusions.

For merit standard, learners will, for the given design and construct project, provide a structured discussion of the effect of BIM-related industry, professional and government policies and legislation on processes, practices, resource requirements, work roles and responsibilities. There may be some imbalance or omissions in their consideration of the interrelationships and their relative importance. A conclusion is not required.

For pass standard, learners will, for the given design and construct project, provide an outline description of the effect of BIM-related industry, professional and government policies and legislation on processes, practices, resource requirements, work roles and responsibilities. Learners will provide an overview of their consideration of interrelationships and their consideration of their relative importance may be limited.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 11: Management of a Construction Project.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- participation in audience assessment of presentations
- ideas to contribute to case-study materials for teaching and assessment
- own BIM-enabled design and construct project materials as exemplars
- work experience in a BIM-enabled environment.

Opportunities to develop transferable employability skills

Learners will have the opportunity to develop the following transferable skills in the completion and assessment of this unit.

- Organisational and team working skills.
- Innovation when using understanding to create practical plans.
- Practical application when reflecting upon experiences of work.

Unit 10: Surveying in Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop the skills to carry out linear, levelling and land surveys, understanding the methods and technologies needed for this work.

Unit introduction

The surveying of land is concerned with the measurement of existing features of the natural and built environment, and the presentation of data in a format suitable for architects and engineers to use when designing construction projects. It plays an important role in the early stages of the design process and links with the setting out phase of construction projects.

In this unit, you will become familiar with basic surveying techniques, carry out surveying tasks and present fieldwork data in a suitable format. You will consider the nature of survey measurements, the instruments used and the errors inherent in the measurement systems, including the best ways to reduce or eliminate them.

Understanding how to carry out surveying in construction to produce suitable and accurate drawings will prepare you for employment or further study in land surveying, site supervision, civil engineering and other branches of construction. The skills you gain from this unit will help you progress to employment in a range of areas in the construction industry, including site supervision, setting out, land surveying, quantity surveying, civil engineering and other branches of construction.

Learning aims

In this unit you will:

A Understand the methods and technologies that underpin surveys

B Undertake fieldwork surveys to collect data for drawings

C Develop drawings from completed fieldwork surveys.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the methods and technologies that underpin surveys	**A1** Linear, levelling and angular measurement **A2** Equipment used to perform fieldwork surveys **A3** Sources of systematic errors	A report on the techniques and instruments used to record survey data, including potential sources of systematic errors and their minimisation to produce accurate data for plan and section details production.
B Undertake fieldwork surveys to collect data for drawings	**B1** Linear surveys **B2** Levelling surveys **B3** Read and record horizontal angles of a closed traverse **B4** Basic arithmetic operations **B5** Application of applied mathematical techniques	Linear survey and level booking sheets to demonstrate accurate recording of surveying measurements. Teacher observation sheets confirming individual understanding and contribution to the practical tasks carried out during fieldwork tasks with others.
C Develop drawings from completed fieldwork surveys	**C1** Conventions used in survey drawings **C2** Production of survey drawings **C3** Corrected closed traverse drawing	A report: · evaluating the methods used to take levelling and angular measurements in terms of accuracy · including linear survey and level booking sheets of reduced levels and check calculations including coordinates, calculations and corrections. A series of plan and section scaled detail drawings, to include a: · linear survey line plotted accurately to scale · contoured plan of a surveyed area of land · long section detail of one surveyed line indicating rise and fall of ground between survey stations · plot of a corrected closed traverse. The drawings/details can be produced using manual or computer-aided design (CAD) drawing techniques.

Content

This unit is an introductory unit to surveying. Learners are expected to use basic surveying equipment and linear surveys that are small in nature. In this way, learners do not have to complete a full linear survey and in B.P4 this is limited to a small survey line. The overall focus of the unit is to allow learners to use modern technology to produce accurate horizontal and vertical surveys.

Learning aim A: Understand the methods and technologies that underpin surveys

A1 Linear, levelling and angular measurement

Surveying terminology principles, their application to fieldwork activity and use of surveying technology to complete fieldwork activities.

- Framework.
- Measuring horizontal and slope distances.
- Chainage:
  - running measurements
  - perpendicular offsets.
- Survey line:
  - baseline
  - check lines.
- Reading levels:
  - backsight
  - intermediate sight
  - foresight.
- Datum terminology:
  - Ordnance Survey Bench Mark (OSBM)
  - Temporary Bench Mark (TBM)
  - reduced level.
- Height of collimation.
- Rise and fall.
- Fly levelling.
- Whole circle bearings.
- Horizontal angles.
- Traverse types:
  - open
  - closed
  - fixed between points
  - rectangular coordinates
  - survey stations.

A2 Equipment used to perform fieldwork surveys

Surveying equipment, their advantages and disadvantages, and use in completing fieldwork activities.

- Tapes.
- Bands.
- Ranging poles.
- Levels:
  - automatic
  - tilting
  - dumpy and builder
  - laser.
- Digital theodolites.
- Electronic distance measurement (EDM) devices.
- Total stations. This could also include the use of Global Positing Systems (GPS).

A3 Sources of systematic errors

How errors impact on the accuracy of fieldwork surveys.

- Plastic tapes – stretching.
- Levels – calibration errors.
- Theodolites:
  - bubble and electronic plummets off-centre errors
  - horizontal collimation errors
  - vertical collimation errors.
- Electronic distance measurement:
  - scale and index errors.
- Performance of systematic checks on surveying instruments:
  - tapes – calibration against standardised steel tapes
  - levels – two-peg test.
- Theodolites:
  - vertical axis check
  - transit axis check
  - spire check.

Learning aim B: Undertake fieldwork surveys to collect data for drawings

Methodologies used in the production of accurate surveys, including systematic checking, instrument adjustment and accuracy of calculations.

B1 Linear surveys

Application of techniques and processes to perform a linear survey.

- Establishing survey stations for a given location.
- Using chainage, offsets, tie lines to record measurements.
- Using correct booking techniques to survey in between survey stations.

B2 Levelling surveys

Application of techniques and processes to perform levelling surveys.

- Using TBM or OSBM or equivalent datum to commence exercises.
- Recording readings using correct booking techniques:
  - height of collimation method
  - rise and fall method
  - flying levels.
- Completion of check calculations on the accuracy of levelling exercises undertaken.

B3 Read and record horizontal angles of a closed traverse

Application of techniques and processes for a closed traverse survey.

  - Establishing survey stations for a closed traverse.
  - Technique and recording requirements for the survey of a closed traverse.
  - Recording horizontal angle readings using correct booking techniques.
  - Detecting and correcting errors.

B4 Basic arithmetic operations

Application of arithmetic operations during fieldwork surveying tasks used to gather data for construction drawings.

- Calculations for levelling exercises and appropriate check calculations:
  - height of collimation method
  - rise and fall method
  - flying levels.
- Calculation of recorded horizontal angles using face left/face right techniques.
- Addition and subtraction of angles.

B5 Application of applied mathematical techniques

Application of applied mathematical techniques during fieldwork surveying tasks to gather data for construction drawings.

- Calculation of rectangular coordinates.
- Adjustment of simple traverse:
  - application to adjust the closing error of a traverse
  - balancing in traverse
  - distribution of closure error.

Learning aim C: Develop drawings from completed fieldwork surveys

Techniques used to produce accurate construction drawings.

C1 Conventions used in survey drawings

- Conventions used in survey drawings.
- Appropriate scales for survey drawings.

C2 Production of survey drawings

Production of survey drawings to incorporate:

- levels survey plan
- plotting linear survey lines accurately to scale
- spot levels
- grid levels
- contours
- site cross section
- long section detail
- cut and fill cross section.

C3 Corrected closed traverse drawing

- Application of corrected traverse station coordinates to plot a closed traverse.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the methods and technologies that underpin surveys		**A.D1** Evaluate the methods and technologies underpinning linear, levelling and angular measurement and surveys.
A.P1 Explain the methods and technologies underpinning linear, levelling and angular measurement surveys. **A.P2** Explain systematic errors in surveying measurements.	**A.M1** Discuss the methods and technologies underpinning linear, levelling and angular measurement and surveys.	
Learning aim B: Undertake fieldwork surveys to collect data for drawings		**B.D2** Evaluate the methods used to produce accurate fieldwork survey information for the development of accurate drawings.
B.P3 Perform systematic checks and adjustments to equipment and instruments appropriate for the fieldwork surveying activity. **B.P4** Perform linear, levelling and angular measurement surveys using appropriate equipment and booking methods. **B.P5** Perform correct calculations to support fieldwork activities.	**B.M2** Justify the selection of equipment, methods used, the application of systematic checking, instrument adjustment and accuracy of calculations to provide accurate fieldwork survey information.	
Learning aim C: Develop drawings from completed fieldwork surveys		**C.D3** Evaluate the production of drawings from completed fieldwork surveys.
C.P6 Produce plans of land and section detail drawings from completed fieldwork surveys.	**C.M3** Produce plans of land and section detail drawings from completed fieldwork surveys to a high level of technical skill and accuracy.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, B.P4, B.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to areas of land with a range of topographic and built features where surveying practical work can be carried out safely.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the methods and technologies that underpin how to complete linear, levelling and angular measurement surveys. The evaluation must be supported with justified, detailed and well-presented examples of the relevant instruments to be used and appropriate booking procedures.

For merit standard, learners will discuss the methods and technologies that underpin how to complete linear, levelling and angular measurement surveys. The discussion must be supported with detailed and well-presented examples of the relevant instruments to be used and appropriate booking procedures.

For pass standard, learners will explain the characteristics that underpin how to complete linear, levelling and angular measurement surveys. The explanations must be supported with examples of the relevant instruments to be used and appropriate booking procedures to record measurements. Learners will explain the types of systematic errors in surveying measurements, which must include equipment used for linear, levelling and angular measurement fieldwork surveys.

Learning aims B and C

For distinction standard, learners will draw on and make supported judgements of the methodologies used to produce their accurate surveys. This will include their choices of equipment selected, in comparison to alternate surveying instruments available to complete similar fieldwork measurements, and consideration of the accuracy of fieldwork readings and calculations completed.

For merit standard, learners will present a methodical and detailed justification of their selection of equipment and methods they have used to perform fieldwork exercises in order to provide accurate and reliable data for accurate drawings. This will include showing a clear understanding of the importance of the systematic checks and equipment/instrument adjustments that are conducted to minimise fieldwork measurements inaccuracies. Their calculations show their understanding of how to adjust a simple traverse network using a standard method of calculation.

Learners will provide accurate, well-presented scaled drawings and details of their surveys, to include a:

- linear plan detail of one surveyed line
- contoured plan of a section of the area surveyed
- section detail along one survey line
- corrected traverse plan detail.

It is acceptable for their drawings/details to be produced manually or by CAD.

Learners will produce drawings and details that meet all of the intended requirements, have the correct application of scale and are presented to a high level of technical skill and accuracy.

For pass standard, learners will participate in fieldwork activities to carry out their linear, levelling and angular surveys using appropriate equipment and recognised booking methods. Their survey measurements will be recorded using an appropriate booking method. Learners will produce evidence of how they completed systematic checks and adjusted equipment/instruments used to perform their fieldwork activities. Learners will produce reduced level calculations, using both the height of collimation and rise and fall methods. Learners will produce angular measurement calculations and record using the correct booking techniques. They will provide calculations for the coordinates of survey stations from data collected for a traverse survey. In this case, correct calculations will be seen as those that show understanding of methodologies.

Learners must provide scaled drawings and details, to include a:

- linear plan detail of one surveyed line
- contoured plan of a section of the area surveyed
- section detail along one survey line
- corrected traverse plan detail.

It is acceptable for these drawings/details to be produced manually or by CAD.

Learners will produce drawings and details that meet the necessary requirements, however there will be some inaccuracies in the correct application of scale and in the presentation of the finished details.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 6: Construction Mathematics
- Unit 7: Graphical Detailing
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction
- Unit 16: Provision of Primary Services in Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers such as a surveyor from a local authority or building control department
- guest speakers from specialist surveying companies
- participation in audience assessment of presentations
- design/ideas to contribute to unit assignment/case study/project materials
- work experience
- own business materials as exemplars
- support from local business.

Unit 11: Management of a Construction Project

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners gain an understanding of management principles and their application to the construction industry.

Unit introduction

Managing and delivering a project to a client on time and within budget is key to modern construction. With so many variables and potential unforeseen challenges, the job of the site or project manager is interesting, demanding and exacting. A satisfactory and rewarding conclusion to a project requires them to have the techniques to plan, programme, budget and manage the workforce, as well as have the skills to control these techniques in many and varied situations.

In this unit, you will examine the techniques needed to manage a project from start to completion. You will learn about the roles and responsibilities of the construction management team, which will include planning, forecasting, organising, buying, motivating and cost control. You will carry out planning and production control techniques and apply these skills to the design of building programmes.

This unit will help you to progress to a higher-level construction programme, such as the Higher National in Construction, or to a degree in project management. Additionally, the content of this unit will support progression to careers in site or project management, or to other professional roles in construction, such as architecture, quantity surveying, building services engineering and structural engineering.

Learning aims

In this unit you will:

A Understand the principles and application of management in construction

B Understand purchasing and cost management techniques

C Develop a programme of activities for construction works.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the principles and application of management in construction	**A1** Principles of management **A2** Application of construction management techniques	A report about the management systems in use in the construction company.
B Understand purchasing and cost management techniques	**B1** Application of purchasing methods **B2** Cost management techniques	
C Develop a programme of activities for construction works	**C1** Production control systems	A training pack for trainee site managers joining a large national housing contractor.

Content

Learning aim A: Understand the principles and application of management in construction

A1 Principles of management

Management principles and their application by the management team in the construction of low- to medium-rise buildings.

- Management style, methods and theories, e.g. Fayol, Maslow, McGregor.
- The roles, responsibilities and interaction of a construction project management team, to include the architect, quantity surveyor, construction manager, project manager, structural engineer, services engineer, site manager, buyer, planner.
- Planning and forecasting a project's needs, requirements and resources.
- On-site, short-term management for projects in progress:
  - pre-construction
  - site preparation
  - construction phase
  - handover.
- Claiming interim payments.
- Managing cash flow.
- Order and delivery of materials.
- Labour requirements.
- Training needs.
- Plant requirements.
- Quality assurance and control.
- Workforce supervision.
- Health and safety requirements.
- Decision making.
- Managing unforeseen events.
- Handover schedule.
- Completion.
- Managing the organisation's viable options:
  - national and local government policies, trends
  - labour requirements, recruitment, investment in skills and training
  - subcontract or direct employment
  - site management structure:
    - fully site based
    - head-office-based functions and support
  - plant and equipment hire, lease or purchase.
- Organising, procuring, co-ordinating and controlling:
  - materials, plant and equipment delivered to site on time
  - site storage facilities
  - site distribution methods
  - workforce requirements.

- Motivating the workforce:
  - incentives, including bonus payments
  - awards and rewards
  - job security, including contract renewal
  - training.
- Communication with the design and management team, the workforce, suppliers:
  - chains of command and management structures
  - team and site meetings
  - written forms of communication, their use and appropriateness, to include letters, architect's instructions, site instructions
  - telecommunications, to include telephones, mobiles and site radios
  - graphical and electronic forms of communication, e.g. emails, texts, instant messaging
  - information technologies, to include building information modelling (BIM).

A2 Application of construction management techniques

Site management responsibilities and the techniques used to manage a project/site to ensure an efficient build from commencement to completion, on programme and to budget.

- Standard planning techniques and how these are applied to control work onsite:
  - production and use of master programmes
  - production and use of progress monitoring techniques:
    - Gantt charts, Critical Path Analysis, Line of Balance charts
  - production of daily activity sheets
  - production of site layout plan, to include access/exit points, materials storage, crane locations, site accommodation, temporary services, temporary site roads and hard standings
  - production and monitoring of delivery schedules
  - production of method statements and risk assessments for the various phases of construction work.
- The application of quality assurance and quality-control requirements:
  - document control
  - drawing registers
  - use of the specification
  - site testing
  - offsite testing
  - site inspection
  - dimensional quality control.
- Compliance with statutory liaison, building regulations, project materials specification requirements:
  - building regulation notices and inspection
  - official house building inspections and standards.
- Application of on-site sampling and material testing techniques.
- Supervision and inspection of the quality of outcomes produced by the workforce.

- Management of direct workforce:
  - recruitment, training, competence requirements, including any official certification schemes requirements
  - monitoring of equal opportunities
  - leadership skills, including how to motivate individual and group members, creating productive team behaviours.
- Management of subcontractors:
  - communication methods, to include language use to instruct, persuade, motivate, discipline
  - checking of insurance and legal requirements and responsibility for compliance
  - retention of payment practice and its use
  - production of snagging lists of remedial works required.

Learning aim B: Understand purchasing and cost management techniques

B1 Application of purchasing methods

Use and application of purchasing techniques to facilitate the effective supply of materials to construction projects and the benefits and drawbacks of their use.

- List of selected suppliers:
  - area of operations
  - previous performance
  - capacity to supply
  - reputation of supplier
  - stock levels
  - ability to meet changes in demand.
- Materials and subcontract enquiries:
  - number of quotations required
  - scheduling materials or extracts from bills of quantities
  - use of correct or appropriate specifications
  - receipt of and checking quotations
  - gap analysis
  - negotiating skills.
- Planning links:
  - purchasing materials to meet the requirements of the construction programme
  - items with long lead times that might impact on construction planning
  - just-in-time deliveries to programme requirements when site storage is limited.
- Ethical purchasing and supply:
  - purchasing policy
  - sustainable and local sourcing
  - minimising transportation
  - use of sustainable materials
  - fair trade agreements
  - abuse of power
  - avoidance of corruption
  - social responsibility.

- Purchase orders:
  - terms and conditions
  - discounts
  - timing of orders
  - clarity of content.
- Benefits and drawbacks of serial and term contracts:
  - annual supply contracts
  - multiple project contracts
  - serial contracts.

B2 Cost management techniques

Recognition and knowledge of cost management techniques applied during a building project and an appreciation of how these assist the manager to plan and manage the budget.

- Analysis of interim claims, to include:
  - preliminary items
  - measured work by trade or element breakdown
  - nominated subcontract values
  - materials onsite.
- Cost value comparisons, to include:
  - costs from management information systems
  - monthly valuations reconciled with project costs
  - profit and loss projections
  - cash flow forecasts.
- Managing costs:
  - selection and application of techniques available to break down, itemise and control the project cost, to include:
    - unit costing
    - element costing
    - marginal costing
    - variance analysis
  - selection and use of techniques to enable prices and budgets to be prepared and compared, to include:
    - estimated costs
    - variable costs
    - target costs
    - actual costs
  - identifying cost savings, to include:
    - labour
    - plant
    - materials
    - site set-up
    - site management structure
    - methodologies
    - programme acceleration or deceleration.
- Preparing and examining elemental and project comparison costs.

Learning aim C: Develop a programme of activities for construction works

C1 Production control systems

Understand the need, and techniques, to plan and control a project onsite, both in terms of physical and financial progress, and to be able to communicate this information to site and management teams.

- Production of programmes of activities:
  - planning project organisation, to include:
    - method statements
    - site layout
    - site accommodation and storage
    - waste management
    - site traffic management
  - use of Gantt charts, bar charts, linked bar charts to show and monitor progress of the construction project
  - use of Critical Path Analysis, network analysis, Line of Balance, precedence diagrams, time change diagrams to show and monitor progress of the construction project:
    - manual and computer-based techniques onsite.
- Measurement of progress:
  - physical progress onsite, to include:
    - regular comparison of planned progress of work onsite with actual progress
    - methods to overcome the consequences of running ahead or behind project schedule
    - causes and effects of delays, the consequences of rescheduling, implementing overtime payments, extensions of time applications
  - preparation of financial progress information, to include:
    - site returns
    - interim valuations and payments
    - claims and variations
    - reviewing events, predicted and unforeseen.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the principles and application of management in construction		**A.D1** Evaluate the different roles of the construction management team, their responsibilities and the techniques applied by a site manager to manage the project.
A.P1 Explain the roles of the members of the construction management team and their individual responsibilities. **A.P2** Explain the techniques applied by a site manager to manage the project.	**A.M1** Discuss the roles of the members of the construction management team and how their individual responsibilities are applied. **A.M2** Discuss the techniques applied by a site manager to manage the project.	
Learning aim B: Understand purchasing and cost management techniques		**B.D2** Evaluate the methods used to facilitate the ethical supply of appropriate materials to site, meeting programme requirements, and how these impact on the cost management and profitability of construction projects.
B.P3 Explain the methods used by construction companies to facilitate the supply of appropriate materials to site. **B.P4** Explain the cost management techniques used to monitor and control the cost and profitability of construction projects.	**B.M3** Assess the methods used to facilitate the cost-effective supply of appropriate materials to site. **B.M4** Analyse the cost management techniques used to effectively monitor and control the cost and profitability of construction projects.	
Learning aim C: Develop a programme of activities for construction works		**C.D3** Produce a comprehensive programme of activities, with graphical representations and highly detailed timings that show critical and non-critical elements for a given construction project, and consider the most appropriate method to monitor progress.
C.P5 Produce a programme of activities with graphical representations for a given construction project. **C.P6** Explain the methods used to monitor the progress of construction projects.	**C.M5** Produce a detailed programme of activities, with graphical representations and appropriately detailed timings for a given construction project, and consider an appropriate method to monitor progress.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.M2, A.D1)

Learning aim: B (B.P3, B.P4, B.M3, B.M4, B.D2)

Learning aim: C (C.P5, C.P6, C.M5, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners would benefit from access to project management planning software and case studies of real-world construction projects, of varying size and scope.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the construction management team roles and responsibilities. They will demonstrate a thorough understanding of how the manager will plan, interact, communicate and motivate within their team and with the production workforce and subcontractors, and how their individual responsibilities are applied and impact on the successful construction of a building.

For merit standard, learners will discuss the different roles of the management team and how their individual responsibilities are applied in the planning and running of a building project. They will also discuss the techniques applied by a site manager to manage the project and coordinate the workforce, including the subcontractors, onsite. They will consider the different aspects of site management, how they interrelate and the extent to which they are important.

For pass standard, learners will explain the roles and responsibilities of the members of the construction management team, including the roles relevant to the project scenario and their duties and involvement in the planning and implementation of a building project. They must describe the techniques applied to manage the project, including the supervision of the workforce and the subcontractors, as well as the coordination of their activities onsite. In explaining, learners will demonstrate that they understand the functions and objectives of construction management techniques and their suitability for the given scenario.

Learning aim B

For distinction standard, learners will evaluate the methods used to facilitate the ethical supply of appropriate materials to site, meeting programme requirements, and how these impact on the cost management and profitability of construction projects. In doing so, they will consider the different aspects of the purchasing function and the cost management techniques used to monitor and control construction costs. When evaluating, learners will draw on their knowledge of purchasing and cost-control methodologies, as well as the concepts and principles applied to the scenario, considering their strengths and weaknesses, their interrelation, relevance or significance, leading to a justified conclusion.

For merit standard, learners will assess the methods used to facilitate the cost-effective supply of appropriate materials to site. They will analyse the cost management techniques used to effectively monitor and control the cost and profitability of construction projects. When discussing, learners will consider the different aspects of purchasing and cost control, their techniques and methodologies, how they interrelate, and the extent to which they are important.

For pass standard, learners will explain the methods used by construction companies to facilitate the supply of appropriate materials to site. They will also explain the cost management techniques used to monitor and control the cost and profitability of construction projects. In explaining, learners will demonstrate that they understand the functions and objectives of purchasing and cost-control techniques and their suitability for the given scenario.

Learning aim C

For distinction standard, learners will produce a comprehensive programme of activities, with graphical representations and highly detailed timings that show critical and non-critical elements for a given construction project. Learners will consider the most appropriate method to monitor progress and the shortest route to completion, with the placement of non-critical elements based on the identified float. The programme will be in an appropriate format with the correct sequence of activities and attention to detail. Learners will clearly explain the appropriate methods for monitoring progress onsite.

For merit standard, learners will produce a detailed programme of activities, with graphical representations and appropriately detailed timings for a given construction project, and consider an appropriate method to monitor progress. Learners will clearly explain the appropriate methods for monitoring progress on site.

For pass standard, learners will produce a programme of activities with graphical representations for a given construction project. The programme will use one of the techniques noted in the specification. They will explain the methods used to monitor the progress of construction projects. In explaining, learners will demonstrate that they understand the functions and objectives of progress monitoring and the suitability of the methods for the given scenario.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 4: Safe Working Practice
- Unit 10: Surveying in Construction
- Unit 13: Site Engineering for Construction
- Unit 20: Quantity Surveying.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from specialist construction project management organisations
- participation in audience assessment of presentations
- design/ideas to contribute to unit assignment/case study/project materials
- work experience
- employer’s business materials as exemplars
- support from local business staff as mentors.

Unit 12: Building Surveying in Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop the skills needed to survey existing buildings, establish current condition and size, and enable detailed survey reports/plans that highlight defects and identify potential issues.

Unit introduction

If something goes wrong with a building, how do you know what the problem is and how to fix it? A building surveyor carries out surveys on existing properties and advises the owners on how to repair, alter or extend the building to meet new needs.

In this unit, you will learn how to carry out a buildings survey, identify defects and record findings in a format suitable for a range of end users. You will gain a good understanding of building defects, their causes and the remedies available. You will learn how to undertake a measured survey of an existing property to produce scale plans and elevations of the building.

The skills in this unit are essential for employment as a building surveyor, building inspector or real estate professional and other related construction roles in a range of areas such as construction management, site supervision, quantity surveying, commercial management and architecture. This unit will give you a good foundation for studying construction-related subjects at a higher level, including degree-level programmes.

Learning aims

In this unit you will:

A Understand the impact of the methods used to construct existing buildings on current and future maintenance requirements

B Explore different defects and methods of repair for low-rise residential properties

C Undertake a building survey of a low-rise residential property.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the impact of the methods used to construct existing buildings on current and future maintenance requirements	**A1** Different styles and types of residential property **A2** Traditional methods of construction **A3** Modern methods of construction	Illustrated report or presentation and information booklet on different types and styles of residential properties.
B Explore different defects and methods of repair for low-rise residential properties	**B1** Defects to the external envelope **B2** Internal defects **B3** Methods of repair and remediation	Building and measured survey of a low-rise residential property. Production of survey report detailing the condition, defects, remedial works, plans and elevations.
C Undertake a building survey of a low-rise residential property	**C1** Types of survey **C2** Undertaking a building survey **C3** Undertaking measured surveys **C4** Skills, knowledge and behaviours	

Content

Learning aim A: Understand the impact of the methods used to construct existing buildings on current and future maintenance requirements

Different methods of construction, styles and periods of architecture.

A1 Different styles and types of residential property

The features and details of residential property types, periods and styles to inform maintenance requirements and remedial works.

- Types of property:
  - detached, semi-detached, terraced, end-terraced, bungalow, flat, duplex, maisonette, cottage, mansion, manor house, ‘prefab’, other types of property found within the architectural vernacular of the host country.
- Key periods and architectural styles of residential property:
  - pre-industrialisation
  - post-industrialisation
  - impact of world and regional wars on architectural styles
  - modern, postmodern, contemporary.

A2 Traditional methods of construction

Recognition and knowledge of construction technologies found in low-rise residential properties and how material evolution and advancement impact on construction to facilitate decisions related to maintenance required and remedial works.

- Foundations:
  - strip foundations
  - raft foundations
  - spreader foundations/corbelled brickwork/masonry foundations
  - timber piles.
- Walls:
  - solid:
    - stone, brick, block, materials within the local architectural vernacular
  - cavity:
    - brick and block, brick and brick, stone and block/brick, block/brick and metal cladding, other combinations appropriate to the local architectural vernacular
  - framed:
    - cruck frame, box frame, post and beam, storey height panels, frames used within the local architectural vernacular.
- Roofs:
  - pitched, mono-pitched, mansard, dormer
    - traditional timber, timber truss, metal truss
    - slate, stone, clay tiles, thatch, metal sheet
  - flat:
    - timber, metal deck, concrete
    - lead, felt, asphalt
    - structure and materials relevant to the local architectural vernacular.

- Floors:
  - concrete/ground-bearing slab
  - suspended timber (ground floor and upper floors)
  - stone slab
  - compacted earth/aggregate.
- Internal walls:
  - concrete block
  - brick
  - stone
  - timber stud
  - solid plaster and plaster and lath finishes
  - materials within the local architectural vernacular.
- Doors and windows:
  - timber, metal, single glazing, secondary glazing, leaded lights, shutters.

A3 Modern methods of construction

Recognition and knowledge of construction technologies found in low-rise residential properties and how material evolution and advancement impacts on construction to facilitate decisions related to maintenance required and remedial works.

- Foundations:
  - strip
  - trench fill
  - raft
  - short bored pile.
- Walls:
  - Solid:
    - thermal blocks, external insulation, internal insulation, external finishes (render, cladding)
    - rainscreen cladding
  - cavity:
    - brick and thermal block, block and block, insulated cavities, internal insulation, internal finishes (plaster, dry lining), external insulations, external finishes (render, cladding)
  - framed:
    - storey height panels, structured insulated panels (SIPs)
    - timber frame construction, platform frames
  - insulation
  - use of thermal mass
  - modern external walling methods used in the local architectural vernacular.
- Roofs:
  - pitched and mono-pitched:
    - timber truss, metal truss, SIPs
    - slate, stone, clay tiles, thatch, metal sheet, green roof, polycarbonate, glass
  - flat:
    - timber, metal, concrete
    - felt, single ply membrane, Green Roof Professional (GRP)

  - insulation
  - modern roofing methods used in the local architectural vernacular.
- Floors:
  - concrete:
    - ground-bearing slab, suspended concrete, insulation, screeds
  - suspended timber:
    - solid timber, engineered joists
  - insulation
  - modern flooring methods used in the local architectural vernacular.
- Internal walls:
  - metal stud
  - timber stud
  - board and skim finishes
  - modern external walling methods used in the local architectural vernacular.
- Doors and windows:
  - timber, PVCu, thermally broken metal, composite frames, composite doors, double and triple glazing, thermal coatings and gases.
- Modular construction:
  - modular room pods
  - modular dwelling pods
  - modular sections.

Learning aim B: Explore different defects and methods of repair for low-rise residential properties

Consideration of the defects to the key elements of a building, focusing on those most commonly noted in the building survey.

B1 Defects to the external envelope

- Foundation defects:
  - settlement:
    - seasonal movement (frost, heave), mining, compression of substrata, landfill, trees, ground shrinkage, seismic movement
  - sulphate attack
  - overloading
  - bad design/poor construction methods.
- Wall defects:
  - bowing/bulging:
    - poor construction detailing, wall tie failure, lack of lateral support, overloading, roof thrust, alterations and changes to original structure
  - failure of arches, lintels, embedded timbers and structural elements
  - expansion of embedded steel and iron fixings
  - surface failure
    - expansion and contraction, UV levels, frost, efflorescence, cracking, sulphate attach, poor specification, bad workmanship/detailing, failed pointing, incorrect pointing mixes, material failure, water ingress.
- Chimney defects:
  - tall and thin stacks with no support, failure of the internal structure, freeze thaw, sulphate attack, water ingress.

- Roof defects:
  - structural failure:
    - poor construction/detailing, lack of ties, lack of lateral restraint, change of covering, water ingress, alterations, rot/insect attack of timber, flashings (missing, sand : cement), no ventilation
  - covering failure:
    - poor construction, corrosion of mechanical fixings, delamination, efflorescence, pointing corrosion, thermal expansion, frost damage.
- Door and window defects:
  - rotten timber, putty failure, fixing failure, failure of hinges and handles, rusting to steel and iron fixings, swelling and poor operation.
- Failure of decoration.

B2 Internal defects

Recognition and knowledge of internal building defects to facilitate decisions related to maintenance required and remedial works.

- Ground floor:
  - concrete:
    - sulphate attack, membrane failure, damp ingress, poor detailing/construction, settlement, heave, screed failure, excessive spans for pre-cast
  - timber:
    - poor construction and detailing, lack of ventilation, damp ingress, excessive spans, lack of support/strutting, insect attack, fungal attack, joist ends built in with no DPC.
  - stone slab:
    - ground movement, lack of support, joint failure, poor detailing/construction, cracking
  - compacted earth / aggregate:
    - surface disaggregation, water ingress.
- Upper floors and ceilings:
  - floors:
    - poor construction and detailing, lack of support to the joist ends, lack of support and strutting causing sagging, alterations and service holes/notches, overloading, insect and fungal attack, joist ends built in with no DPC, failure of mechanical fixings
  - ceilings:
    - poor construction and detailing, failure of fixings to plaster laths or boards causing debonding of surface finish, water leaks causing stains.
- Walls:
  - masonry:
    - overloading, alterations, poor detailing and construction, damp (rising and penetrating), lack of lateral support, lack of support below
  - timber:
    - overloading, alterations, poor detailing and construction, damp, lack of lateral support, lack of support below, lack of strutting, insect and fungal attack, service holes and notches
  - walling methods used in the local architectural vernacular:
    - relevant defects relating to the local architectural vernacular and local natural environment/climate.

- Stairs:
  - overloading, insect and fungal attack, poor detailing and design, loose spindles and handrails, loose tread and risers, movement, wear and tear.
- Decoration:
  - damp staining, wallpaper peeling, paint finish imperfections.

B3 Methods of repair and remediation

Determining appropriate repairs from which options are selected.

- Repair:
  - minimal intervention to affected area only
  - repairs to the obvious damage but not necessarily the root cause (stitching cracks, sealing damp areas, redecoration to cover defects).
- Methods of repair for common defects:
  - damp, cracking, insect and fungal infestation.
- Replace/renew:
  - extensive repairing option to remove root cause and makes good to wider area
  - underpinning
  - taking down and rebuilding
  - complete removal of damaged area, rebuilding with new materials, e.g. structural timbers.

Learning aim C: Undertake a building survey of a low-rise residential property

Understanding of different survey types, their use and application, and the actual process of undertaking a survey.

C1 Types of survey

Survey types, purpose, essential content and use.

- Building survey.
- Types offered by national and international surveying organisations.
- Mortgage valuation.
- Schedule of Dilapidations (Landlord and Tenant).
- Schedule of Condition (Landlord and Tenant).
- Maintenance survey.
- Alteration survey.
- Stock condition survey.
- Mortgage drawdown.
- Access audits.
- Elemental survey.
- Insurance reinstatement survey.
- Defect analysis survey.
- Health and safety survey.
- Measured survey.

C2 Undertaking a building survey

Surveying a building and recording findings to produce a building survey report.

- Pre-survey protocol:
  - confirmation of instruction, access arrangements, health and safety considerations.
- Property inspection requirements:
  - inspection of the building's main elements (walls, roof, floors, doors and windows)
  - recording inspection findings – element condition, defects
  - photographic record requirements, e.g. of the property, defects
  - measurement of defects, e.g. levels of damp, width of cracks, distance of deflection or movement.
- Survey report requirements and completion: general description of the property, details of condition and specific defects, photographic record of condition and defects.

C3 Undertaking measured surveys

Measured survey requirements to produce survey drawings.

- Pre-survey protocol:
  - confirmation of instruction, access arrangements, health and safety considerations.
- Property inspection requirements:
  - sketching the layout of floor plans and elevations
  - measurements and recording requirements to produce floor plans and elevations.
- Survey drawings:
  - production of scale plans
  - production of elevations.

C4 Skills, knowledge and behaviours

Demonstrate behaviour and its impact on outcomes, to include professionalism, etiquette, working to deadlines, accountability and individual responsibility.

- Evaluating outcomes to help inform high-quality, justified recommendations and decisions.
- Media and communication skills, including:
  - the ability to convey intended meaning, e.g. written (design documentation, recording documentation, reports, visual aids for presentation use), verbal communication requirements (one to one and group, informal and formal situations)
  - use of tone and language for verbal and written communications to convey intended meaning and make a positive and constructive impact on audience, e.g. positive and engaging tone, technical/vocational language suitable for intended audience.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the impact of the methods used to construct existing buildings on current and future maintenance requirements		
A.P1 Describe the different styles and types of residential housing. **A.P2** Describe the different methods of traditional and modern construction used for residential housing and their impact on current and future repair and remedial work.	**A.M1** Discuss the different residential housing styles and types, how their construction methods are applied and their impact on the current and future requirements for repair and remedial work.	**A.D1** Evaluate the different residential housing styles and types, how their construction methods are applied and their impact on the current and future requirements for repair and remedial work.
Learning aim B: Explore different defects and methods of repair for low-rise residential properties		
B.P3 Describe a range of external and internal defects commonly occurring in residential properties. **B.P4** Explain different methods of repair and remediation to a range of internal and external defects of a residential property.	**B.M2** Discuss appropriate repair and remedial measures for a range of external and internal defects for a residential property	**BC.D2** Evaluate the repair and remedial work options for the defects identified in the building survey. **BC.D3** Demonstrate individual responsibility, creativity and self-management when preparing for and undertaking the building survey and producing the survey report and drawings.
Learning aim C: Undertake a building survey of a low-rise residential property		
C.P5 Perform a building survey, detailing the condition and defects with required remedial works for a residential property. **C.P6** Record the findings of the survey in a survey report. **C.P7** Perform a measured survey on a residential property. **C.P8** Produce accurate scale plans and elevations for a residential property to standard conventions.	**C.M3** Produce a comprehensive and detailed building survey, detailing the condition, defects and remedial works required, with plans and elevations for a residential property.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, B.P4, C.P5, C.P6, C.P7, C.P8, B.M2, C.M3, BC.D2, BC.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must:

- have access to a suitable property to undertake a building survey and a measured survey (ideally of typical residential scale)
- be supervised during the survey
- have measures in place to ensure health and safety, including the provision of appropriate safety briefings and the use of appropriate safety equipment.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the evolution and development of residential housing types and styles, methods of construction and the impact on the current and future requirements for repair and remedial work. Learners will demonstrate a thorough understanding of the changes in design and style and how different methods of construction have contributed to these changes. They will demonstrate how material evolution and advancement has allowed for changes in style. For example, learners can demonstrate how, through the use of engineered joists, layouts in modern houses do not need as many supporting walls. Similarly, they can explain how developments in concrete technology in the 1960s saw an increase in concrete structures, even on a domestic scale, and show how a lack of understanding led to problems with damp and condensation. Information will be well researched and presented in a clear and coherent manner for the intended audience, with clearly described examples and annotated visual elements.

For merit standard, learners will discuss the evolution and development of housing types, styles and construction methods and the impact on the current and future requirements for repair and remedial work. They may not necessarily make the links between changing styles and material development but will consider how different techniques can allow for different designs and styles. Learners' work will be clear and provide sufficient detail as to construction methods and how the elements fit together. Information will be technically correct and at an appropriate level for the intended audience.

For pass standard, learners will describe the different methods and styles of housing used in traditional and modern methods of construction and the impact on the current and future requirements for repair and remedial work. They will be technically accurate but will not make links between different styles and changes in materials. Learners will consider the three different architectural styles, and traditional and modern construction methods, and will demonstrate a good understanding of them.

Learning aims B and C

For distinction standard, learners will demonstrate a high level of technical knowledge, autonomy and self-reliance. They will also demonstrate a high level of skill in inspecting an existing property, recording the condition and analysing the defects found. They will develop a detailed schedule for the repair and remediation of the defects noted. This will typically be located in the recommendations section of the report they produce. The report will be to a very high standard, technically accurate and will contain very few errors or omissions.

Learners will take individual responsibility for their own work, for example identifying potential issues and resolving them, reviewing their work and making improvements, and keeping their work safe and secure. They will show their creativity, for example through taking modern approaches to the solving of building defects. Learners will refer to tangible evidence, such as survey records, to support their evaluation.

For merit standard, learners will produce a detailed, illustrated survey report in a standard format that identifies the condition of the property defects and examples of remedial action. During the survey, learners will exhibit awareness for health and safety and produce a detailed record of field observations.

For pass standard, learners will undertake a building and measured survey, and produce a survey report and a set of plans and elevations using standard formats and conventions. The report will be limited in detail but will record the condition of the property and identify the defects. They will show gaps in knowledge and the report may not contain appropriately annotated photographs. Field observations can be limited and another surveyor may struggle to use them. Learners will act in a timely fashion and will undertake the survey and produce the report in accordance with agreed timescales.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 4: Safe Working Practice
- Unit 7: Graphical Detailing
- Unit 10: Surveying in Construction.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- ideas to contribute to unit delivery and assignments
- work experience in the construction settings where building surveying knowledge and skills are used.

Unit 13: Site Engineering for Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners undertake site engineering processes used to set out construction and built environment projects.

Unit introduction

The skills required for setting out construction and civil engineering works involves a high degree of accuracy. This is essential in meeting the tolerances of the elements that form the substructure and the superstructure so that the building, and its components, fit into position correctly. For example, the specification for the installation of roads is often in terms of +/− 3 mm in level. Also, as a site engineer, you will need to be able to read dimensions from drawings provided by the designer and produce calculations to assist in setting out the work. Building modern city landscapes requires the ability to control the verticality of multi-storey buildings to a high degree of accuracy from storey to storey.

In this unit, you will use a range of surveying equipment to set out construction work, including string lines, pegs and total stations to ensure that the completed structure meets the designer's specification in terms of appearance and accurate positioning.

This unit gives you the opportunity to progress to site-management, project-management and supervision roles in the construction sector as a site manager or site engineer, or to progress to specialist civil engineering qualifications.

Learning aims

In this unit, you will:

A Undertake the setting out of construction work on plan

B Undertake the setting out of infrastructure works

C Explore how to maintain horizontal and vertical control in setting out.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Undertake the setting out of construction work on plan	**A1** Setting-out terminology **A2** Basic setting-out processes **A3** Interpreting drawn information to set out construction work **A4** Site engineering equipment	A case study scenario where learners have to acquire all the information, equipment and data for a setting-out project. They will produce a method statement detailing all requirements, then set out a building on plan.
B Undertake the setting out of infrastructure works	**B1** Setting out drainage **B2** Setting out embankment and cutting profiles **B3** Interpreting drawn information to set out roads	Fieldwork practical tasks to defined levels of accuracy. Learners will evaluate methodologies used in undertaking a series of practical setting-out tasks.
C Explore how to maintain horizontal and vertical control in setting out	**C1** Vertical and horizontal control of structures **C2** Vertical and horizontal control of excavation	

Content

Learning aim A: Undertake the setting out of construction work on plan

A1 Setting-out terminology

Setting-out terminology use and its application to associated equipment and methods.

- Base line as the starting point used to offset the grid lines on plan.
- Corner pegs are used to indicate the corner points of structures.
- Profile boards are used to indicate the inside, outside and centre lines of walls and indicate levels for depth and height control.
- A traveller is used between profile boards to indicate the extent of reduced-level excavation.
- The centre line follows a midpoint between the inside and the outside face of a wall.
- Coordinates are indicated by northings and eastings, polar or Cartesian systems.
- Grids are square arrangements of intersecting lines.
- String lines are drawn between two points to denote a grid, building element face or centre line.
- Diagonal measurement is taken across two opposing corners to confirm accuracy of setting out squares and rectangles.
- Offset measurement is taken perpendicular from a base line.

A2 Basic setting-out processes

Application of techniques used to establish basic setting-out points in the field.

- Construction of a right angle using the following methods:
  - Pythagoras' theorem
  - builder's square
  - optical square
  - base line and scribing equal arcs
  - theodolite
  - coordinates from a total station
  - calculation of diagonal from two sides
  - the three, four, five technique.
- Transferral of bench mark to establish a temporary bench mark (TBM) onsite:
  - sourcing a bench mark
  - digital information reference to drawings and design levels
  - methods of recording on site and protecting TBM
  - use of storey tapes for vertical heights.

A3 Interpreting drawn information to set out construction work

Fieldwork in setting out buildings on plan for initial excavation and for external wall positions.

- Setting out buildings for initial excavation to reduced level of foundations:
  - interpretation of drawings for setting-out information and dimensions onsite
  - square or rectangular shapes containing voids on plan for excavation using corner pegs to indicate centre of foundation trench.

- Setting out buildings for outlines of external walls:
  - the use of profile boards for a building's external walls, centre line, foundations and position of cavity.

A4 Site engineering equipment

- How and when traditional setting-out tools and equipment are used:
  - pegs, to include basic pegs, string lines, nails, saw cuts
  - tools, to include sledgehammer, claw hammer, lump hammer, saw
  - profile rails and boards, including use of saw cuts and pins
  - road pins and tape
  - markers, to include marker spray, paint, sand, lime
  - measuring, to include tape measures, steel and fibre, retractable steel tape measure
  - optical surveying equipment, to include level, tripod, theodolites, staff.
- How to use and the benefits of digital technology, to include:
  - total station
  - equipment using laser levelling
  - laser measuring devices.

Learning aim B: Undertake the setting out of infrastructure works

The use and application of methods employed in the field to set out the following types of construction and civil engineering work.

B1 Setting out drainage

- Calculating the gradient from invert levels taken from design drawings.
- Transferring TBM to drainage position onsite.
- Positioning manholes.
- Calculating heights of profile rails.
- Setting up profile boards.
- Establishing profile rails and highlighting with spray paint.
- Calculating the length of traveller.
- Constructing traveller.
- Positioning cover level indicators.

B2 Setting out embankment and cutting profiles

- Positioning base of embankment on plan, using pegs.
- Calculating embankment gradient from road levels and ground levels.
- Positioning profile sight rails to gradient.
- Checking that rails are parallel.
- Calculating drainage ditch profile.
- Positioning profile.

B3 Interpreting drawn information to set out roads

- Establishing road curve points and all data from road design drawings.
- Selecting and applying the following methods to set out curves based on given information:
  - using the chord point method, how to:
    - establish intersection points
    - establish tangent points
    - calculate the deflection angle, radius of curvature, centre of curvature
    - establish setting-out data for a number of points on the curve
    - set out road kerb curve using pins
  - using the deflection angle method, how to:
    - establish deflection angle
    - establish tangent angles
    - establish chord lengths
    - set up theodolite over starting point
    - establish each tangential point by deflection angle and chord length.

Learning aim C: Explore how to maintain horizontal and vertical control in setting out

C1 Vertical and horizontal control of structures

Techniques used and their application to control vertical structures maintaining tolerances in accordance with specifications.

- Concrete works, to include:
  - positioning of kickers for in-situ concrete columns
  - checking verticality of column shuttering in two directions
  - confirming within tolerances
  - checking squareness and diagonals of shuttering profile on plan
  - checking cover to reinforcement.
- Structural steel works:
  - positioning holding down bolt boxes in line with grid
  - checking verticality of steel columns in two directions
  - confirming within tolerances
  - checking columns' profile lines in the grid.

C2 Vertical and horizontal control of excavation

Application of techniques to record data before setting out of construction work for secondary purposes.

- Establishing and recording a grid of ground levels before excavation, to include:
  - setting out a grid over the area of the excavation
  - taking flying levels over the area
  - plotting grid of levels to reduced level.
- Interim and final grid of levels from reduced excavation to establish volumes, to include:
  - setting out a grid over the area of the excavation
  - taking flying levels over the area
  - plotting grid of levels to excavation level
  - calculating of the formation level achieved and confirmation of depth
  - providing records for quantity surveying applications.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Undertake the setting out of construction work on plan		
A.P1 Explain the setting-out procedures using traditional tools, equipment and processes to a given level of accuracy. **A.P2** Perform setting out a structure to define the centre line, and the external and internal faces of the enclosing wall to a given tolerance.	**A.M1** Discuss the selection of setting-out tools, equipment and processes for the accurate setting out of a given structure.	**A.D1** Justify the selection of setting-out tools, equipment and processes for the accurate setting out of a given structure.
Learning aim B: Undertake the setting out of infrastructure works		
B.P3 Perform setting out a drainage run to given tolerances. **B.P4** Perform setting out the position of an embankment, cutting and profiles. **B.P5** Perform setting out a complex road curve using appropriate methods.	**B.M2** Analyse the setting-out methodologies used to accurately set out infrastructure works.	**B.D2** Evaluate the setting-out methodologies used to accurately set out infrastructure works.
Learning aim C: Explore how to maintain horizontal and vertical control in setting out		
C.P6 Produce a pre-excavation survey grid in a drawn format and calculate volumes. **C.P7** Calculate the volumes of excavation using an appropriate method. **C.P8** Explain how accuracy is achieved in setting out vertical and horizontal elements.	**C.M3** Discuss the methods used to achieve accurate setting out and excavated volume calculation.	**C.D3** Evaluate the methods used to achieve accurate setting out and excavated volume calculation.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, B.P4, B.P5, C.P6, C.P7, C.P8, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to a range of setting-out equipment to meet the needs of the practical assessment. This can be achieved using (traditional) optical equipment or digital technologies. One option could be to hire a total station,).
A suitable location that is safe to use for setting-out purposes will need to be established.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will justify the equipment used for specific setting-out tasks. This must be in terms of the accuracy that has to be achieved. Their justification will cover a range of setting-out equipment, tools and processes, and they will give reasons to support and confirm the appropriate methodologies used. Learners will perform the setting out of a structure and will refer to this during their justification.

For merit standard, learners will discuss the equipment used for specific setting-out tasks. This must be in terms of the accuracy that has to be achieved. Their discussion must cover a range of setting-out equipment, tools and processes, and they will consider the importance of elements of the process and how they interrelate. Learners will perform the setting out of a structure and will refer to this during their discussions.

For pass standard, learners will produce a report for the setting out of a rectangular structure to a given level of accuracy. Their setting out must include the positioning of profile boards or rails. The level of accuracy should reflect the application, for example excavation or external wall construction. Learners will set out a building or structure that includes profile boards or rails and establishes three grid lines. These will be completed to a given tolerance. Learners will explain the setting-out procedures, equipment and methodologies adopted to produce work to a given level of accuracy.

Learning aims B and C

For distinction standard, learners will evaluate the methods used to achieve accuracy in the setting out of infrastructure works, including horizontal and vertical elements and the production of a pre-excavation survey grid. They will complete the setting out of a drainage run, an embankment and a complex road curve that includes calculating the theoretical distances and angles using trigonometry, which is then used to compare the actual lengths and angles achieved in the setting-out exercises. They will also complete a pre-excavation survey grid. In a fieldwork book, learners can record the communication used in setting out so that a third party can understand the notes made. Communication needs to be clear and professional in its layout and methodology.

In evaluating this, learners will draw on their knowledge to consider the strengths and weaknesses of each method and their relevance or significance, leading to supported judgements.

For merit standard, learners will discuss and analyse the methods used to achieve accuracy in the setting out of infrastructure works, including horizontal and vertical elements and the production of a pre-excavation survey grid. They will complete the setting out of a drainage run, an embankment and a complex road curve that includes calculating the theoretical distances and angles using trigonometry, which is then used to compare the actual lengths and angles achieved in the setting-out exercises. They will also complete a pre-excavation survey grid. In a fieldwork book, learners can record the communication used in setting out so that a third party can understand the notes made. Communication needs to be clear and professional in its layout and methodology.

In discussing this, learners will draw on their knowledge to consider the different aspects of each method, how they interrelate and the extent to which they are important. Learners will consider the different aspects of the methodologies and how they interrelate, including their importance in terms of achieving accuracy.

For pass standard, learners will set out three items: a drainage run, including the excavation for a manhole, an embankment and cutting, and a complex road curve from two straight entries and exits. Their pre-excavation survey evidence needs to be a grid of reduced levels taken across sloping or uneven ground so a range of ground levels can be established. Their booking and drawing should be to a standard that a client would expect to be given. Their explanation of accuracy for vertical and horizontal control must evidence tolerances required for functions, for example the tolerances on holding-down bolts for steel stanchions. Learners must explain how accuracy is achieved when setting out vertical and horizontal elements.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 3: Construction Science
- Unit 6: Construction Mathematics
- Unit 10: Surveying in Construction
- Unit 12: Building Surveying in Construction.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers from a specialist setting out firm, or a project management specialist
- participation in audience assessment of presentations
- design/ideas to contribute to unit assignment/case study/project materials
- work experience
- employer’s business materials as exemplars
- support from local business staff as mentors
- site visits.

Unit 14: Low Temperature Hot Water Systems in Building Services

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of low-temperature hot-water (LTHW) systems that provide hot water for domestic use and heating.

Unit introduction

In many buildings around the world, heating installations are essential for providing hot water and heating. Modern heating systems are expected to do much more than maintain the temperature of a space. They must be efficient, functional and environmentally friendly, and should contribute to sustainable development. Space heating is a major consumer of energy and therefore a significant source of carbon dioxide (CO_2) emissions. Plumbers and heating engineers are responsible for the installation of such systems.

In this unit, you will investigate the development of low temperature hot water (LTHW) heating installations. This begins with the agreement of client needs and design requirements for a system, continues through the design of layouts, proceeds to the sizing, selection and specification of pipes and equipment, and concludes with the commissioning of a system and its subsequent maintenance. This ensures that hot water is delivered at the right temperature and the heating functions correctly when switched on.

This unit will support you in progressing to a higher-level construction programme such as the Higher National in Construction with the Building Services pathway, or a general construction or building services degree. Additionally, this unit will give an insight into LTHW systems for supporting site managers, quantity surveyors and other professionals, who need a generic understanding of these systems. It also supports progression to the workplace as a technician or direct entry as an assistant services engineer in a construction company.

Learning aims

In this unit you will:

A Understand the design requirements for a LTHW system

B Undertake the design of a LTHW installation for a domestic property

C Develop a specification for materials, components and ancillary equipment for a domestic LTHW system.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the design requirements for a LTHW system.	**A1** Heating requirements **A2** Design conditions **A3** External considerations **A4** Heat losses	Learners are given a client brief, which they have to analyse in terms of all of the heating and hot water requirements.
B Undertake the design of a LTHW installation for a domestic property.	**B1** Pipework circuits **B2** Pumps **B3** Heat emitters **B4** Boilers and heat generators **B5** Expansion vessels **B6** Hot-water storage tanks **B7** Access and maintenance	Learners design a LTHW system for a domestic, two-storey building from given design parameters. As part of the design, learners produce a specification for all the primary elements of the LTHW system.
C Develop a specification for materials, components and ancillary equipment for a domestic LTHW system.	**C1** Pipework **C2** Pumps **C3** Heat emitters **C4** Boilers **C5** Expansion vessels **C6** Hot-water storage tanks	

Content

Learning aim A: Understand the design requirements for a LTHW system

A1 Heating requirements

The needs of the stakeholders, in terms of the heating requirements in their building or structure.

- Factors that need to be considered when designing heating systems:
  - building use:
    - activity levels
    - density of occupancy
    - age profile of occupants
  - the requirement for single or multiple heating zones
  - client requirements:
    - comfort levels
    - building type
    - building users
  - environmental requirements:
    - minimising emissions
    - recommended internal temperature levels
    - sustainability
  - control of the system:
    - timing of heating
    - period of heating
    - time of year
    - temperature control
  - sustainability:
    - future requirements
    - capacities for expansion
    - life expectancy of the installation
    - reduction of fossil fuel usage
  - performance requirements:
    - temperature of zones
    - warming-up duration
    - heat retention and insulation levels
    - effect of glazed areas.

A2 Design conditions

The statutory measures that must be met in the design of a LTHW system for a domestic situation.

- Regulations and standards that have to be met.
- Emissions legislation.
- Local building regulations or standards that have to be met.
- Standard Assessment Procedure (SAP) calculations.

A3 External considerations

The impact of external factors on the design of domestic heating systems.

- The desired internal temperature to be maintained.
- The heat losses through the fabric of the building.

- Solar gains.
- Internal heat gains.
- Environmental considerations.
- Location with regard to external-design temperatures.
- Geographical location.
- Thermal response and risk of exceedance.
- Infiltration rates for winter heating applications.
- Boiler efficiency and green grants.
- Orientation of the building.

A4 Heat losses

- Calculation of existing u-values of a retained structure.
- Calculation of proposed u-values for the structure and fabric of the building.
- Calculated heat losses through the building fabric.
- Calculated heat losses due to air changes.
- Impact of heat losses through air leaks.

Learning aim B: Undertake the design of a LTHW installation for a domestic property

The design of a domestic heating and hot-water system, to include the primary elements of heat generation.

B1 Pipework circuits

Design of pipework circuits that are efficient in terms of the delivery of hot water to the discharge point or tap.

- Pipe sizing calculations.
- Flow rates required.
- Friction losses.
- Maintaining a balanced system.
- Use of secondary returns.
- Means of isolation for maintenance purposes.
- Requirements for zoning of systems.

B2 Pumps

The selection of a pump to meet the design parameters of:

- sizing of pumps for volumes of water to be moved
- pump margin and duty
- selection in balancing design against availability
- pump efficiency
- reliability
- lifespan
- pump maintenance
- positioning and access for servicing
- use of valves to allow easy replacement.

B3 Heat emitters

The selection of a heat emitter, including the assessment of output requirements in meeting the design parameters, to include:

- size of heat emitters required for comfortable temperature, taking into account the floor area and volume of the space being heated
- heat losses associated with the area and volume being heated
- size requirements of heat emitters compared to available space
- aesthetics of emitter
- heat output and efficiency
- positioning and access for servicing.

B4 Boilers and heat generators

The selection of an appropriate boiler to meet the design parameters of:

- maintaining effective flow rates
- efficiency of boilers to meet applicable regulations and/or legislation
- reduction in CO_2 emissions
- output required
- operating costs
- type of available fuels
- combustion and ventilation requirements
- capacity for future expansion
- positioning and access for servicing.

B5 Expansion vessels

The selection of appropriate expansion vessels to meet the system's requirements.

- Size and capacity needed to meet required flow rates for heat distribution.
- Anticipated thermal expansion.
- Location in the installation.
- Means of pressure adjustment.

B6 Hot-water storage tanks

Design parameters of hot-water storage tanks.

- Storage volumes to meet anticipated demand.
- Required storage temperature of water.
- Indirect heating for the stored water.
- Immersion heater back-up requirements.

B7 Access and maintenance

Accounting within the design for the access to valves, radiators, boilers, pipework for maintenance and adaptation, to include thermal expansion consideration.

- Air bleeding of system, either manually or automatically.
- Position of boiler for ventilation and combustion requirements.
- Position of boiler flue.
- Combustion air-flow requirements.
- Access panels to valves.

Learning aim C: Develop a specification for materials, components and ancillary equipment for a domestic LTHW system

C1 Pipework

The characteristics of the materials and components that will be used to carry hot water efficiently.

- Materials selection:
  - plastics
  - copper.
- Type of jointing method:
  - soldered
  - push fit
  - crimped
  - compression.
- Sizes required.

C2 Pumps

Pumps to suit heating and hot-water circuit, and to cover any zoning requirements.

- Single.
- Multiple.

C3 Heat emitters

The type and selection of a heat emitter in terms of its characteristics and appearance.

- Radiators, to include panel, sectional, low surface temperature, compact.
- Towel rails.
- Underfloor heating:
  - layout of pipework and manifold
  - position of insulation
  - finishes for solid and suspended floors.

C4 Boilers

The type of boiler used to convert fuel into heat energy and distribute water around the pipework system.

- Combination condensing systems.
- System boilers.
- Traditional/conventional boiler – vented.
- Biomass fuel boilers.

C5 Expansion vessels

- Appropriate capacity.
- Pressure valve.
- Flexible connector with inlet valves.

C6 Hot-water storage tanks

- Unvented hot-water cylinders.
- Vented hot-water cylinders.
- Provision of secondary heating source via immersion heater.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the design requirements for a LTHW system		**A.D1** Evaluate the factors that need to be considered when designing heating installations for a given building.
A.P1 Explain the factors that need to be considered when designing heating installations.	**A.M1** Analyse the factors that need to be considered when designing heating installations for a given building.	
Learning aim B: Undertake the design of a LTHW installation for a domestic property		**B.D2** Produce a comprehensive heating design that fully meets the needs of a given domestic property.
B.P2 Produce a pipework layout for a domestic situation that includes the positioning and requirements of all key components. **B.P3** Assess the required heat output for the emitters in each room for a domestic property. **B.P4** Assess the boiler output requirements for a given domestic property.	**B.M2** Produce a detailed heating design that meets the needs of a given domestic property.	
Learning aim C: Develop a specification for materials, components and ancillary equipment for a domestic LTHW system		**C.D3** Evaluate the selection of a boiler, materials and equipment that fully meets the needs of a given domestic property.
C.P5 Select a boiler to meet the needs of a given domestic property. **C.P6** Produce schedules of materials and equipment that meet some of the needs of a given domestic property.	**C.M3** Justify the selection of a boiler, materials and equipment that meets most of the needs of a given domestic property.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aims: B and C (B.P2, B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

Learners taking this unit would benefit from access to a low-temperature hot-water control rig, a solar collector, a workshop and site visits.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the factors, in feasibility terms, that need to be considered when designing the installation of a LTHW system for a given building. They will support and fully reference these factors using their research. Their evaluation should consider the requirements of the client linked to heating requirements, design conditions, external considerations and heat losses. The evaluation will draw on their knowledge of the factors to consider and their relevance or significance to the design of the heating system for the given building.

For merit standard, learners will analyse the factors, in feasibility terms, that need to be considered when designing the installation of a LTHW system for a given building. Their analysis will include heating requirements, design conditions, external considerations and heat losses. The analysis of these factors will consider their conflicting interrelationships and present the outcome of learners' detailed and methodical examination.

For pass standard, learners will explain the factors that will be considered for the design of a heating installation for a selected building. Their explanation will include heating requirements, design conditions, external considerations and heat losses. The explanation will demonstrate that learners comprehend the need to consider these factors during the design of the system.

Learning aims B and C

For distinction standard, learners will produce, for a given building, a comprehensive design and report that is detailed in its compilation and contains full manufacturers' details, with drawings produced to a professional design standard. They will evaluate the selection of all equipment in meeting the design needs of the scenario. In their evaluation, learners will draw on their knowledge of the design of LTHW systems to consider the relevance or significance of key aspects of their designs, and their benefits and drawbacks, to the design of the heating system for the given building.

For merit standard, learners will produce, for a given building, a design and report that is detailed in its compilation and contains full manufacturers' details, with learners' drawings produced to a good design standard. They will justify their selection of all equipment in meeting the design needs of the scenario. Learners will draw on their knowledge of the design of LTHW systems to prove that key aspects of their designs are correct for the situation.

For pass standard, learners will produce, for a given building, a pipework design for a domestic installation. This should include the heat-generation equipment, its distribution and control. Heating requirements should be linked to the stakeholders who will occupy the building, in terms of their human comfort. Learners will support their descriptions with diagrammatic illustrations of the heating distribution pipework and equipment manufacturers' details, including all key elements. They will assess the amount of heating required in each space and then size heat emitters accordingly, using manufacturers' published information. Learners will select the primary heat-generating plant with a heating output to meet the building's design requirements. They will produce a schedule of materials and equipment for the full heating system, with total quantities summarised.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 6: Construction Mathematics
- Unit 15: Measurement Techniques in Construction
- Unit 16: Provision of Primary Services in Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of guest speakers from:

- boiler manufacturers
- green technology solution firms
- gas suppliers
- low-temperature hot-water installation companies
- wholesale organisations.

Unit 15: Measurement Techniques in Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners undertake the quantitative techniques used to apply measurement rules in the production of a building.

Unit introduction

Measurement is the first process that turns a construction design into a monetary value. Measurement quantifies the physical resources required for a project to be constructed. Each element is measured using a standard method of measurement. These quantities are then abstracted and entered into a document with descriptions of the work and quantities in some countries known as bills of quantities, this is then used in the tendering process to obtain quotations from the main contractors, in the form of a written tender document. The total quantities can then be published in a form that is used to rate and value the total sum for the project.

In this unit, you will examine the processes of taking off quantities for the production of tender and contract documentation that are used for the financial control of a client's project. You will learn how employers and client organisations use agreed methods of measurement for construction and civil engineering work. These standard methods set out clearly the rules for measuring quantities from the drawings and schedules created by architects and other members of the design team. You will use these methods to produce quantities for structural elements and then undertake the production of a document that can be used when producing a tender, and for financial control of the project.

This unit gives you the opportunity to progress to construction sector roles, including estimator, bid writer, buyer, quantity surveyor, cost engineer, construction economist or costing surveyor. It can also give you the skills for progression to Higher Nationals in Construction and degrees in construction specialisms.

Learning aims

In this unit you will:

A Examine the measurement rules for building and civil engineering

B Undertake the production of quantities for substructure and superstructure elements

C Undertake the production of bills of quantities.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine the measurement rules for building and civil engineering	**A1** Introduction to taking off quantities **A2** Standard methods of measurements	A guidance document for new learners to comprehend the use of quantities in construction and the standard methods of measurement available in the construction industry.
B Undertake the production of quantities for substructure and superstructure elements	**B1** Processes in the production of quantities **B2** Production of substructure quantities for a building **B3** Production of superstructure quantities for a building **B4** Production of quantities for a civil engineering project	A set of quantities from teacher-provided drawings for a building, substructure, elements of a superstructure and elements of external works. Bills of quantities for a building substructure, elements of superstructure and elements of external works.
C Undertake the production of bills of quantities	**C1** Abstraction of quantities **C2** The production of a bill of quantities for a building or civil engineering project	

Content

Learning aim A: Examine the measurement rules for building and civil engineering

A1 Introduction to taking off quantities

Reasons for producing both approximate and accurate quantities and their use for:

- the production of bills of quantities and/or tender documentation
- tendering and estimating
- budgets for feasibility studies during design stages
- cost comparison of different designs
- preparation of estimates
- estimation of a project's value
- final account measurements and variations
- ordering materials
- producing a quotation for a work element.

A2 Standard methods of measurement

The use of the Standard Methods of Measurement (SMM) rules in the production of quantities.

- Measurement rules:
  - the need for rules
  - origins of measurement rules
  - status of the Royal Institution of Chartered Surveyors (RICS) New Rules of Measurement (NRM) as appropriate in the international context
  - status of the Institution of Civil Engineers (ICE) Civil Engineering Standard Method of Measurement (CESMM) as appropriate in the international context
  - status of the International Construction Measurement Standards (ICMS)
  - status of the International Property Measurement Standards (IPMS)
  - national and local standard methods of measurement used in the host country as appropriate
  - typical considerations:
    - units of measurement
    - deduction of voids
    - deemed to be included
    - item description
    - hierarchy of description
    - key content
    - preliminaries and measured work
    - guidance on the preparation of bills of quantities.
- The New Rules of Measurement (NRM) as appropriate in the host country:
  - NRM1 – order of cost estimating and cost planning for capital building works:
    - application of this to budgeting for projects
    - uses of NRM 1
  - NRM2 – detailed measurement for building works:
    - application of this to taking off quantities for projects
    - uses of NRM 2

- NRM3 – order of cost estimating and cost planning for building maintenance works:
  - application of this to maintaining projects
  - uses of NRM 3.
- CESMM as appropriate in the host country:
  - content and its application to civil engineering projects
  - differences against the NRM volumes.
- ICMS as appropriate in the host country:
  - content and its application to construction projects
  - minimising risk and improving global consistency.
- IPMS as appropriate in the host country:
  - content and its application to construction projects
  - minimising risk and improving global consistency
  - consistency of international approach to measuring buildings
  - reducing the risk of cross border property investment.

Learning aim B: Undertake the production of quantities for substructure and superstructure elements

B1 Processes in the production of quantities

The use of dimension paper, direct billing paper, spreadsheets and the techniques used to take off quantities.

- Preparation and planning, to include the compilation of a take-off list.
- The vocationally correct format and layout of quantities and calculations using the appropriate media:
  - enumerated
  - linear
  - area
  - volumes
  - itemised
  - multiplying (including additional multipliers and 'dotting-on')
  - totalling dimensions
  - deductions and omission quantities
  - page numbering
  - carried-forward and brought-forward dimension totals
  - use of standard abbreviations
  - marking the extent of a calculation
  - waste calculations, to include centre lines.

B2 Production of substructure quantities for a building

- The substructure of a building, to include:
  - excavations for foundations
  - short-bored piles
  - mass concrete foundation works
  - formwork
  - earthwork support
  - substructure external and internal walls to damp-proof course (DPC) level or ground floor level

- ground floor construction:
  - excavation
  - hardcore filling
  - sand blinding
  - damp-proof membrane (DPM)
  - insulation
  - concrete beds
  - reinforcement
  - finishes to concrete
  - floor finishes.

B3 Production of superstructure quantities for a building

- The superstructure of a building, to include:
  - external wall construction:
    - timber framed, to include sole plates, softwood stud frames, plywood coverings, insulation, DPM, head frames
    - masonry, to include skins of hollow walls, forming cavities, cavity insulation
    - construction methods appropriate in the host country
  - windows, to include: the formation of openings, glazing, lintels, reveals, sills, window boards
  - doors, to include the formation of openings: lintels, reveals, thresholds, architectural ironmongery
  - intermediate floors, to include timber joists, precast concrete beam and block or flooring methods appropriate to the host country
  - roof construction, to include trussed rafter construction, traditional rafter roof construction or roofing methods appropriate to the host country
  - roofing, to include coverings, breather membranes, tile battens or methods appropriate to the host country

B4 Production of quantities for a civil engineering project

The taking off of quantities for a civil engineering project using CESMM or other appropriate method of measurement used in the host country:

- excavation works
- filling
- formwork
- reinforcement
- concreting works
- drainage, manholes.

Learning aim C: Undertake the production of bills of quantities

Abstraction from dimension sheets into item summaries.

C1 Abstraction of quantities

- Use of spreadsheets:
  - use of direct input
  - use of formulae.
- Use of ‘cut and shuffle’ paper.
- Use of direct billing paper.

- Use of abstract paper:
  - assembly of quantities taken from dimension sheets
  - final item quantity calculations.

C2 The production of a bill of quantities or building price calculation documentation for a building or civil engineering project

How the quantities and descriptions are summarised in documentation:

- production of a bill of quantities or other documentation vocationally appropriate in the host country for a building work section:
  - assembly of quantities taken from dimension sheets
  - writing item descriptions using the method of measurement for substructure and superstructure items
  - collections and summaries
  - final summary
  - format and layout of the document.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine the measurement rules for building and civil engineering		**A.D1** Evaluate the use of recognised standard methods of measurement to ensure consistency when tendering and estimating for buildings and civil engineering projects.
A.P1 Explain how approximate and accurate quantities are used for different applications by construction cost experts. **A.P2** Explain the reasons for the use of a recognised standard method of measurement.	**A.M1** Discuss the benefits of using recognised standard methods of measurement for buildings and civil engineering projects.	
Learning aim B: Undertake the production of quantities for substructure and superstructure elements		**B.D2** Produce accurate and comprehensive quantities for a project using a recognised standard method of measurement and a vocationally correct layout of dimensions and methodology.
B.P3 Produce quantities for a project using a recognised standard method of measurement and an appropriate layout of dimensions. **B.P4** Explain the difference between the production of quantities for building projects and the production of quantities for civil engineering projects.	**B.M2** Produce accurate quantities for a project using a recognised standard method of measurement and a vocationally correct layout of dimensions.	
Learning aim C: Undertake the production of bills of quantities		**C.D3** Produce comprehensive bills of quantities for a construction project.
C.P5 Produce bills of quantities or building price calculation documentation for a construction project. **C.P6** Explain the different methods used to convert the take-off into bills of quantities.	**C.M3** Produce accurate bills of quantities or building price calculation documentation for a construction project.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to copies of standard methods of measurement, to include NRM1, NRM2, NRM3, CESMM, CCMS, APMS and standard methods of measurement used in the host country. Note it is not expected that international centres provide access to all of these documents but make an appropriate selection relevant within the context of the construction industry within the host country / region.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the use of recognised standard methods of measurement to ensure consistency when tendering and estimating for buildings and civil engineering projects. They will consider how quantities are used for construction projects during the various stages of a project, and the benefits and drawbacks of the use of a recognised standard method of measurement. In their evaluation, learners will consider the strengths and weaknesses of standard methods of measurement and their significance in generating accurate and consistent tender outcomes across a range of tender bids. They will provide a conclusion relating to the use of an appropriate standard method of measurement.

For merit standard, learners will discuss the benefits of using recognised standard methods of measurement for buildings and civil engineering projects. They will consider how quantities are used for construction projects during the various stages of a project and consider the relevant use of a recognised standard method of measurement. In their discussion, learners will consider the different aspects of the standard methods of measurement and the extent of their importance.

For pass standard, learners will explain how approximate and accurate quantities are used for different applications by quantity surveyors. Additionally, learners will explain the reasons for the use of a recognised standard method of measurement. In their explanation, learners will show that they comprehend the origins, functions and objectives of standard methods of measurement and the quantities that they produce.

Learning aims B and C

For distinction standard, learners will perform an accurate and comprehensive production of quantities for a project using a recognised standard method of measurement and a vocationally correct layout of dimensions and methodology (for example, correct centre-line calculations, dimension layout, codification etc.). Their production of quantities will include a substructure, elements of superstructures and elements of external works. Learners will explain the difference between the production of quantities for building projects and for civil engineering projects. They will produce comprehensive bills of quantities or building price calculation documentation for a construction project with clarity of language and layout, including vocationally correct layout, bill or section format, units of measurement, codification of items, ordering of sizes and use of headings. They will explain the different methods used to convert the quantities produced into bills of quantities or building price calculation documentation. In their explanation, learners will show that they comprehend the origins, functions and objectives of methods of producing bills of quantities or building price calculation documentation.

For merit standard, learners will perform an accurate production of quantities for a project using a recognised standard method of measurement and using a vocationally correct layout of dimensions. The production of quantities will include a substructure, elements of superstructures and elements of external works. Learners will explain the difference between the production of quantities for building projects and for civil engineering projects. They will produce accurate bills of quantities or building price calculation documentation for a construction project with appropriate use of language and layout, including vocationally correct layout, bill or section format, units of measurement, ordering of sizes and use of headings. They will explain the different methods used to convert the quantities produced into bills of quantities or building price calculation documentation. In their explanation, learners will show that they comprehend the origins, functions and objectives of methods of producing bills of quantities or building price calculation documentation.

For pass standard, learners will perform a production of quantities for a project using a recognised standard method of measurement and an appropriate layout of dimensions, allowing for some computational inaccuracy. The production of quantities will include a substructure, elements of superstructures and elements of external works. Learners will explain the difference between the production of quantities for building projects and for civil engineering projects. They will produce bills of quantities or building price calculation documentation for a construction project with appropriate use of language and layout, including vocationally appropriate layout, units of measurement and use of headings. They will explain the different methods used to convert the quantities produced into bills of quantities or building price calculation documentation.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 5: Management of Commercial Risk
- Unit 6: Construction Mathematics
- Unit 9: Graphical Detailing
- Unit 20: Quantity Surveying
- Unit 32: Highway Construction and Maintenance in Civil Engineering.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 16: Provision of Primary Services in Buildings

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners examine the four primary services to understand the installation, operation and integration of these services.

Unit introduction

The provision of high-quality building services differentiates modern buildings from those constructed in earlier times. There are four primary services that are essential for a building to be habitable: hot and cold water, drainage, electricity and gas. You must therefore develop a basic understanding of building services and construction methods so that you can contribute to their safe and effective integration. You also need to learn the installation, operation and maintenance of all the primary services.

In this unit, you will learn the principles and practices that underpin the design and installation of hot and cold water systems, above-ground and below-ground drainage, single-phase electrical systems and gas installations. You will examine the specification of building services systems in terms of the materials used, the appropriate dimensions, capacities and falls, and any health and safety issues. You will gain an understanding of the advantages and disadvantages of the different systems available to justify the selection of the systems used.

This unit will help you to progress to relevant higher-level programmes. Entry to higher-level building services programmes is also possible if supported by evidence of competence in mathematics and science. The unit will support progression to work in a variety of construction roles, both on site and off site, including trainee positions in architectural technology, site supervision, site engineering, estimating, buying, quantity surveying, building surveying, land surveying and town planning, among others.

Learning aims

In this unit, you will:

A Examine the practices associated with the provision of hot- and cold-water systems

B Examine the principles and approaches associated with the provision of above- and below-ground drainage systems

C Understand the principles of the provision of simple, single-phase electrical systems and domestic gas installations.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine the practices associated with the provision of hot- and cold-water systems	**A1** Direct cold-water systems **A2** Indirect cold-water systems **A3** Direct hot-water systems **A4** Indirect hot-water systems	Learners will be given construction drawings of a domestic building and associated external areas. They will be required to provide a report that includes details of an appropriate direct and indirect hot- and cold-water system.
B Examine the principles and approaches associated with the provision of above- and below-ground drainage systems	**B1** Above-ground drainage principles **B2** Above-ground drainage approaches **B3** Below-ground drainage principles **B4** Below-ground drainage approaches	
C Understand the principles of the provision of simple, single-phase electrical systems and domestic gas installations	**C1** Electrical principles **C2** Electrical components **C3** Ring final circuits **C4** Radial circuits **C5** Gas installation principles **C6** Gas installations	Learners will be given construction drawings of a domestic building. They will be required to provide a report that includes details of an appropriate layout of single-phase electrical systems to buildings, and the internal layouts of ring final circuits and radial circuits, including line drawings, materials and components.

Content

Learning aim A: Examine the practices associated with the provision of hot- and cold-water systems

The systems used to supply buildings with potable cold water for drinking, flushing toilets, bathing, laundry and to feed heating systems, including the provision of hot water, together with an understanding of the situations in which each system would be appropriate.

A1 Direct cold-water systems

- Distribution to buildings:
  - service pipe minimum of 750 mm below ground
  - pipe to pass through wall above foundations
  - pipe to be sealed at entrance to wall
  - first 600 mm of pipe to be insulated
  - stop valve
  - rising main to drinking water tap
  - storage cistern.
- Internal layout of system, to include:
  - direct supply to all outlets
  - requirement for low-capacity cistern to feed a hot-water storage cylinder if installed
  - annotated line diagram for the layout showing key components.
- Selection of materials used, dimensions and capacities:
  - externally – 22 mm diameter service pipe, generally plastic (blue polyethylene or uPVC), although copper is acceptable
  - internally – copper or plastic pipes (generally 15 mm diameter, 20 mm for baths), 115-litre feed cistern (with 22 mm diameter overflow and feed to copper hot-water storage cylinder if installed), cisterns made from polyethylene, polypropylene or polyvinyl chloride (galvanised steel in older systems).
- Situations where system is appropriate:
  - where water pressure is high (e.g. from a high-level reservoir) or where drinking water is required from all outlets (but inappropriate when supply is cut off or reduced in periods of peak demand, or where there is a danger of back-siphonage).

A2 Indirect cold-water systems

- Internal layout of system, to include:
  - cold water supplied to all outlets (except the sink) from a cold-water storage cistern, sink connected directly to rising main for supply of potable water
  - annotated line diagram for the layout showing key components.
- Selection of materials used, dimensions and capacities, to include:
  - copper or plastic pipes (generally 15 mm diameter, 20 mm for bath), 115-litre feed cistern (with 22 mm diameter overflow and feed to minimum 140-litre copper hot-water storage cylinder if installed), 230-litre cisterns in polyethylene, polypropylene or polyvinyl chloride (galvanised steel in older systems)
  - situations where system is appropriate, to include where a reserve is required should supply be cut off or reduced, where there is a risk of back-siphonage.

A3 Direct hot-water systems

- Mains pressure systems, to include combi boilers.
- Traditional systems, to include water heated in boiler, rises by convection to hot-water storage cylinder, replaced by colder water from bottom of storage cylinder, hot water drawn from storage cylinder is replaced with cold water from cistern.
- Selection of materials used, dimensions and capacities to include copper pipes (28 mm diameter primary feed from boiler to hot-water cylinder, 22 mm diameter cold feed from cistern to hot-water cylinder, 22 mm for hot water supply to bath, otherwise 15 mm diameter), minimum 140-litre hot-water cylinder, 230-litre cold-water cistern.
- Situations where system is appropriate, to include in soft water areas and where there is no associated central heating circuit.
- Annotated line diagram for the layout showing key components.

A4 Indirect hot-water systems

- Mains pressure system using pressure vessels.
- Traditional system similar to direct system, but with a separate small-capacity-feed cistern to charge and top up the primary circuit, hot-water storage cylinder to act as a heat exchanger providing heat for secondary circuit from which hot water is drawn.
- Selection of materials used, dimensions and capacities:
  - as for direct systems plus 36-litre plastic feed and expansion cistern
  - situations where system is appropriate, to include hard water areas and systems with associated central heating circuits.
- Annotated line diagram for the layout showing key components.

Learning aim B: Examine the principles and approaches associated with the provision of above- and below-ground drainage systems

The above-ground and below-ground systems used to remove foul water and surface water from a building, and the plot on which the building stands, together with an understanding of the difference between combined and separate systems.

B1 Above-ground drainage principles

The design of above-ground drainage systems, to include:

- need for water seal
- reduction of siphonage effect
- provision of ventilation
- fall for the waste pipes.

B2 Above-ground drainage approaches

Single-stack and two-pipe systems designed to prevent siphoning and discharge of gases.

- Single-stack and two-pipe systems, to include:
  - single-stack, to include waste from washbasins, sinks, baths and WCs fed into single 100 mm vertical waste pipe, vented to outside above the roof line; all appliances have U-bend trap full of water (exceptions may be kitchen sink and cloakroom WC)

  - two-pipe system, to include older properties only, WC waste fed into a large-bore soil pipe leading directly to sewage network; remaining waste waters from washbasins, bath and kitchen sink are combined and led to a gully just below ground level.
- Selection of layout, materials used, dimensions and falls, to include:
  - all in uPVC or polypropylene
  - 100 mm diameter soil and vent pipe (SVP)
  - appliances connected separately into the stack to prevent induced and self-siphonage
  - limits on the length and levels of branch connections
  - all branch pipes to have 50 mm sweep into SVP
  - compliance with regulatory requirements
  - annotated line diagram for the layout showing key components.

B3 Below-ground drainage principles

The design of below-ground drainage systems, to include:

- capacity
- fall for self-cleansing flow
- ventilation
- support
- avoidance of leakage
- access at every change in gradient (inspection chambers, manholes, rodding points)
- pipe size or bend
- minimisation of pipe runs
- all junctions oblique and in direction of flow.

B4 Below-ground drainage approaches

- Separate systems used for surface and foul water as the standard modern method, to include:
  - separate systems used for surface and foul water where surface water and foul water are conveyed in separate drains and sewers
  - surface water requires no treatment before final outfall.
- Combined systems for surface and foul water where surface water and foul water are both conveyed in the same drain and sewer, to include:
  - entire effluent requires treatment
  - simpler and cheaper to construct, but more expensive to operate
  - a traditional approach not preferred in new constructions.
- Selection of layout, materials used, dimensions, falls and capacities:
  - rigid pipes, to include vitrified clay, concrete, cast iron
  - flexible pipes, to include uPVC, polyethylene, ductile iron, glass-reinforced plastic
  - appropriate falls for surface water and foul-water drainage
  - appropriate bedding materials for pipes and surrounds
  - annotated line diagram for the layout showing key components.

Learning aim C: Understand the principles of the provision of simple, single-phase electrical systems and domestic gas installations

The systems used for single-phase electrical supplies, gas installations and understanding of good health and safety.

C1 Electrical principles

- Electrical principles, to include sufficient capacity, prevention of excess current, protection from shock, prevention of fire, means of isolation, health and safety issues.

C2 Electrical components

A typical circuit to include the following components:

- mains isolation switches, to include main service fuse, meter, main switch
- consumer control unit, to include residual current devices (RCD), miniature circuit breakers (MCB) or fuses
- earth connectors
- outlet sockets
- switches and light fittings.

C3 Ring final circuits

Ring final circuits for a maximum permissible floor area.

- Circuits, to include:
  - live conductor and neutral conductor
  - earth looped from socket to socket
  - protected by 32 amperes (A) fuse or miniature circuit breaker.
- Socket outlets, to include individual as well as spur outlets:
  - individual socket outlets to accept fused appliances up to 13 A
  - unlimited number of socket outlets
  - spur outlets not to exceed number of primary outlets
  - maximum of two outlets per spur.

C4 Radial circuits

Radial circuits for lighting and individual high-power appliances.

- Lighting, to include loop-in method using earthed twin cable with 6 A protection:
  - individual high-power appliances, to include electric cookers, showers, water heaters, protected up to 45 A depending on power taken by appliance.

C5 Gas installation principles

Gas installation principles to support combustion and disposal of combustion products.

- Adequate supply of ventilation air to support combustion.
- Effective flue arrangements to dispose of combustion products:
  - conventional flues, to include brick or stone chimney, prefabricated or precast systems
  - balanced flues, to include air for combustion drawn in through the outer pipe, inner pipe removes combustion gases to outside.

C6 Gas installations

Metering arrangement, connecting of gas mains and entry of gas service pipes into a building, in compliance with the relevant legislation.

- Compliance with relevant legislation, to include Part P of the Building Regulations 2010, and the Gas Safety (Installation and Use) Regulations 1998:
  - connection to gas main, to include slope towards house, arrangements for collecting condensate.
- Entry of gas service pipe into building:
  - arrangement, to include from side nearest main, not under foundations, not run in a cavity, sleeved if passing through solid floor or wall, not housed in an unventilated void
  - dimension, to include minimum 25 mm diameter pipe
  - enter building 375+ mm below ground
  - gas meter arrangements, to include generally external (but can be internal) meter box to contain control level, situated at height sufficient to facilitate access and reading.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine the practices associated with the provision of hot- and cold-water systems		
A.P1 Explain, with appropriately annotated illustrations, the distribution and layout of cold water by direct and indirect systems. **A.P2** Explain, with appropriately annotated illustrations, the distribution and layout of hot water by direct and indirect systems.	**A.M1** Analyse, with clear and accurate line drawings, the distribution of hot- and cold-water systems in terms of materials used and the dimensions and capacities of fittings and components, and their relative positioning.	**A.D1** Evaluate, with detailed and comprehensive line drawings, the distribution of hot- and cold-water systems in terms of materials used and the dimensions and capacities of fittings and components, and their efficient positioning.
Learning aim B: Examine the principles and approaches associated with the provision of above- and below-ground drainage systems		
B.P3 Explain, with appropriately annotated illustrations, the distribution and layout of above-ground drainage systems. **B.P4** Explain, with appropriately annotated illustrations, the distribution and layout of below-ground drainage systems.	**B.M2** Analyse, with clear and accurate line drawings, the distribution of above- and below-ground drainage systems in terms of materials used, appropriate falls, and the dimensions and capacities of fittings and components, and their relative positioning.	**B.D2** Evaluate, with detailed and comprehensive line drawings, the distribution of above- and below-ground drainage systems in terms of materials used, appropriate falls, and the dimensions and capacities of fittings and components, and their efficient positioning.

Pass	Merit	Distinction
Learning aim C: Understand the principles of the provision of simple, single-phase electrical systems and domestic gas installations		**C.D3** Evaluate the installation of single-phase electrical systems and domestic gas installations in terms of components, layout, integration of both services, and compliance with health and safety legislation.
C.P5 Explain the installation of single-phase electrical systems for both radial and ring final circuits. **C.P6** Explain domestic gas installations from entry to the building to the point of use. **C.P7** Outline the important health and safety requirements relevant to the installation of single-phase electrical systems and domestic gas installations.	**C.M3** Analyse the installation of single-phase electrical systems and domestic gas installations in terms of components and layout. **C.M4** Discuss the important health and safety requirements relevant to the installation of single-phase electrical systems and domestic gas installations.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, A.D1, B.D2)

Learning aim: C (C.P5, C.P6, C.P7, C.M3, C.M4, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional resource requirements for this unit.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, learners will evaluate, with the aid of detailed and comprehensive line drawings indicating the layout of service runs, the distribution of both direct and indirect hot- and cold-water systems in terms of materials used, and the dimensions and capacities of fittings and components and their efficient and appropriate positioning. They will also evaluate, with detailed and comprehensive line drawings, the distribution of above- and below-ground drainage systems in terms of materials used, appropriate falls, access arrangements, and the dimensions and capacities of fittings and components, and their efficient positioning. In their evaluation, learners will consider the advantages and disadvantages of alternate systems and the significance of key performance requirements. Their inquiry will lead to a supported judgement showing clear links to the domestic installation scenario.

For merit standard, learners will analyse, with clear and accurate line drawings, the distribution of hot- and cold-water systems in terms of materials used, and the dimensions and capacities of fittings and components, and their relative positioning. They will also analyse, with clear and accurate line drawings, the distribution of above- and below-ground drainage systems in terms of materials used, appropriate falls, dimensions and capacities of fittings and components, and their relative positioning. In conducting their analysis, they will consider the key components of the system and how these combine to provide effective performance.

For pass standard, learners will explain, with appropriately annotated illustrations, the distribution and layout of hot and cold water by direct and indirect systems. They will also explain, with appropriately annotated illustrations, the distribution and layout of above- and below-ground drainage systems. In their work, learners will demonstrate that they understand the functional requirements of the system and whether the system can be considered to be fit for purpose.

Learning aim C

For distinction standard, learners will evaluate the installation of single-phase electrical systems and domestic gas installations in terms of components, layout, integration of both services and compliance with health and safety legislation. In their evaluation, they will consider the advantages and disadvantages of alternate systems and the significance of key performance requirements, including associated health and safety considerations. Their inquiry will lead to a supported judgement showing clear links to the domestic installation scenario.

For merit standard, learners will analyse the installation of single-phase electrical systems and domestic gas installations in terms of components and layout. In conducting their analysis, they will consider the key components of the system and how these combine to provide effective performance. They will discuss the important health and safety requirements relevant to the installation of single-phase electrical systems and domestic gas installations. In their discussions, learners will consider the key health and safety considerations and how they interrelate, together with some consideration of their relative importance.

For pass standard, learners will explain the installation of single-phase electrical systems for both radial and ring final circuits. They will also explain domestic gas installations from entry to the building to the point of use, and outline the important health and safety requirements relevant to the installation of single-phase electrical systems and domestic gas installations. In their work, learners will demonstrate that they understand the functional requirements of the systems and the associated health and safety considerations, including and whether the system, and the safety precautions, can be considered to be fit for purpose.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 7: Graphical Detailing
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 17: Further Mathematics for Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop and use skills to apply rules of transposition of formulae, arithmetical methods, calculus and statistics to construction problems.

Unit introduction

Many of the buildings and structures that we encounter in our daily lives are the result of projects that civil engineers and building services engineers have worked on. They use a range of mathematical techniques and formulae to find out important physical properties of the buildings and structures. These could include finding the centre of gravity of an irregular shaped, precast cladding unit so that it can be safely lifted, using arithmetic or trigonometric techniques to determine areas of sites, or calculating the root mean square value of an alternating electric current to make sure the supply is suitable.

In this unit, you will investigate relevant aspects of pure mathematics and explore how you can solve complex practical problems. You will learn how to solve applied mathematical problems involving statistical data, structural properties for beams and columns, complex measurements, trigonometric identities, rates of change and decay, differentiation of maxima and minima, numerical integration, and complex areas or volumes by definite and indefinite integration.

These mathematical skills are transferable and will be used to support your study of other topics in this qualification, for example in *Unit 8: Surveying in Construction*, *Unit 28: Electrical Principles and Installations Standards in Building Services Engineering* or *Unit 29: Principles and Applications of Structural Mechanics*.

As a civil engineer or building services engineer, you will need to understand and develop the skills required to solve contextual problems using mathematical methods. This unit will prepare you for progression to higher education to study in the construction, civil engineering or building services engineering sectors at degree level. It will also prepare you for an apprenticeship or employment in a range of construction disciplines as a technician and will help you work with professionals as part of a team working on cutting-edge products and systems.

Learning aims

In this unit you will:

A Examine how algebraic and trigonometric techniques can be used to solve a construction problem

B Examine how calculus can be used to solve a construction problem

C Investigate the use of statistical methods to solve a construction problem.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine how algebraic and trigonometric techniques can be used to solve a construction problem	**A1** Transposition techniques **A2** Trigonometric techniques **A3** Construction-related problems	A report containing the results of learners' analysis and calculation; carried out under controlled conditions, supported by text and diagrams as appropriate.
B Examine how calculus can be used to solve a construction problem	**B1** Differential calculus **B2** Integral calculus **B3** Numerical integration	A report containing the results of learners' analysis and calculation; carried out under controlled conditions, supported by text and diagrams as appropriate.
C Investigate the use of statistical methods to solve a construction problem	**C1** Statistical methods **C2** Use of statistical methods in construction contexts	A report that includes appropriate graphs and charts to represent collated statistical data for a construction activity.

Content

Learning aim A: Examine how algebraic and trigonometric techniques can be used to solve a construction problem

A1 Transposition techniques

Rearrangement of formulae to determine new subjects and their use in evaluating data.

- Mathematical formulae to transpose, to include:
  - linear, quadratic and cubic expressions
  - trigonometric functions, to include sine, cosine, tangent ratios
  - logarithmic functions
  - binomial theorem applied to errors.

A2 Trigonometric techniques

Application of trigonometric techniques to 2D scenarios to solve construction problems involving the calculation of dimensions, angles, regular areas and irregular areas.

- Trigonometric functions, to include sine, cosine, tangent ratios.
- The sine rule, including ambiguous case.
- The cosine rule.
- Area rules for triangles.

A3 Construction-related problems

Typical problems that transposition and trigonometric techniques will solve.

- Application of properties of sections:
  - simple shapes, regular shapes, irregular shapes, to include:
    - cross-sectional area
    - location of centroid
    - section modulus
    - moment of inertia
    - radius of gyration.
- Application of trigonometry to determine dimensions in 2D and 3D:
  - in surveying
  - in setting out
  - other practical contexts, to include calculating heights, lengths, etc.

Learning aim B: Examine how calculus can be used to solve a construction problem

B1 Differential calculus

Application of differentiation techniques to algebraic (polynomial), trigonometric (sine, cosine), logarithmic and exponential functions, for solving construction engineering problems.

- Standard differential calculus methods:
  - polynomial equations of the form $s = 5t^2 - 3t + 4$
  - trigonometric (sine, cosine) equations of the form $y = \sin^2 4x$
  - logarithmic equations of the form $v = 8\log e(5x)$
  - exponential equations of the form $y = 2e^{(3x + 5)}$
- Differentiation by standard results, e.g. $y = ax^n$, where $\frac{dy}{dx} = nax^{(n-1)}$
- Derivatives of algebraic (powers) ax^n

- Derivatives of trigonometric (sine, cosine) s $\sin ax$, $\cos ax$
- Derivatives of logarithmic functions, e.g. $\log_e$ ax
- Derivatives of exponential functions, e.g. e^{ax}
- Product rule, e.g. $\frac{dy}{dx} = \frac{vdu}{dx} + \frac{udv}{dx}$
- Quotient rule, e.g. $\frac{dy}{dx} = \frac{\frac{vdu}{dx} + \frac{udv}{dx}}{v^2}$
- Function of a function (chain rule) method.
- Second order derivatives:
  - second derivative of algebraic (polynomial), e.g. $y = axn$, where $\frac{d^2y}{dx^2} = n(n-1)ax^{(n-2)}$
  - second derivative of trigonometric (sine, cosine) functions
  - the location of stationary values, to include turning points, points of inflection.

B2 Integral calculus

Application of indefinite and definite integration techniques to algebraic (polynomial), trigonometric and exponential functions, in order to solve construction problems.

- Routine functions integrated in one step without the need for manipulation, using standard integral calculus methods, to include:
  - polynomial, e.g. $\int\left(x^2 - 3x + 4\right)dx$
  - trigonometric (sine, cosine), e.g. $\int(\sin 5\theta - 3\cos 4\theta)d\theta$
  - reciprocal, e.g. $\int\left(\frac{3}{x}\right)dx$
  - exponential, e.g. $\int\left(e^{3t}\right)dt$
- Integration of common functions by standard results, e.g. ax^n, $\sin ax$, $\cos ax$, $\frac{1}{x}$, e^{ax}
- Indefinite integrals, constant of integration, initial conditions.
- Definite integrals – limits and square bracket notation.

B3 Numerical integration

Application of the formulae for irregular areas and volumes for numerical integration.

- Trapezoidal rule:
  - for comparison of methods in terms of complexity and accuracy.
- Mid-ordinate rule:
  - for comparison of methods in terms of complexity and accuracy.
- Simpson’s rule:
  - area under a curve determined using Simpson’s rule for comparison with values obtained using calculus.
- Numerical integration using a spreadsheet.
- Arithmetical calculation of various properties of sections, including:
  - cross-sectional area
  - location of centroid
  - neutral axis
  - moment of inertia
  - section modulus
  - radius of gyration.

Learning aim C: Investigate the use of statistical methods to solve a construction problem

C1 Statistical methods

How statistics are used in a construction context to convey relevant information that is in a useful format, appropriate to the audience.

- Presentation of data:
  - histograms
  - bar charts
  - pie charts
  - frequency graphs
  - cumulative frequency graphs.
- Sampling distributions:
  - normal distribution tables
  - confidence limits
  - significance testing.

C2 Use of statistical methods in construction contexts

How statistics are used in a construction context to solve problems.

- Measures of central tendency:
  - mean
  - mode
  - median.
- Measures of dispersion:
  - range
  - variance
  - standard deviation.
- Cumulative frequency:
  - quartiles, deciles and percentiles
  - interquartile range.
- Types of data:
  - discrete data
  - continuous data
  - grouped data
  - ungrouped data.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine how algebraic and trigonometric techniques can be used to solve a construction problem		
A.P1 Demonstrate, using simple algebraic and trigonometric techniques, the calculation for a given construction problem.	**A.M1** Demonstrate, using advanced algebraic and trigonometric techniques, the calculation for a given construction problem.	**A.D1** Demonstrate, using complex algebraic and trigonometric techniques, the calculation for a given construction problem.
Learning aim B: Examine how calculus can be used to solve a construction problem		
B.P2 Demonstrate, using simple differential calculus techniques, the solution for a given construction problem. **B.P3** Demonstrate, using simple integral calculus techniques, the solution for a given construction problem. **B.P4** Demonstrate, using simple numerical integration techniques, the solution for a given construction problem.	**B.M2** Demonstrate, using advanced differential calculus, solutions for each type of given routine function for a given construction problem. **B.M3** Demonstrate, using advanced integral calculus and numerical integration, the solution for a given construction problem.	**B.D2** Demonstrate, using complex differential and integral calculus techniques, the solution for a given construction problem, validating results achieved by numerical integration.
Learning aim C: Investigate the use of statistical methods to solve a construction problem		
C.P5 Demonstrate simple techniques to present grouped and ungrouped statistical data related to a given construction problem. **C.P6** Demonstrate, using simple statistical analysis methods, the outcome of a given construction problem.	**C.M4** Demonstrate, using advanced statistical analysis and assessment techniques, the outcome of a given construction problem.	**C.D3** Demonstrate, using complex statistical analysis and assessment techniques, the outcome of a given construction problem.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aim: B (B.P2, B.P3, B.P4, B.M2, B.M3, B.D2)

Learning aim: C (C.P5, C.P6, C.M4, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to maths support websites, spreadsheet software, for example www.mathcentre.ac.uk/students/topics

Essential information for assessment decisions

Learning aims A

For Distinction standard, learners must independently solve industry-related problems using appropriate algebraic, trigonometric and logarithmic functions. Their work should have a neat, efficient, logical and clear structure. They should apply the correct mathematical conventions and use the correct units throughout. Their evidence will be logically structured and easy to understand by a third party with a mathematical background, who may or may not be a construction engineer. For example, learners will use mathematical terminology correctly and use relevant units when working with functions set in construction contexts. Small and large numerical values will be correctly presented in an appropriate format, such as standard form. Learners will work to a specified numerical precision (as determined by the assessor), through the use of appropriate significant figures or decimal places.

For Merit standard, learners must demonstrate throughout their work that they are able to apply appropriate transposition techniques to mathematical formulae and expressions. Learners must show evidence that they can transpose, simplify and solve by substitution, at least one example of each type of formula (linear, quadratic and cubic expressions, binomial expansions for errors, logarithms, and fractional powers).Typical problems could include the moment of inertia, section modulus or radius of gyration of given standard symmetrical (about y-y axis only) composite cross-sections. Learners' numerical work will be accurate; using an appropriate degree of precision as specified by the assessor in significant figures or decimal places, and relevant units will be used for all functions. A limited number of arithmetic follow-through errors are acceptable for more advanced functions. Learners' work will have a clear, understandable and well-presented structure. Learners should apply the correct mathematical conventions and use the correct units throughout.

For Pass standard, learners must show evidence that they can transpose, simplify and solve by substitution formulae, including linear and quadratic expressions. Their work must have a logical structure, using correct mathematical conventions and appropriate units where required. Learners must use arithmetical techniques to determine values for a range of properties of sections, including irregular areas and volumes. They must find the cross-sectional area, volumes and position of the centroid for a variety of symmetrical and non-symmetrical composite shapes, using a range of arithmetic and trigonometrical formulae. Their work will have a logical structure, use correct mathematical conventions and the correct units should be stated for the final answer. Learners will carry out calculations to give solutions that clearly show how they have approached construction engineering problems using trigonometric methods. For example, the appropriate use of labelled diagrams to determine the areas of building plots or the volume of material that would be required to fill a void. Solutions will be set out methodically and using the correct mathematical conventions clearly, but may contain numerical errors. Units must be clearly stated for the problems involving physical properties.

Learning aims B

For Distinction standard, learners will demonstrate high levels of skill in applying differential and integral calculus methods to the solution of a given construction problem, using mathematical functions. For differential calculus, learners will correctly and efficiently manipulate six complex routine functions, while for integral calculus, learners will correctly and efficiently manipulate 11 complex routine functions when producing indefinite and definite integrals. Alternative methods of solution must be carried out for integration where appropriate, in order to compare the results found and the accuracy of values. For example, validating values using the mid-ordinate rule by comparing them to those achieved using calculus. The evidence will be logically structured and will be easy to understand by a third party with a mathematical background, who may or may not be a construction engineer. For example, learners will use mathematical terminology correctly and use relevant units when working with functions set in construction contexts. Small and large numerical values will be correctly presented in an appropriate format, such as standard form. Learners will work to a specified numerical precision (as determined by the assessor), through the use of appropriate significant figures or decimal places.

For Merit standard, learners will apply the correct skills and methods when producing the derivatives of functions and determining their gradients. Learners will correctly manipulate six routine functions (two polynomial, two trigonometric, one logarithmic and one exponential). Some functions will be sufficiently complex to enable learners to select and apply the correct method (product, quotient, function of a function and substitution) when producing first and second derivatives. Learners will select and apply the correct methods when producing the definite and indefinite integrals of functions and determining the properties of periodic functions. Learners will correctly manipulate eight routine functions, with a further three functions being sufficiently complex to enable learners to select and apply the correct method (substitution and by parts) when producing indefinite and definite integrals.

Numerical integration will have been accurately completed for four definitive routine functions, using each of the three techniques given (trapezoidal rule, mid-ordinate rule and Simpson's rule). Learners' numerical work will be accurate; using an appropriate degree of precision as specified by the assessor in significant figures or decimal places, and relevant units will be used for all functions. A limited number of arithmetic follow-through errors are acceptable for non-routine functions.

For Pass standard, learners will apply the correct methods when differentiating at least six given routine mathematical functions. Learners will correctly manipulate at least two polynomial functions, two trigonometric functions, one logarithmic function and one exponential function. Learners will apply the correct methods when integrating at least eight given routine mathematical functions. Learners will correctly manipulate at least two routine functions for each of the different function types (polynomial, trigonometric, reciprocal and exponential). At least one of each type will be an indefinite integral and one of each type will be a definitive integral. In total, at least eight different routine functions will be solved.

Numerical integration will be completed using each of the three approaches for at least two routine functions; these can be manipulated using a spreadsheet, provided that formulae are visible (printed out). Learners must demonstrate a clear understanding that integration arises out of considering a thin strip of area summated between limits along the x-axis of a graph. There will be evidence of simple checks to determine if numerical answers are reasonable.

Learners must demonstrate the correct use of a method when differentiating and integrating functions and use the correct units. They must also demonstrate the correct use of a method and units when integrating functions by a numerical method – minor arithmetic and scaling errors are acceptable. There will be evidence of simple checks to determine if numerical answers are reasonable.

Learning aims C

For Distinction standard, learners will demonstrate high levels of skill in presenting data from given sources and applying processing and analysis of statistical data generated from construction engineering sources. When presenting data, charts and sampling distributions will be accurate and fully reflect the data (including grouped, ungrouped, discrete and continuous) that has been given. Learners must make sure that when determining the results of a statistical analysis, it is sufficiently complex to allow learners to apply a range of routine operations (skills and methods) to their solution. For example, in terms of measures of central tendency and dispersion, learners will analyse one set of measured and four sets of equivalent historical data, such as climatic information for a location or data related to structural analysis sourced from testing and simulations. Before starting to process any data, learners will establish that the sample sizes are large enough to enable reliable analysis to be carried out.

The evidence, including graphical representations, will be easily understood by a third party with a mathematical background, who may or may not be a construction engineer. There will be correct use of mathematical terminology and the application of relevant units. Learners will work to a specified numerical precision, as determined by the assessor or that is appropriate for their chosen problems being solved, through the use of appropriate significant figures or decimal places. Small and large numerical values will be correctly presented in an appropriate format, for example standard form.

For Merit standard, learners will present accurate solutions and analysis for construction engineering problems related to measures of central tendency, dispersion and distribution, breaking them down into planned stages to complete their analysis and to obtain solutions. They will apply appropriate routine operations (skills and methods) to present and process statistical data (including grouped, ungrouped and discrete data) accurately. For example, tabulation of data, graphical presentation of grouped and ungrouped data, and accurate calculations of mean and standard deviation comparing measured values with historical data. The numerical work will be to an appropriate degree of accuracy, as specified by the assessor or appropriate for the chosen problems being solved. Graphical representations and numerical solutions will contain an explanation of the process that will be logically structured, with the correct mathematical terminology and relevant units used. There may be a limited number of minor errors or omissions in calculations or graphical representations. For example, when analysing sampled dimensional data from climatic information, learners may determine the mean and standard deviation for a sample and find a degree of correlation between samples, but not draw conclusions from the values.

For Pass standard, learners will produce at least one histogram, one chart, one frequency graph, and one cumulative frequency graph to represent grouped and ungrouped data related to a construction engineering problem, such as climatic information or ground conditions for a specific location. Learners will present the solutions of construction engineering problems involving measures of central tendency, dispersion and probability distribution. Ideally, they will research their data sets, but if this is not possible then they can be given problems to solve. The analysis may not be complete and there may be some inaccuracies or omissions but there should be evidence of some proficiency of method. Learners will apply appropriate routine operations (skills and methods) required to process statistical data. For example, when interpreting sampled wind speed data from a coastal location for one year, learners will present data appropriately and determine routine values, such as the mean and standard deviation for a sample but may not compare the values with historical data. The report must be logically structured. It may contain some arithmetic errors which 'carry-through'. For example, the value of the mean of a set of sampled rainfall data from a weather station may be incorrect but the value is used correctly to find the standard deviation. The methods chosen may not be optimal, but the chosen statistical methods will be applied correctly. Minor errors and omissions are acceptable. Learners will include evidence of simple checks to determine if numerical answers are reasonable.

Links to other units

This unit links to:

- Unit 6: Construction Mathematics
- Unit 10: Surveying in Construction
- Unit 12: Building Surveying in Construction
- Unit 13: Site Engineering for Construction
- Unit 15: Measurement Techniques in Construction
- Unit 20: Quantity Surveying
- Unit 23: Construction in Civil Engineering
- Unit 24: Conversion, Adaptation and Maintenance of Buildings.

Unit 18: Work Experience

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners explore the benefits of work experience, carrying out and reflecting on a period of work experience and planning for their personal and professional development.

Unit introduction

If you are thinking about a career in construction, you should carry out some work experience to make you aware of the kinds of tasks and activities you may be required to complete. It will help you to reflect on, and develop, the attributes and skills required for work in the construction sector. It will also help to extend your knowledge and understanding of the roles and responsibilities of construction professionals.

In this unit, you will learn about the benefits of work experience in construction. You will examine how work experience can help you to develop personal and professional skills, such as communication and teamwork, and it will help you to understand more about the expectations of different professional roles. You will develop a plan to support your learning when on a work experience placement and you will monitor your progress through a reflective journal. This is a practical unit that will support your work experience placement in construction and give you a foundation to develop, apply and reflect on knowledge and skills in a realistic situation.

A work experience placement will help you prepare for further study in a variety of higher education programmes. It is an important factor in progression to higher education and is a component of many degree courses accredited by the construction sector professional bodies.

Learning aims

In this unit you will:

A Examine the benefits of work experience in construction for own learning and development

B Develop a work experience plan to support own learning and development

C Carry out work experience to meet set objectives

D Reflect on the development of own personal and professional skills and practices.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine the benefits of work experience in construction for own learning and development	**A1** Developing skills and attributes **A2** Clarifying expectations for employment in construction **A3** Exploring career options	A report evaluating the benefits of work experience in the construction sector and the importance of preparing for placement. The report must include a plan to meet personal and professional goals.
B Develop a work experience plan to support own learning and development	**B1** Preparing for work experience **B2** Setting goals and learning objectives	
C Carry out work experience to meet set objectives	**C1** Work experience tasks **C2** Work shadowing and observation	Observation of learners on work placements in the construction sector, carrying out tasks and activities and interacting with customers and staff, evidenced by an observation report signed by the assessor. Reflective log evaluating learners' own development on work placement.
D Reflect on the development of own personal and professional skills and practices	**D1** Reviewing personal and professional development **D2** Using feedback and action planning	

Content

Learning aim A: Examine the benefits of work experience in construction for own learning and development

A1 Developing skills and attributes

- Reflecting on own skills, attributes and areas for development.
- Developing professionalism.
- Communication and interpersonal skills.
- Organisational skills, e.g. time management, prioritising tasks.
- Technical and professional skills and their application in the workplace.
- Ability to link theory with practice.
- Teamwork skills.
- Confidence and personal responsibility.
- Developing a work ethos, to include a positive attitude to work.
- Understanding the importance of working relationships and agreed ways of working in construction – developing trust, mutual respect, mindfulness, open communication, welcoming diversity.

A2 Clarifying expectations for employment in construction

- Understanding the rights and responsibilities of employees.
- Respecting diversity, equality and dignity in the workplace.
- Respecting confidentiality.
- Understanding health, safety and security regulations that apply in the workplace.
- Preparing for employment in the sector.

A3 Exploring career options

- Working in different construction professional roles, e.g. quantity surveying, construction design, structural engineering.
- Working in different construction technical roles, e.g. architectural technician, assistant site engineer, planner.
- Sources of information about careers and career pathways in construction.
- Professional construction bodies and types of membership, e.g. Royal Institution of Chartered Surveyors (RICS), Chartered Institute of Building (CIOB), Institution of Civil Engineers (ICE), Royal Institute of British Architects (RIBA), International Construction Project Management Association (ICPMA)
- Using work experience to inform career choices, confirm ideas or consider alternative options.

Learning aim B: Develop a work experience plan to support own learning and development

B1 Preparing for work experience

- Expectations for learners carrying out work experience, to include dress, behaviour, attitude.
- Responsibilities and limitations for learners carrying out work experience, e.g. restrictions due to lack of experience or training requirements to carry out tasks.
- Researching specific work experience placements, e.g. organisation, roles.
- Role of placement supervisors/mentors.
- Planning for work experience, to include own expectations, provider's expectations, intended outcomes, negotiation of specific areas of experience.
- Initial contact with work experience provider to establish working relationship.

B2 Setting goals and learning objectives

- Reflecting on current knowledge and skills.
- Identifying own strengths and areas for development.
- Identifying established standards and values required for professionals, e.g. entry requirements for membership of local and regional professional bodies.
- Identifying SMART (specific, measurable, attainable, realistic, time-related) targets for own work experience.
- Setting personal development goals, e.g. developing communication skills, confidence.
- Setting professional development goals, e.g. developing competence, technical ability.
- Recording goals and objectives in a work experience journal or record.

Learning aim C: Carry out work experience to meet set objectives

C1 Work experience tasks

- Assisting and participating in construction tasks, e.g. preparing the workplace to carry out given tasks.
- Assisting and participating in non-construction tasks, e.g. attending meetings, general office tasks.
- Participating as part of a team.
- Understanding the importance of supervision of work activities.
- Using work experience reflective journals to link theory with practice, reflecting on how work experience placement influences own professional development.
- Involvement in project work directed by the employer.

C2 Work shadowing and observation

- Observing working relationships.
- Work shadowing different professionals to appreciate the range of construction roles and activities.
- Observing specific procedures to gain new knowledge and skills.
- Reflecting on work practice and procedures observed in the setting.

Learning aim D: Reflect on the development of own personal and professional skills and practices

D1 Reviewing personal and professional development

- Understanding that reflective practice is an ongoing activity.
- Theories and frameworks for reflective practice:
  - Schön – reflection in action and reflection on action
  - Gibbs – reflective cycle
  - Kolb – experiential learning.
- Reviewing work experience reflective journal.
- Reflecting on personal and professional development.
- Monitoring, evaluating and revising own practice.
- Supporting continuous quality improvement.

D2 Using feedback and action planning

- The importance of continuing professional development (CPD).
- Identifying areas of positive and constructive feedback.
- Highlighting areas for improvement.
- Creating an action plan for personal and professional development.
- Identifying career goals.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine the benefits of work experience in construction for own learning and development		**AB.D1** Evaluate your own preparation and planning for work experience in the construction sector.
A.P1 Explain how your own preparation for work experience focuses on the development of personal skills and attributes. **A.P2** Explain how your own preparation provides opportunities to reflect on career choices in the construction sector.	**A.M1** Discuss your own preparation for work experience in the construction sector.	
Learning aim B: Develop a work experience plan to support own learning and development		
B.P3 Produce a plan for your own work experience in the construction sector. **B.P4** Explain how to meet own specific personal and professional development goals while on work placement.	**B.M2** Discuss your own planning for work experience in the construction sector.	
Learning aim C: Carry out work experience to meet set objectives		**C.D2** Demonstrate work-related skills proficiently, taking the initiative to carry out activities according to own responsibilities, and selecting appropriate skills and techniques for different situations.
C.P5 Demonstrate work-related skills to meet set objectives for work experience tasks. **C.P6** Discuss ways in which work shadowing and observation can support development of own skills while on work placement.	**C.M3** Demonstrate work-related skills with confidence and proficiency to meet objectives in different situations.	

Pass	Merit	Distinction
Learning aim D: Reflect on the development of own personal and professional skills and practices		
D.P7 Review own strengths and areas for development in response to feedback on work experience placement. **D.P8** Produce a personal development plan that identifies improvements to personal and professional skills.	**D.M4** Discuss how self-reflection can contribute to personal and professional development and future planning, following a work experience placement.	**D.D3** Evaluate how reflecting on skills developed during own work experience placement can inform plans for personal and professional development.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, AB.D1)

Learning aims: C and D (C.P5, C.P6, D.P7, D.P8, C.M3, D.M4, C.D2, D.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to a ten working-day (or equivalent) work experience placement in an appropriate construction setting.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, learners will reach valid judgements about the benefits of preparation for work experience placements. They must use research to justify the validity of proposals about the expectations of work experience and articulate their views concisely to justify conclusions. They must draw on and show knowledge to make suitable justifications and recommendations for their planned placement.

For merit standard, learners will make reasoned, analytical judgements involving comparison and discussion. They must use research to extend their understanding about the expectations of work experience placements. They must select and apply knowledge to demonstrate the relevance and purpose of their work experience plan to support their learning and development.

For pass standard, learners will recall key knowledge to demonstrate their understanding of how work experience can provide preparation for employment in construction. Learners must use research with relevance to given situations to explain their responsibilities and limitations in a work experience placement. They must select and organise information using appropriate knowledge and concepts to produce a plan to meet their specific personal and professional development goals while on work placement.

Learning aims C and D

For distinction standard, learners will make valid judgements about the risks and limitations of techniques and processes used in relation to desired outcomes and own skills development. They must select appropriate skills and techniques in relation to the work situation and desired outcomes, and show that they have developed their skills to achieve increased quality of outcomes while on placement. For example, they must communicate professionally using appropriate methods for their audience to achieve desired outcomes.

Learners must show initiative while acting within expected constraints and assess their contribution to at least three different work-related tasks and three work-shadowing tasks or observations. Learners must justify any decisions taken related to their work situation. They must manage themselves successfully to prioritise activities and monitor their own progress.

They must engage actively with others and on their own initiative to gain feedback and to create opportunities for personal improvement. They must evaluate the basis for taking decisions in their work experience placement and respond effectively to feedback. They must draw together their learning and experiences gained across the learning aims, demonstrating valid insights into their own planning and performance in order to plan their future personal and professional development.

For merit standard, learners will act within given work-related contexts to show required attributes and select and deploy appropriate techniques, processes and skills with increased confidence and proficiency to meet set objectives in three different work experience situations. Learners will modify techniques and processes to suit different situations and to deal with contingencies. For example, they must select and use appropriate communication methods to suit particular audiences, such as interacting with different staff or contributing to a team meeting. They will reflect on knowledge and skills gained through three work-shadowing experiences or observations. They must manage their time to prioritise activities and progress towards required outcomes.

Learners will use knowledge, skills and understanding to select and justify solutions in relation to how work experience tasks support their personal and professional development. They must monitor their achievement against their work experience plan to ensure the relevance of targets, and must reflect actively on evidence of their own performance using feedback from others.

For pass standard, learners will carry out tasks and activities fully, correctly and safely to achieve required outcomes. Learners must select appropriate techniques, processes or skills in well-defined situations, and review the success of these techniques, processes and skills in relation to three work experience tasks and three work-shadowing experiences or observations. They must identify the responsibilities of staff in the placement and relate this knowledge to occupational roles and organisational structures. They must communicate in a variety of ways, using appropriate English, vocational language and graphical methods, responding to communication from others. They must manage their time effectively to carry out work activities and manage outcomes.

Learners will apply knowledge, skills and understanding to explore solutions to realistic and vocational tasks in relation to the ways in which work shadowing and observation can support personal and professional development.

Learners must maintain structured records of their work experience that show how they have planned opportunities to develop their skills and gain feedback on their performance from others.

Links to other units

This unit links to all the other units in the qualification.

Employer involvement

This unit would benefit from employer involvement in the form of:

- opportunities for observation during the work experience
- assessment of any project work.

Unit 19: Projects in Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners explore a real-life construction project and consider the different aspects of the project, from design through to impact in use.

Unit introduction

Every year across the globe both big and small construction projects take place. Have you ever considered what the thought process was for a design, why they chose to clad a building with stone and not glass, or why they designed a flat roof and not a pitched roof? What about the impact a building has on the local environment, or how the building design can impact on local climatic conditions?

In this unit, you will explore a real-life construction project. You will consider the categorisation of the project and the associated design considerations. You will examine the methods and techniques of construction, and the materials used in the project, before developing an understanding of the potential economic and social impacts of the project. You will consider the positive and negative impacts on the natural environment, locally and globally.

This unit will help you to progress to a higher-level construction programme, or to a degree in construction or architecture. Additionally, the content of this unit will support progression to careers in site or project management, or to other professional roles in construction, such as architecture, quantity surveying, building services engineering and structural engineering.

Learning aims

In this unit you will:

A Examine the design of a construction project

B Investigate methods and techniques used in a construction project

C Explore the impact of a construction project.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine the design of a construction project	**A1** Types of construction project **A2** Design considerations of construction projects	Part one of a presented or written and illustrated portfolio, analysing and discussing a given construction project scenario that builds on and references other learning aims.
B Investigate methods and techniques used in a construction project	**B1** Methods and techniques for different construction projects **B2** Material selection for construction projects	Part two of a presented or written and illustrated portfolio, analysing and discussing a given construction project scenario that builds on and references other learning aims.
C Explore the impact of a construction project	**C1** Economic impacts of a construction project **C2** Societal impacts of a construction project **C3** Environmental impacts of a construction project	Part three of a presented or written and illustrated portfolio, analysing and discussing a given construction project scenario that builds on and references other learning aims.

Content

Learning aim A: Examine the design of a construction project

The different sectors, design options and the context in which the project has been developed.

A1 Types of construction project

The categorisation of construction projects and how the design of the project meets the needs of stakeholders, to include new build, conversion and refurbishment.

- Commercial projects.
- Industrial.
- Residential.
- Educational.
- Leisure.
- Mixed-use.
- Civil engineering:
  - infrastructure
  - large structures.

A2 Design considerations of construction projects

The design style and considerations to meet the functional and aesthetic requirements of a construction project.

- Architectural style.
- Size and massing.
- Local vernacular.
- Design influences:
  - planning requirements
  - legislation
  - client needs
  - building use.
- Environmental influences.

Learning aim B: Investigate methods and techniques used in a construction project

B1 Methods and techniques for different construction projects

Methods and techniques of construction, their environmental impact and suitability for different building types and uses.

- Forms of construction, to include:
  - traditional
  - frame
    - rectangular skeletal
    - portal
    - prefabricated timber
    - in-situ concrete
    - precast concrete

- crosswall
- surface structure
- cellular
- modular.

- Methods and techniques used in the construction of:
  - groundworks and substructures
  - superstructures
  - external works
  - use of construction plant.

B2 Material selection for construction projects

Selection and use of different materials, and why they are fit for purpose, for the following elements.

- Foundations and substructure.
- Structural elements of the superstructure.
- External envelopes.
- Internal finishes.
- Fixtures and fittings.
- Services installations.
- External works.

Learning aim C: Explore the impact of a construction project

C1 Economic impacts of a construction project

Economic benefits and drawbacks of a project.

- Growth and development of the area.
- Regeneration.
- Economic blight, to include increased rental costs and the cost of maintaining the quality of older structures.
- Employment opportunities during and after construction.
- Benefits to the local supply chain.
- Multiplier effect of local spending.
- Economic sustainability:
  - short-term versus long-term benefits of a project
  - life expectancy of a project.

C2 Societal impacts of a construction project

Benefits and drawbacks of a project in terms of its impact on the local population.

- Provision of fit-for-purpose:
  - services
  - housing
  - leisure facilities
  - infrastructure
  - public buildings
  - public spaces
  - transport links.

- Feelings of wellbeing and security.
- Improved public health.
- Provision of community focus.
- Disruption during construction:
  - noise
  - dust
  - restrictions, e.g. roads closed, service reductions.
- Increased traffic.
- Incongruent design and materials.
- Increased urban density.
- Loss of local open space.
- Obstructed views.
- Climatic changes.

C3 Environmental impacts of a construction project

Benefits and drawbacks of a project in terms of its impact on the local environment and the wider environmental consideration.

- Local environment:
  - improved public spaces
  - removal of derelict or obsolete properties
  - environmental clean-up
  - increase in pollution, to include water, ground, air, noise and light
  - increased demand on services provision
  - increased traffic flow.
- Climatic impacts.
- Wider environmental considerations:
  - reduction in natural resources
  - increased use of energy
  - micro-regeneration
  - carbon offsetting.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine the design of a construction project		**A.D1** Evaluate the design choices made in meeting the functional and aesthetic requirements of the project and the needs of stakeholders.
A.P1 Explain how the design of the project meets functional requirements. **A.P2** Explain how the design of the project meets aesthetic requirements.	**A.M1** Discuss the design choices made in meeting the functional and aesthetic requirements of the project.	
Learning aim B: Investigate methods and techniques used in a construction project		**B.D2** Justify the methods, techniques and materials used in the construction of the project.
B.P3 Explain the methods and techniques used in the construction of the project. **B.P4** Explain the selection of materials used in the construction of the project.	**B.M2** Assess the methods, techniques and materials used in the construction of the project.	
Learning aim C: Explore the impact of a construction project		**C.D3** Evaluate the overall impact of the construction project.
C.P5 Explain the economic impacts of the construction project. **C.P6** Describe the societal impacts of the construction project. **C.P7** Explain the environmental impacts of the construction project.	**C.M3** Assess the economic, societal and environmental impacts of the construction project.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.P4, B.M2, B.D2)

Learning aim: C (C.P5, C.P6, C.P7, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to design plans for a project that is sufficiently detailed and sized to allow access to the higher grades. A simple single-storey house extension, for example, will not allow this. However, a new shopping centre would be too large at this level.

Essential information for assessment decisions

Centres are encouraged to allow learners the opportunity (with guidance) to self-select a project for the assessment. The assessment instrument(s) should then be written in such a way that learners can build and develop their learning. The unit is best considered holistically for assessment purposes. Learners should be encouraged to think of the project as a whole and not take each aspect in isolation.

Learning aim A

For distinction standard, learners will evaluate the design choices made in meeting the functional and aesthetic requirements of the project, as well as the needs of stakeholders associated with it. They will draw on varied information to consider the strengths and weaknesses of the choices made and consider why, on a given project, some design considerations have greater importance than others. They will show an explicit understanding of how each project is unique, and how the considerations for one will be very different to others, highlighting which are more important and why. Learners will consider conflicting requirements, such as function and form, in the context of the stakeholder needs and the aesthetics specific to the location of the project.

For merit standard, learners will discuss the design choices made in meeting the functional and aesthetic requirements of the project. They will consider how these requirements interrelate, considering a range of design aspects, as well as the construction of the project and the extent to which they are important, giving reasons why.

For pass standard, learners will explain how the design of the project meets the functional requirements of the brief and the needs of the end user. They will also explain how the design of the project meets aesthetic requirements, taking into account the local vernacular and the specific location of the project. Learners will show that they comprehend the objectives of the project in terms of meeting aesthetic and functional requirements.

Learning aim B

For distinction standard, learners will justify the methods, techniques and materials used in the construction of the project, analysing the design and construction decisions of others and drawing on appropriate supporting evidence from multiple sources. (It is not acceptable to simply state that this is the best method of construction or the best material in this environment.) Learners will use sound reasoning or evidence to prove that the methods and techniques used in the construction of the project are appropriate for use in the context of the project.

For merit standard, learners will assess the methods, techniques and materials used in the construction of the project, presenting a careful consideration of the various methods and techniques that apply to the situation. They will identify the key methods and techniques that are most relevant to the project, relating them to their suitability for the project.

For pass standard, learners will explain the methods and techniques used in the construction of the project, considering why they are the most appropriate. They will focus on the rationale for the selection of materials rather than the material choice alone. Learners will show that they comprehend the reasons for the use of the various methods, techniques and materials in the project.

Learning aim C

For distinction standard, learners will evaluate the overall impact of the construction project, including detailed consideration of its economic, societal and environmental impact. They will consider both positives and negatives, and how these combine or balance. Learners will make an evidence-based, evaluative judgement on the overall impact that the specific construction project has had.

For merit standard, learners will assess the economic, societal and environmental impacts of the construction project, identifying the important factors. They will arrive at an appropriate conclusion, taking into account both positive and negative aspects of the project.

For pass standard, learners will consider the economic, societal and environmental impacts of the construction project. In describing societal impacts, learners will give a clear, objective account of the impact of the project on society, demonstrating application of knowledge and understanding relevant to the project scenario. In explaining economic and environmental impacts, they will show that they comprehend the effect that the project will have on the local and/or national economy and the environment locally, and in a wider context.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 12: Building Surveying in Construction.

Employer involvement

This unit would benefit from employer involvement in the form of:

- site visits to both current and completed projects
- talks from designers and specifiers on projects that learners can access readily
- workplace visits to observe construction in action, especially to the offices of design professionals.

Unit 20: Quantity Surveying

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners understand the underlying principles of quantity surveying when working for both the client and main contractor.

Unit introduction

The financial management of construction projects has to be closely monitored to ensure that projects meet the financial needs of both the client and the contractor. The client needs the project to be completed within budget and the contractor needs to maximise return on the project.

In this unit, you will gain an understanding of the role of a quantity surveyor or commercial manager and the differences when working for a client and a main contractor. You will learn about the financial management of contracts, including the preparation of valuations and the administration of variations, through to the preparation of the final account. You will also learn about the management of cash flow in an organisation, including valuations and payments to subcontractors, suppliers and manufacturers. You will complete a final account for a given project.

This unit will support you in progressing to a higher-level construction programme, or to a general construction or quantity surveying degree. It also supports progression to the workplace as a technician, or direct entry as an assistant quantity surveyor or assistant commercial manager with a construction company.

Learning aims

In this unit you will:

A Understand the functions of a quantity surveyor/commercial manager

B Undertake the production of bills of quantities or a building price calculation document for a project

C Undertake the production of a final account for a project.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the functions of a quantity surveyor/commercial manager	**A1** Functions of the professional quantity surveyor (PQS)/commercial manager when representing the client **A2** Main contractor quantity surveyor functions **A3** Preparation of bills of quantities **A4** Financial management **A5** Contractual management	Learners will explain the differences between representing the client and representing the main contractor as a quantity surveyor/commercial manager.
B Undertake the production of bills of quantities or a building price calculation document for a project	**B1** Producing quantities **B2** Abstraction of quantities and document production	Using a set of given drawings, learners will produce bills of quantities/ building price calculation documents for two elements: a substructure and an element of superstructure.
C Undertake the production of a final account for a project	**C1** Variations **C2** Valuations and final accounts	Using a scenario and information given, learners will produce a final account for a given project.

Content

Learning aim A: Understand the functions of a quantity surveyor/commercial manager

A1 Functions of the professional quantity surveyor (PQS)/commercial manager when representing the client

The PQS client's commercial manager acts mainly for a client in the preparation of the following, in support of the feasibility of a proposal.

- The preparation of cost budgets:
- To provide guidance to the architect or building designer on the scale and type of construction that can be designed within a given budget
  - using historical cost data:
    - obtained from similar developments
    - analysis of elements
    - elemental analysis using bills of quantities data from previous projects
  - using data provided by national professional associations/organisations:
    - identifying types of available data
    - identifying appropriate data from similar construction project types
    - applying approximate quantities
    - superficial application on a cost per m^2 basis
    - updating costs to current price levels using cost indices
  - using approximate quantities:
    - from available drawn information
    - using direct billing techniques
    - interpreting missing requirements
    - formulation of the cost budget
  - comparison and feasibility:
    - project feasibility studies
    - comparison of alternative project costs
    - leading value engineering workshops.
- The preparation of tender documentation to be sent out to contractors for pricing:
  - specification and drawings:
    - drawings to be provided
    - content of the specification
    - how preliminary items are included
    - how prime cost (PC) and provisional sums (PS), including contingencies, are included
  - bills of quantities or building price calculation documents:
    - content and layout
    - preliminaries
    - preambles
    - measured work sections
    - PC sums and provisional sums, including contingencies and dayworks
    - final summary

  - tender documentation:
    - covering letter
    - invitation to tender
    - form of tender and return envelope
    - bill of quantities, building price calculation documents or specification and drawings
    - pre-contract programme
    - pre-construction information
    - tender drawings
    - form of contract and terms and conditions.
- Analysis of submitted tenders:
  - checking submitted bills of quantities, building price calculation document or priced specification
  - notifying errors to the lowest tendering organisation
  - adjustment of errors – standby or withdraw
  - analysing abnormal or variant bids
  - recommending final appointment of successful tendering organisation.
- Preparation of contract documents.
- Post-contract activities:
  - providing ongoing cost advice to the client
  - administration of nominated subcontracts
  - updating the projected final cost
  - remeasuring the work as required
  - producing monthly valuations in conjunction with the main contractor's quantity surveyor
  - pricing variations
  - negotiating any contractual claims for loss and expense
  - producing the final account
  - negotiating and agreeing the final account with the main contractor's quantity surveyor/commercial manager.

A2 Main contractor quantity surveyor functions

The functions of the main contractor's quantity surveyor or commercial manager and how these differ from the PQS or the commercial manager representing the client in terms of working for a client.

- Agreeing monthly valuations of work undertaken.
- Remeasuring the work as required.
- Pricing of variations and architect's instructions, and agreement with the PQS or the commercial manager representing the client.
- Agreeing subcontract accounts and authorising payments.
- Final account preparation:
  - providing information to the PQS, or commercial manager representing the client, to facilitate final account preparation
  - pricing dayworks
  - agreeing the final account with the PQS, or commercial manager representing the client.
- Cost control and reconciliation, including cost value comparisons.

- Preparing claims for loss and expense:
  - contractual notification letters
  - providing information to determine extensions of time
  - calculation of loss and expense claims
  - negotiating loss and expense claims.
- How, in smaller organisations, quantity surveyors or commercial managers may have multiple roles, to include:
  - buying:
    - negotiating prices
    - scheduling materials
    - placing all orders for resources
  - estimating:
    - sending out materials and subcontract enquiries
    - pricing tenders
    - participating in tender settlement or adjudication
  - bonus surveying and labour-only subcontract payments.

A3 Preparation of bills of quantities

The preparation of a bill of quantities, building price calculation documents, schedules and specifications for the procurement processes.

- Use of standard methods of measurement:
  - New Rules of Measurement (NRM 2)
  - Civil Engineering Standard Method of Measurement, Fourth Edition (CESMM4)
  - International Construction Measurement Standards (ICMS)
  - International Property Measurement Standards (IPMS)
  - National and local standard methods of measurement used in the host country as appropriate.
- Use of measurement, bills of quantity or building price calculation documents production software packages.
- Use of spreadsheets, dimension paper, direct billing paper and cut and shuffle paper.
- Working out quantities and abstraction.
- Producing bill of quantities or building price calculation documents pages.
- Inclusion of PC sums and provisional sums.
- Direct billing and bills of approximate quantities.

A4 Financial management

The control of construction costs to ensure that a client's budget is not exceeded. Control of main contractor's costs against the tender value to maximise contribution.

- Professional quantity surveyor or commercial manager representing the client:
  - changes to specifications to lower costs
  - monitoring monthly valuations
  - valuing variations
  - forecasting projected final account
  - life cycle analysis.

- Main contractor quantity surveyor or commercial manager:
  - buying efficiently against estimate values
  - subcontract procurement
  - main contractor's discounts
  - changes to specifications to lower costs
  - ensuring delays are minimised
  - claims for variations.

A5 Contractual management

The administration of a contract on a project in terms of the clauses relating to time, risks, insurance, compensation, payments and termination.

- Joint Contracts Tribunal Contracts (JCT).
- New Engineering Contract (NEC).
- Recognised standard forms of contract used in the host country or region.

Learning aim B: Undertake the production of bills of quantities or a building price calculation document for a project

The production of quantities by taking off dimensions from drawings, in accordance with a standard method of measurement. Production of a bill of quantities page that covers a construction element by writing item descriptions presented in a vocationally correct format.

B1 Taking off

Taking off quantities using appropriate mensuration techniques to produce bills of quantities for a building element.

- Substructure elements:
  - excavation
  - earthwork support
  - treatments
  - fill
  - concrete works
  - reinforcement
  - blockwork
  - cavity walls
  - damp-proof course (DPC).
- Superstructure elements:
  - solid ground floors
  - external cavity walls
  - internal partitions
  - intermediate floors.

B2 Abstraction and bill production

- Abstraction of quantities.
- Use of cut and shuffle.
- Use of direct billing methods.
- Writing bill item descriptions in accordance with a standard method of measurements.
- Format and presentation of bill items on pages.
- Page totals, collections, bill summaries and final summary.
- Use of measurement and bills of quantity production software packages.

Learning aim C: Undertake the production of a final account for a project

C1 Variations

The administration and management of a contract variation through an Architect's Instruction (AI) or a supervising officer's instruction.

- Site instructions, confirmation and issue of an instruction.
- Preparation of quotations.
- Valuation and measurement of variations.
- Remeasurement of the works.
- Adjustment of provisional quantities.
- Use of unit rates and dayworks.
- Acceptance and agreement.
- Disputes and claims.
- Changes to design and significant contract durations.

C2 Valuations and final accounts

The preparation of an interim valuation to obtain a progress payment and the compilation of the final account.

- Tender sum.
- Use of bills of quantities to value the works.
- Adjustments as additions and omissions.
- Architect's instructions or supervising officer's instructions and variations.
- Dayworks.
- Adjustments to PC sums and provisional sums.
- Contingency adjustments.
- Extensions of time.
- Loss and expense claims.
- Adjustment for liquidated and ascertained damages.
- Calculation of the final account sum.
- Presentation of a final account, timelines and format.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the functions of a quantity surveyor/commercial manager		**A.D1** Evaluate the roles of quantity surveyors/ commercial managers for a given project scenario.
A.P1 Explain the role of the professional quantity surveyor/ commercial manager. **A.P2** Explain the role of the contractor's quantity surveyor/ commercial manager.	**A.M1** Discuss the roles of quantity surveyors/ commercial managers for a given project scenario.	
Learning aim B: Undertake the production of bills of quantities or a building price calculation document for a project		**B.D2** Produce bills of quantities/building price calculation documents for construction elements in an appropriate format, with precision, accuracy and attention to detail.
B.P3 Produce quantities for a complete substructure element. **B.P4** Produce quantities for a complete superstructure element.	**B.M2** Produce bills of quantities/building price calculation documents for construction elements, in an appropriate format.	
Learning aim C: Undertake the production of a final account for a project		**C.D3** Produce a final account in an appropriate format, with precision, accuracy and attention to detail.
C.P5 Produce costings for variations. **C.P6** Produce costings for dayworks.	**C.M3** Produce a final account in an appropriate format.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.P4, B.M2, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners must evaluate the roles of quantity surveyors/commercial managers for a given project scenario. Learners will consider how the roles of the professional quantity surveyor/client's commercial manager and the contractor's quantity surveyor/commercial manager differ and interact in the context of a complex building project. Learners will compare the differing objectives of both roles and draw conclusions relating to the key priorities for both parties in the pre- and post-contract phases of the project. Learners will demonstrate a developed understanding of the role of the quantity surveyor/commercial manager.

For merit standard, learners must discuss the roles of quantity surveyors/commercial managers for a given project scenario. Learners will cover both client's and contractor's quantity surveyors/commercial managers and their roles in the given scenario. Learners will consider the objectives, key focus and content in their discussions, covering the quantity surveyor's/commercial manager's work linked to the project scenario. This will include the work of the quantity surveyors/commercial managers during both the pre- and post-contract phases of construction projects. Learners will demonstrate a good understanding of the role of the quantity surveyor/commercial manager.

For pass standard, learners must explain the roles of the professional quantity surveyor/client's commercial manager and the contractor's quantity surveyor/commercial manager. Learners will consider, within their explanations, the key objectives and content of the quantity surveyor's/commercial manager's work in generic terms but without focus on the project scenario. Learners will cover the work of the quantity surveyors/commercial managers during the pre- and post-contract phases of construction projects. Learners will demonstrate a generic understanding of the role of the quantity surveyor/commercial manager.

Learning aim B

For distinction standard, learners must produce bills of quantities/building price calculation documents for construction elements in an appropriate format and with precision, accuracy and attention to detail. These will include a substructure and a superstructure element produced using vocationally relevant mensuration techniques and in accordance with an appropriate standard method of measurement. The production of quantities and subsequent abstracting and billing can be completed using traditional paper-based methods or by using an appropriate software package. Learners will demonstrate a developed understanding of the techniques, methodologies and standards used in the production of bills of quantities/building price calculation documents.

For merit standard, learners must produce bills of quantities/building price calculation documents for construction elements in an appropriate format. These will include a substructure and a superstructure element produced using vocationally relevant mensuration techniques and generally following an appropriate standard method of measurement. The production of quantities and subsequent abstracting and billing can be completed using traditional paper-based methods or by using an appropriate software package. Learners will demonstrate a good understanding of the techniques, methodologies and standards used in the production of bills of quantities/building price calculation documents.

For pass standard, learners must produce quantities for a complete substructure element and a complete superstructure element produced using some vocationally relevant mensuration techniques and generally following an appropriate standard method of measurement. The production of quantities can be completed using traditional paper-based methods or by using an appropriate software package. Learners will demonstrate a generic understanding of the techniques, methodologies and standards used in the take-off of quantities for the elements.

Learning aim C

For distinction standard, learners produce a final account, in an appropriate format, with precision, accuracy and attention to detail. Learners will complete the final account accurately, using sector-specific methodologies and layout. Using the contract sum as a starting point, learners will make adjustments to consider AIs/supervising officer's instructions, dayworks, adjustment of prime cost and provisional sums, loss and expense or liquidated and ascertained damages, and adjustment of contingencies. Learners will demonstrate a developed understanding of the techniques, methodologies and standards utilised in the production of final accounts.

For merit standard, learners produce a final account in an appropriate format. Learners will complete the final account using some sector-specific methodologies and layout. Using the contract sum as a starting point, learners will make adjustments to consider AIs/supervising officer's instructions, dayworks, adjustment of prime cost and provisional sums, and adjustment of contingencies. Learners will demonstrate a good understanding of the techniques, methodologies and standards utilised in the production of final accounts.

For pass standard, learners produce costings for variations and dayworks. Learners will include a cost analysis of AI and the accurate pricing of dayworks using sector-specific methodologies. Learners will demonstrate a generic understanding of the techniques, methodologies and standards utilised in the production of aspects of final accounts.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 5: Management of Commercial Risk
- Unit 6: Construction Mathematics
- Unit 7: Graphical Detailing
- Unit 10: Surveying in Construction
- Unit 12: Building Surveying in Construction
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction
- Unit 16: Provision of Primary Services in Buildings
- Unit 22: Economics and Finance in Construction
- Unit 23: Construction in Civil Engineering
- Unit 24: Conversion, Adaption and Maintenance of Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of:

- office visits to a quantity surveying practice
- a guest speaker in the form of a professional quantity surveyor and a contractor's quantity surveyor
- employer case studies
- site visits to study quantity surveying roles.

Unit 21: Building Services Science

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners apply the principles of heat transfer, thermodynamics, electricity, combustion and psychrometry to solve problems related to the building services industry.

Unit introduction

Building services are primarily concerned with creating comfortable living and working environments and are an integral part of building design. Good building services design requires an understanding of the underpinning scientific principles so that internal environmental conditions can be examined and changes made to improve or modify those conditions.

In this unit, you will learn about the nature of energy, examine heat transfer mechanisms and the combustion of solid, liquid and gas fuels, all while considering the implications of incomplete combustion and the methods to prevent this. You will gain an understanding of the principles of electrical generation, transmission and distribution. You will also learn about thermodynamics and develop the skills to use psychrometric charts and pressure-enthalpy (P-H) diagrams to solve a variety of problems related to building services.

The knowledge and skills acquired in this unit will prepare you for progression to employment as an electrical engineer, a building services systems designer, an HVAC specialist or an alternative energy specialist. It will also enable entry to a higher education programme in building services or one that contains elements of building services.

Learning aims

In this unit you will:

A Understand the principles of energy, heat transfer and combustion applicable to building services systems

B Explore the characteristics of electrical supply systems applicable to building services systems

C Examine the thermodynamic properties for heating, air conditioning and refrigeration.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the principles of energy, heat transfer and combustion applicable to building services systems	**A1** Energy **A2** Heat transfer **A3** Combustion of fuels	Analysis of a given client brief in relation to the heat transfer and combustion system applicable to the context.
B Explore the characteristics of electrical supply systems applicable to building services systems	**B1** Electrical principles **B2** Generation, transmission and distribution of electricity	A report for a given project scenario that covers the different transmission methods that can be used to provide electricity to a particular site, including the use of appropriate transformers.
C Examine the thermodynamic properties for heating, air conditioning and refrigeration	**C1** Ideal gases and application to building services engineering applications **C2** Thermodynamic properties and processes **C3** Changes of state **C4** Air conditioning systems and refrigeration	A report for a given project scenario that covers the evaluation and interpretation of a P-H diagram.

Content

Learning aim A: Understand the principles of energy, heat transfer and combustion applicable to building services systems

A1 Energy

The nature of energy and its use in building services installations.

- Energy forms used in building services systems, to include electricity, thermal.
- Units of energy and power and their application, to include joule (J), British thermal unit (Btu), watt (W), kilowatt (kW), kilowatt hour (kWh).
- Principle of the conservation of energy and its use in building services contexts.
- Temperature scales, to include absolute, kelvin, Celsius, Fahrenheit.
- Specific heat capacity, to include its effect on a selection of materials and building components.

A2 Heat transfer

The principle of conservation of energy applied in heat transfer situations to the design and performance of installations and equipment.

- Methods of heat transfer, to include conduction, convection, radiation.
- Factors affecting the rate of heat transfer, to include temperature difference between an object and the surrounding area, surface area, material heat transfer properties.
- Calculating conduction through single slab and composite structures.
- Calculating free or natural convection in air from:
  - vertical and horizontal panels
  - horizontal cylindrical objects.
- Calculating radiation heat transfer from plane surfaces.

A3 Combustion of fuels

The principles of fuel combustion, to include associated calculations, and their impact on the design and performance of installations and equipment.

- Properties and constituents of common fuels, to include:
  - solids, e.g. coal, anthracite, coke, biomass
  - liquid, e.g. petrol, fuel oil, paraffin
  - gas, e.g. liquid propane gas (LPG), natural gas, e.g. methane.
- Combustion:
  - requirements for safe and efficient combustion
  - difference between complete and incomplete combustion
  - causes and implications of incomplete combustion
  - methods used to prevent incomplete combustion
  - implications of fuel-lean and fuel-rich combustion.
- Products of complete and incomplete combustion and their effects, to include excess oxygen, nitrogen, carbon monoxide, carbon dioxide, incombustible constituents of fuel.
- Minimum air requirements for stoichiometric combustion, to include stoichiometric air/fuel ratio.
- Requirements for excess air.
- Need for control of excess air quantities.

Learning aim B: Explore the characteristics of electrical supply systems applicable to building services systems

B1 Electrical principles

- Principles of direct current (DC), alternating current (AC).
- Electrical units of measurement:
  - the relationship between volts, amperes, ohms, joules and watts and what they measure.
- Calculations, to include voltage, current, resistance, energy, power.

B2 Generation, transmission and distribution of electricity

Generation and distribution of power through the national grid to local level.

- Generation of electricity, to include nuclear, coal, gas, oil, wind, tidal, hydroelectric.
- Local generation, to include solar, wind, biomass.
- Application of electromagnetic induction to generators.
- Transformer principles, to include step-up, step-down, associated calculations.
- Application of transformers in the transmission and distribution of electrical power.
- Characteristics of transmission and distribution lines to buildings, to include typical voltages during various stages.
- Calculation of AC voltage and current, to include during generation, transmission, distribution.
- Different voltage for different settings, to include portable workshop equipment (110 V), home supply (230 V), three phase (415 V).

Learning aim C: Examine the thermodynamic properties for heating, air conditioning and refrigeration

C1 Ideal gases and application to building services engineering applications

The principles and calculations of gases and their impact on the design and performance of installations and equipment.

- Relationship of pressure to temperature, volume, mass:
  - units of pressure, to include Pascal (Pa), newtons per square metre (N/m^2)
  - units of temperature, to include degrees Celsius (C)
  - units of volume, to include cubic centimetres (cm^3), cubic metres (m^3), litres (l)
  - units of mass, to include kilograms (kg).
- Application of general gas law, to include systems under pressure.
- Application of characteristic gas equations to solve problems related to building services science.
- Application of Dalton's law ($P_{total} = P_1 + P_2 + \ldots + P_n$) to solve problems involving multiple pressures.

C2 Thermodynamic properties and processes

- Relationship between pressure, saturation temperature and enthalpy.
- Thermodynamic properties for water and refrigerants.
- Identification and interpretation of various zones of a pressure-enthalpy (P-H) diagram, to include:
  - sub-cooled liquid
  - latent heat
  - super-heated vapour
  - saturated liquid
  - saturated vapour.
- Graphical representation of thermodynamic processes:
  - isothermal evaporation
  - adiabatic compression
  - simple vapour compression
  - refrigeration cycles.
- Use of tables and P-H diagrams to obtain values in solving problems, to include:
  - saturation temperature and enthalpy of dry saturated vapour at n bar pressure
  - enthalpy at n bar pressure with x degrees of superheat
  - refrigeration plant and equipment.

C3 Changes of state

- Kinetic theory of matter.
- Reasons for change of state, to include changes in temperature, changes in pressure.
- Sensible and latent heat, to include latent heat of fusion, latent heat of vaporisation.
- Application of the theory of enthalpy to solve problems where change of state occurs and latent heat is encountered.

C4 Air conditioning systems and refrigeration

- Air conditioning processes and cycles.
- Psychrometric terms and properties of air and water vapour, to include calculation, measurement, tables, charts.
- Psychrometric process lines, to include:
  - sensible heating and cooling
  - dehumidification and humidification (using different types of humidifiers)
  - resulting condition from mixture of two air streams.
- Plotting summer and winter psychrometric cycles for given arrangements of air conditioning plant and operating conditions, to include:
  - heater batteries
  - cooler batteries (operating in sensible cooling and dehumidification mode)
  - humidification, to include steam, adiabatic, humidity ratio, relative humidity
  - air mixing applications.
- Determine plant duties from psychrometric chart.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the principles of energy, heat transfer and combustion applicable to building services systems		**A.D1** Evaluate the significance of heat transfer and combustion in the design and performance of installations and equipment, taking into account the principles of conservation of energy, and the combustion and characteristics of fuels.
A.P1 Explain the methods for calculating heat transfer in conduction, convection and radiation through materials and structures. **A.P2** Explain the principles of fuel combustion and their impact on the design and performance of installations and equipment.	**A.M1** Assess the implications of heat transfer and combustion in the design and performance of installations and equipment, taking into account the principles of conservation of energy and combustion of fuel.	
Learning aim B: Explore the characteristics of electrical supply systems applicable to building services systems		**B.D2** Justify, for a given scenario, the use of transformers in the transmission and distribution of electrical power, with reference to generation and end use.
B.P3 Explain the principles of generation, transmission and distribution of electrical energy.	**B.M2** Assess the use of different voltages during generation, transmission and distribution of electrical energy.	
Learning aim C: Examine the thermodynamic properties for heating, air conditioning and refrigeration		**C.D3** Evaluate produced solutions to thermodynamic and psychrometric problems to heating, air conditioning and refrigeration.
C.P4 Produce a solution to a thermodynamic problem where there are multiple pressures, with reference to enthalpy. **C.P5** Produce a solution to a thermodynamic problem involving identification, interpretation and plotting of P-H diagrams and processes. **C.P6** Interpret a given psychrometric chart involving properties of air and water vapour mixtures and air conditioning systems in order to determine relative humidity and temperature.	**C.M3** Produce clear and accurate solutions to thermodynamic problems with reference to enthalpy and P-H diagrams and processes. **C.M4** Produce clear and accurate solutions to psychrometric problems involving properties of air and water vapour mixtures and air conditioning systems in order to determine relative humidity and temperature.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.M2, B.D2)

Learning aim: C (C.P4, C.P5, C.P6, C.M3, C.M4, C.D3)

Further information for teachers and assessors

Resource requirements

Learners taking this unit would benefit from access to experiments, a workshop and site visits.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate, with the aid of detailed and comprehensive line drawings, the significance of heat transfer and combustion in the design and performance of an installation. They will also evaluate, with a detailed report, the principles surrounding the conservation of energy and the combustion and characteristics of the fuel selection. In evaluating, they will also consider the advantages and disadvantages of alternative systems and the significance of performance requirements, including what equipment will be required. Learners' enquiries will lead to a supported judgement, showing clear links to the installation scenario.

For merit standard, learners will analyse, with clear and accurate line drawings, the implications of heat transfer and combustion in the design and performance of an installation. They will also analyse, with a clear and accurate report, the principles surrounding the conservation of energy and the combustion of fuel. In conducting their analysis, learners will consider the key components and equipment required in the system and how these combine to provide effective performance.

For pass standard, learners will explain, with appropriately annotated illustrations, the methods for calculating heat transfer in conduction, convection and radiation through structures and materials. They will also explain, with appropriately annotated illustrations, the principles of fuel combustion and the impact they have on the design and performance of installations and equipment. In their work, learners will demonstrate that they understand the functional requirements of the system and whether the system can be considered fit for purpose.

Learning aim B

For distinction standard, learners will evaluate, with the aid of detailed and comprehensive line drawings, the use of transformers in the transmission and distribution of electrical power with reference to generation and end use. In evaluating, they will also consider the advantages and disadvantages of alternative systems and the significance of key performance requirements. Learners' enquiries will lead to a supported judgement, showing clear links to the scenario.

For merit standard, learners will analyse, with clear and accurate line drawings, the use of different voltages during the generation, transmission and distribution of electrical energy. In conducting their analysis, learners will also consider the key components and equipment required within the system and how these combine to provide effective performance.

For pass standard, learners will explain, with appropriately annotated illustrations, the principles of the generation, transmission and distribution of electrical energy. Within their work, learners will demonstrate that they understand the functional requirements of the system and whether the system can be considered fit for purpose.

Learning aim C

For distinction standard, learners will evaluate, with the aid of detailed and comprehensive line drawings, a minimum of two solutions to thermodynamic and psychrometric problems to heating, air conditioning and refrigeration systems using tables and diagrams. In evaluating, they will also consider the advantages and disadvantages of alternative systems and the significance of performance requirements, including what equipment will be required. Learners' enquiries will lead to a supported judgment, showing clear links to the installation scenario.

For merit standard, learners will produce, with clear and accurate line drawings, a minimum of two solutions to thermodynamic problems with reference to enthalpy and P-H diagrams and processes. They will also produce a clear and accurate report relating to psychrometric problems involving properties of air and water vapour moistures and air conditioning systems in order to determine relative humidity and temperature. In producing the report, learners will also consider the key components and equipment required within the system and how these combine to provide effective performance.

For pass standard, learners will produce a solution, with appropriately annotated illustrations, to a thermodynamic problem where there are multiple pressures, with reference to enthalpy. They will also produce a solution to thermodynamic problems involving identification, interpretation and plotting of P-H diagrams and processes. They will interpret a given psychrometric chart involving properties of air and water vapour mixtures and air conditioning systems in order to determine relative humidity and temperature. In their work, learners will demonstrate that they understand the functional requirements of the system and whether the system can be considered fit for purpose.

Links to other units

This unit links to:

- Unit 11: Management of a Construction Project
- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 16: Provision of Primary Services in Buildings
- Unit 19: Projects in Construction
- Unit 24: Conversion, Adaptation and Maintenance of Buildings.

Employer involvement

This unit would benefit from employer involvement in the form of:

- site visits to manufacturers and suppliers to view equipment
- a guest speaker, such as an air conditioning or boiler and heating sales representative
- a guest speaker from an air conditioning or heating subcontractor or organisation
- a guest speaker from an electrical installations company
- a guest speaker from a services design consultant
- services engineer case studies
- professional bodies associated with the building services sector
- participation in audience assessment of presentations
- design/ideas to contribute to the unit.

Unit 22: Economics and Finance in Construction

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners investigate economic principles and how the availability of resources and the impact of the economic environment affect the financial planning, costing and feasibility of construction projects.

Unit introduction

The financial success of construction projects depends on timescales, location, the economic climate and meeting customer needs. This, in turn, creates employment, secures the efficient use of natural resources and underpins economic growth both locally and nationally.

In this unit, you will gain an insight into how the economic principles of demand, supply and price interact. You will learn how the availability of resources and the economic environment can determine which projects to develop, where they will be developed and when construction will commence, including how government policies on regeneration, taxation and sustainability impact on activities.

In developing a sound knowledge of construction economics and finance, this unit will help you to progress to employment or to study construction-related subjects at a higher level, including degree-level programmes in construction, quantity surveying, commercial management and building surveying.

Learning aims

In this unit you will:

A Examine how economic principles underpin the construction industry

B Investigate the impact of economic factors on construction projects

C Explore how to plan and control construction costs

D Examine the factors determining the feasibility of construction projects.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine how economic principles underpin the construction industry	**A1** Structure and size of the construction industry **A2** Market structures, supply and demand **A3** Interaction of supply, demand and price	A report, presentation or booklet that examines the effects of economic principles, resources and environment on a sector of the construction industry and how it has/will react to economic changes.
B Investigate the impact of economic factors on construction projects	**B1** Economic resources **B2** Internal environment **B3** External environment	
C Explore how to plan and control construction costs	**C1** Cost control **C2** Cost planning **C3** Cost-control techniques **C4** Budgeting **C5** Reconciliation of costs	A report that investigates the consideration of cost planning and control and the financial viability of a construction project.
D Examine the factors determining the feasibility of construction projects	**D1** Business analysis methods **D2** Feasibility factors **D3** Modelling and testing of factors impacting on projects	

Content

Learning aim A: Examine how economic principles underpin the construction industry

The characteristics of the construction industry, in a regional and national context, and the impact of the principles of supply, demand and markets on price.

A1 Structure and size of the construction industry

How the structure and size of the industry influences supply and demand and the impact on tender prices or the cost of construction projects.

- Size, range and legal status:
  - sole traders, partnerships, small and medium-sized companies and large companies
  - range of activities – local, regional, national and international activities
  - private, partnership, public and cooperative ownership.
- Sectors and activities:
  - housing, commercial, industrial, civil engineering, infrastructure
  - new build, maintenance, renovation, refurbishment, extension, regeneration
  - greenfield development, brownfield development.

A2 Market structures, supply and demand

How the competitive environment and market structures influence supply and demand and their impact on tender prices or the cost of construction work.

- Competitive environment:
  - competition – local, national and international
  - competitive advantage – differentiation, pricing policies, reputation, market share
  - level of commercial intelligence
  - market structures
  - perfect competition, imperfect competition, monopoly
  - features of markets – number of firms, freedom of entry, nature of product
  - barriers to entry – tariffs, quotas, contractor selection, other limiting factors
  - regional stability
  - political climate.

A3 Interaction of supply, demand and price

- Demand theory and what influences demand, including affordability, substitutes, competition, incentives.
- Supply theory and what influences supply, including availability of resources, reliability and stability of supply chains, government policies and level of intervention, proximity to market, profitability.
- Elasticity – price elasticity of demand.
- Impact on pricing and output decisions:
  - supply and demand graphs
  - pricing decision
  - output decisions
  - impact of movements of the supply and demand curve.
- Responses to pricing and output.
- Impact of supply and demand in different market structures.

- Market changes:
  - impact on contractors in a declining market or economic environment
  - impact on contractors in an improving market or economic environment.

Learning aim B: Investigate the impact of economic factors on construction projects

The relationships between the availability of economic resources and changes in the internal and external economic environment, and how they influence production in the construction industry.

B1 Economic resources

- Land:
  - types of land and location
  - factors affecting price and availability.
- Capital and finance:
  - types of finance and availability
  - government grants and incentives
  - capital and revenue income and goods
  - overseas investment
  - income and taxation
  - cash flow.
- Labour:
  - demographics
  - availability and mobility
  - efficiency and quality of labour
  - education and skills
  - skills and incentives.
- Enterprise and entrepreneurship:
  - innovation, business efficiency, profitability, new opportunities
  - benefits and risks, including improvements, development of new products and markets, recognition and reputation, culture and failure
  - market data, trends and forecasting
  - commercial intelligence and networking.

B2 Internal environment

- Organisational culture:
  - attitude to risk
  - attitude to change
  - sphere of comfort
  - organisational flexibility.
- Corporate social responsibility (CSR) and sustainability:
  - impacts
  - opportunities
  - benefits and drawbacks.
- Ethics and their impact throughout the supply chain.

B3 External environment

- Political:
  - government legislation and policies
  - government incentives
  - legislative approach to health and safety in the host nation
  - legislative approach to sustainability and the environment.
- Economic:
  - fiscal and monetary policies, exchange rates, interest rates.
- Social:
  - attitudes to saving, spending, debt, social responsibility requirements, changes in demographic trends, personal tastes and preferences.
- Technological changes:
  - innovation in communications, research and development, and automation.
- Environmental and ethical factors:
  - sustainability, recycling, public attitudes, carbon offsetting, ethical purchasing and supply.
- Legal environment:
  - changes in government, legislation, legal requirements and regulations.

Learning aim C: Explore how to plan and control construction costs

The reasons why costs need to be controlled in construction projects and the methods used to plan and control costs.

C1 Cost control

- History of cost control.
- Need for cost control – aim, objectives and strategies.
- Cost control:
  - estimated cost
  - planned performance cost
  - actual cost
  - cash flow.
- Budgeting:
  - elemental
  - trade
  - alternative cost centres.
- Comparison of alternative schemes.
- Cost, price and value.
- Construction cost price indices.

C2 Cost planning

- Reasons for cost planning.
- Cost value engineering:
  - value engineering workshops
  - appropriate participation
  - costing outcomes.
- Financial appraisal.

- Sources of cost data:
  - cost information available through organisations in the host nation
  - historical data
  - tender analysis
  - use of indices to update costs.
- Sources of finance.

C3 Cost-control techniques

- Standard techniques:
  - cost modelling
  - use of appropriate cost per m^2
  - use of ICT-based systems.
- Purchasing decisions.
- Types of contract and effects on costs:
  - transfer of risk
  - impact of the contract on cash flow
  - commercial decisions.
- Resources and costs, e.g. materials, labour, plant and machinery.
- Calculation and monitoring of resources.

C4 Budgeting

- Preparation of preliminary estimates:
  - use of New Rules of Measurement (NRM) 1, 2 and 3 or measurement rules available and in use within the host nation
  - use of a Code of Estimating Practice as appropriate to the host nation.
- Land purchase and other costs:
  - updating land stock to current valuation
  - associated legal costs
  - compensation for planning gain.
- Construction costs.
- Profit and loss.

C5 Reconciliation of costs

- Cost and value reconciliation.
- Value-time relationships.
- Cost-time relationships.

Learning aim D: Examine the factors determining the feasibility of construction projects

D1 Business analysis methods

- Feasibility study methodology and approaches.
- Other feasibility and viability methods:
  - PESTEL (political, economic, social, technological, environmental, legal) analysis
  - SWOT (strengths, weaknesses, opportunities, threats) analysis
  - 5 Cs (customer, company, competition, collaborators, context) analysis
  - Porter’s Five Forces
  - cost-benefit analysis
  - residual method of valuation.

D2 Feasibility factors

- Changes in floor area, volume, elements price indices and use.
- Availability of land, labour and finance.
- Client requirements.
- Planning and regeneration policy changes.
- Legal and environmental requirements.
- Specification standards.
- Local property market and rental yield.
- Client’s approach/attitude to sustainability and the impact on the environment.

D3 Modelling and testing of factors impacting on projects

- Modelling and testing of current costs, opportunities and constraints.
- Modelling and testing of alternative scenarios.
- Forecasting and reporting techniques:
  - cost forecasting, including cash flow, profit, return, cost and value
  - liquidity, including borrowing, working capital and profitability.
- Use of software packages.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine how economic principles underpin the construction industry		**A.D1** Evaluate how the structure of the construction industry and the changes in the market impact on a given sector, allowing it to plan for future changes.
A.P1 Explain how the construction industry is structured and its features. **A.P2** Explain how the interaction of supply and demand, price, and market structures affect the pricing and production decisions for a given sector of the construction industry.	**A.M1** Analyse how the structure of the construction industry allows a given sector to respond to market constraints and changes.	
Learning aim B: Investigate the impact of economic factors on construction projects		**B.D2** Evaluate how resources and the economic environment can be managed for a given project.
B.P3 Explore the range of resources required to deliver a given construction project. **B.P4** Explain the internal and external economic environmental factors on a given project.	**B.M2** Analyse how resources and the economic environment affect a given project.	
Learning aim C: Explore how to plan and control construction costs		**C.D3** Evaluate how changes in costs occur and how this impacts on the detailed cost budget produced, and the efficacy of using appropriate cost-control techniques for a given construction project.
C.P5 Examine how cost control and planning and budgeting techniques are used in construction projects. **C.P6** Produce a cost budget for a given construction project.	**C.M3** Produce, having considered appropriate techniques, a detailed cost budget for a given construction project.	
Learning aim D: Examine the factors determining the feasibility of construction projects		**D.D4** Justify the feasibility of a given project as factors change.
D.P7 Explain the factors that influence the feasibility of a given construction project. **D.P8** Explore the relationship between the factors that influence the feasibility of a given construction project.	**D.M4** Analyse how the feasibility of a given construction project is affected by changes in factors.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, A.D1, B.D2)

Learning aims: C and D (C.P5, C.P6, D.P7, D.P8, C.M3, D.M4, C.D3, D.D4)

Further information for teachers and assessors

Resource requirements

There are no specific additional requirements for this unit but centres must give learners access to information on a range of businesses and projects, including local, regional, national and international.

Essential information for assessment decisions

It is expected that learners will individually select and research different sectors of the construction industry.

Learning aims A and B

For distinction standard, learners will carry out in-depth research on the extent to which economic principles affect a given sector of the construction industry. They will look at how they could affect the sector in the future and how resources and the economic environment impact on a specific project. They should make judgements on how risks can be mitigated through business planning methods. The report, booklet or presentation will be professionally written and structured, use correct economic terminology and be of a high quality.

For merit standard, learners will apply the effects of economic principles to a given sector of the construction industry and explain how it has responded to changes in the market. They will select and assess how relevant resources and the environment influence a given project. The report, booklet or presentation will be professional, logically structured, use appropriate economic terminology, and will be of a very good written quality, demonstrating that they fully comprehend the interaction of these economic theories on the construction industry.

For pass standard, learners will carry out research that allows them to explain the effect of economic principles on a given sector of the construction industry. They will show a good understanding of how resources and the economic environment influence a construction project. The report, booklet or presentation will be structured, use some economic terminology and will be of a good written quality.

Learning aims C and D

For distinction standard, learners will carry out detailed research on costs and the wider factors affecting the budget for a given construction project. They will evaluate how these can vary over the construction planning and development phases of a given construction project through the generation of comprehensive calculations. Learners must make qualified judgements to justify the feasibility of the proposed options for the given construction project based on cost and wider business analysis processes. The report and calculations will be professional, totally accurate and of a high quality, demonstrating a developed understanding of construction economics and financial processes.

For merit standard, learners will develop a detailed budget and feasibility study for a given construction project, considering the interaction of cost planning and management over the planning and construction phases. Learners will make recommendations based on their calculations, their review of budgeting techniques and their analysis of the factors influencing the project. The report will be of a very good professional standard, calculations will be mostly accurate and the submission will demonstrate a full comprehension of construction economics and financial processes, using appropriate terminology.

For pass standard, learners will produce a simple budget based on research and explain the variations that can occur during the project planning and construction phases. They will show an understanding that the feasibility of a project can change as costs and circumstances change. The report and calculations will be structured and of a good quality, containing some economic terminology, and will be generally accurate.

Links to other units

This unit links to:

- Unit 2: Construction Design
- Unit 5: Management of Commercial Risk
- Unit 11: Management of a Construction Project
- Unit 20: Quantity Surveying.

Employer involvement

This unit would benefit from employer involvement in the form of:

- guest speakers
- site visits
- input into unit assignment, case-study/project materials
- work experience
- business materials as exemplars
- support from local business staff as mentors.

Unit 23: Construction in Civil Engineering

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop designs for the substructures and superstructures in large-scale construction projects, for example roads, drainage and public facilities at railways, airports and harbours.

Unit introduction

The civil engineering industry covers the heavy side of construction and requires knowledge of the large plant and equipment used for earthworks and concreting operations. Civil engineers are involved in the construction of some of the world's largest and most iconic building and construction projects. These projects can include everything from the tallest skyscrapers, to the highest bridges and busiest airports. The expertise of civil engineers is needed all over the world, and they can expect to travel to the biggest international economic hubs to be involved in big and important projects.

In this unit, you will gain an understanding of the substructures and earthworks associated with civil engineering. You will learn how water is contained and controlled, and how the excavation of earth can form cuttings, trenches and deep excavations. The pouring of concrete and the formation of bridges, walls, foundations and other civil engineering structures is covered in terms of the plant and equipment used in construction. You will consider the building of superstructures and retaining walls in terms of the different structural frames and the methods used to retain earth at different levels.

This unit will support you to progress to a higher-level civil engineering programme such as the Higher National in Civil Engineering, or to a general construction or civil engineering degree. It also supports progression to the workplace as a technician, direct entry as a trainee designer with a civil engineering company or work as a trainee site engineer with a contractor.

Learning aims

In this unit you will:

A Understand the methods and techniques used to perform earthwork activities

B Develop a substructure design for a civil engineering project

C Develop a superstructure design and specification for a civil engineering project.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the methods and techniques used to perform earthwork activities	**A1** Earthwork activities **A2** Earthmoving and compaction equipment **A3** Concreting equipment **A4** Temporary works **A5** Dewatering operations **A6** Piling operations	A written evaluation of the methods that could be used in a large-scale excavation for a given scenario.
B Develop a substructure design for a civil engineering project	**B1** Foundations **B2** Design and drainage systems **B3** Utilities	A design for a civil engineering substructure, drainage system and utilities distribution for a given scenario.
C Develop a superstructure design and specification for a civil engineering project	**C1** Structural frames **C2** Retaining walls	A design for a civil engineering superstructure and a retaining structure for a given scenario.

Content

Learning aim A: Understand the methods and techniques used to perform earthwork activities

A1 Earthwork activities

Features and use of excavation methods to reduce ground levels down to formation levels for services, foundations and basements.

- Excavation methods and their advantages and disadvantages in installing substructures:
  - trench excavation:
    - trenching machines
    - tracked and wheeled excavators
    - 360 degree back-actor excavator
  - basement excavations:
    - trench method
    - open excavation
    - supported systems
  - formation of cuttings
  - formation of embankments
  - earthwork support:
    - diaphragm wall
    - trench boxes
    - traditional timber.

A2 Earthmoving and compaction equipment

Features of plant and equipment used in earth moving and compaction, and the advantages and disadvantages of each in terms of their use, time and cost.

- Excavation plant:
  - 360 degree tracked and wheeled excavators
  - tracked loader
  - towed scrapers
  - motorised scrapers.
- Earthmoving plant:
  - large dumpers
  - bulldozers
  - conveyor delivery systems
  - tipper trucks.
- Compaction plant:
  - graders
  - compactor rollers
  - sheep's foot rollers/tamping roller.

A3 Concreting equipment

Features and comparison of equipment that is used to transport, place and compact in-situ concrete into formwork.

- Concrete pumping:
  - static
  - boom.
- Rollover skip delivery.
- Conveyor belt delivery system.
- Compaction and vibration equipment:
  - poker vibrators
  - external shuttering compactors
  - beam screeders
  - vacuum dewatering.

A4 Temporary works

Features of temporary support systems and the advantages and disadvantages of each in terms of effectiveness.

- Support systems to excavations:
  - diaphragm walling
  - contiguous piling
  - bentonite slurry
  - trench sheets
  - propping systems
  - sheet piling
  - trench boxes.

A5 Dewatering operations

Features of equipment used to reduce the impact from groundwater on excavation works and their advantages and disadvantages.

- Sump pumping.
- Well points dewatering.
- Permanent exclusion:
  - diaphragm walling
  - filter drains.

A6 Piling operations

Types of piling operations to support foundations, retain earth and act as permanent dewatering, and their advantages and disadvantages.

- Interlocking sheet steel piling.
- Driven precast.
- Contiguous.
- Secant.
- Cut-off walls.

Learning aim B: Develop a substructure design for a civil engineering project

Design and construction of foundation types for commercial applications and their advantages and disadvantages.

B1 Foundations

The design and construction of the following types of foundation:

- piled and ground beam
- isolated pad
- pad supported on piles or pile cap
- raft foundations
- basements.

B2 Design of drainage systems

The design and use of drainage installations:

- installation of deep sewers
- pipework
- reinforced concrete culverts for stream and river containment, diversion and flood prevention.

B3 Utilities

Application of techniques used for the installation of water, electrical, gas and data services:

- infrastructure developments
- cable trenching
- deep sewer installation
- water discharge pipes
- service tunnels
- structured cable installation
- water wells and pumps.

Learning aim C: Develop a superstructure design and specification for a civil engineering project

C1 Structural frames

Design of steel and concrete-framed buildings, including connections between elements, and the advantages and disadvantages of each method.

- Steel frames:
  - universal columns
  - universal beams
  - pad and column connections
  - column and beam connections
  - wind-bracing
  - composite floor decks.

- Concrete frames:
  - columns
  - beams
  - pad and column connections
  - column and beam connections
  - floors
  - reinforcement
  - formwork requirements for columns, beams and floors.
- Composite construction:
  - integration of concrete and steel
  - combination of alternative materials and their detailing
  - slip form cores.

C2 Retaining walls

Design of retaining structures using a variety of methods, and the evaluation of their effectiveness over their life cycle, to include:

- gabions
- precast concrete systems
- in-situ reinforced concrete
- earth-retaining structures
- integral drainage to retaining structures
- revetment works to sloping walls.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the methods and techniques used to perform earthwork activities		**A.D1** Evaluate the excavation methods, earthwork support and dewatering systems required for large-scale excavations.
A.P1 Explain the methods and plant used for large excavations. **A.P2** Describe the earthwork support and dewatering systems required for large-scale excavations.	**A.M1** Compare the excavation methods, earthwork support and dewatering systems required for large-scale excavations.	
Learning aim B: Develop a substructure design for a civil engineering project		**B.D2** Evaluate the design for a foundation, drainage installation and utility provision for given ground conditions.
B.P3 Produce designs for civil engineering foundations for given ground conditions. **B.P4** Produce designs for civil engineering drainage and utilities for given ground conditions.	**B.M2** Justify the design produced for a foundation, drainage installation and utility provision for given ground conditions.	
Learning aim C: Develop a superstructure design and specification for a civil engineering project		**C.D3** Evaluate the specifications produced for the superstructure frame and a retaining structure against design parameters.
C.P5 Produce a specification for a superstructure frame that meets design parameters. **C.P6** Produce a drawing and specification for a retaining structure that meets design parameters.	**C.M3** Assess the specifications produced for the superstructure frame and a retaining structure against design parameters.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.P4, B.M2, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the excavation methods, earthwork support and dewatering systems required for large-scale excavations on civil engineering projects. They will consider a wide range of different options and methods, including the plant used in the overall task, and arrive at a supported conclusion. Learners will demonstrate a developed understanding of the methods used in civil engineering for performing earthwork activities.

For merit standard, learners will compare the excavation methods, earthwork support and dewatering systems required for large-scale excavations. They will consider a range of different options and methods, including the plant used in the overall task, and will provide some logical comparisons. Learners will demonstrate a good understanding of the methods used in civil engineering for performing earthwork activities.

For pass standard, learners will explain some of the methods and plant used for large-scale excavations. They will describe the earthwork support and dewatering systems required for large-scale excavations and explain why the different methods are appropriate for the given scenario. Learners will demonstrate a generic understanding of the methods used in civil engineering for performing earthwork activities.

Learning aim B

For distinction standard, learners will evaluate their designs for a foundation, drainage installation and utility provision for a given scenario and ground conditions. They will produce designs for civil engineering foundations, drainage systems and utility distribution. They will consider a range of different foundation methods, drainage systems and utility layouts, and arrive at a supported conclusion relating to the suitability of their designs. Learners will demonstrate a developed understanding of the methods used in civil engineering for foundation work, drainage and utility distribution.

For merit standard, learners will justify their designs produced for a foundation, drainage installation and utility provision for given ground conditions. Their justification will consider some different foundation methods, drainage systems and utility layouts to arrive at a justification relating to the suitability of their designs. Learners will demonstrate a good understanding of the methods used in civil engineering for foundation work, drainage and utility distribution.

For pass standard, learners will produce designs for civil engineering foundations, drainage and utilities distribution for given ground conditions. Learners will demonstrate a generic understanding of the methods used in civil engineering for foundation work, drainage and utility distribution.

Learning aim C

For distinction standard, learners will evaluate their specifications for a superstructure frame and a retaining structure against given design parameters. They will produce a drawing for a retaining structure that meets design parameters. They will consider a range of different frame options and retaining methods, arriving at a supported conclusion relating to the suitability of their specifications. Learners will demonstrate a developed understanding of the methods used in civil engineering for the construction of framed structures and retaining walls.

For merit standard, learners will assess their specifications produced for the superstructure frame and a retaining structure against design parameters. They will produce a drawing for a retaining structure that meets design parameters. They will consider a range of different frame options and retaining methods, and consider how the designs can meet the design parameters provided. Learners will demonstrate a good understanding of the methods used in civil engineering for the construction of framed structures and retaining walls.

For pass standard, learners will produce an appropriate specification for a superstructure frame that meets the design parameters and a drawing and specification for a retaining structure that meets the design parameters. Learners will demonstrate a generic understanding of the methods used in civil engineering for the construction of framed structures and retaining walls.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 4: Safe Working Practice
- Unit 6: Construction Mathematics
- Unit 7: Graphical Detailing
- Unit 13: Site Engineering for Construction
- Unit 35: Construction in Extreme Environments.

Employer involvement

This unit would benefit from employer involvement in the form of:

- site visits to observe heavy civil engineering equipment in operation
- a guest speaker in the form of a technical plant sales representative
- a guest speaker from a structural engineering design company
- employer case studies
- Institution of Civil Engineers (ICE) good practice seminars.

Unit 24: Conversion, Adaptation and Maintenance of Buildings

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners gain an understanding of how to adapt, convert and maintain buildings, and develop the skills for the processes involved.

Unit introduction

This unit focuses on existing properties and how to ensure their suitability for continued use, both now and for future generations. All countries have many existing properties that require ongoing maintenance, alterations, changes and upgrades.

In this unit, you will understand the reasons why buildings need to be converted or adapted and why maintenance is so important in the preservation of the fabric of a property. You will learn the processes involved, as well as the methods employed to develop a successful project, before applying these skills to your own design scheme.

This unit provides the essential knowledge and skills for all disciplines as it broadens construction knowledge. It particularly supports careers in building surveying, architecture and design, project management, property development and construction management. It also provides progression opportunities to higher education, including HND and degree programmes in construction-related disciplines.

Learning aims

In this unit you will:

A Examine the need for conversion and adaptation of a property

B Develop a maintenance plan for a property

C Develop a scheme design and specification for the conversion and adaptation of a property.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine the need for conversion and adaptation of a property	**A1** Conversion and adaptation **A2** Levels of intervention	A written report that considers the need for conversion and adaptation, looking at the options for and levels of intervention.
B Develop a maintenance plan for a property	**B1** Need for maintenance **B2** Maintenance approaches **B3** Levels of maintenance intervention and repair	A written report that considers the need for maintenance of a property, and the different options, to allow for the production of a maintenance plan for a specified property.
C Develop a scheme design and specification for the conversion and adaptation of a property	**C1** Process of conversion and adaptation **C2** Legislative requirements **C3** Options for conversion and adaptation **C4** Proposals for conversion and adaptation schemes	A written report, annotated drawings and specification for a conversion and adaptation project for a given scenario.

Content

Learning aim A: Examine the need for conversion and adaptation of a property

Why properties require conversion and adaptation, and the different levels of intervention and approaches available.

A1 Conversion and adaptation

Reasons why existing properties need to be adapted or converted.

- Old and dilapidated properties:
  - properties no longer fit for the intended purpose
  - lack of maintenance
  - historic properties not suitable for modern life
  - listed building status.
- For increased brownfield development:
  - government requirements
  - lack of available greenfield sites
  - pressure groups/public discontent with overdevelopment of greenfield sites
  - public image and the desire for sustainable development.
- Legislative changes.
- Preservation of the historic environment.
- Architectural trends and fashion changes.
- Building obsolescence:
  - technical
  - economic
  - social.
- Changes in societal needs:
  - ageing population
  - increase in need for single-person households
  - people living longer
  - cohabitation due to unaffordable properties
  - increased diversity.
- Financial:
  - maintaining property values
  - need for affordable housing
  - promoting urban regeneration.
- Technological advancements:
  - construction materials
  - smart buildings
  - electronic infrastructure advancements.
- Improving energy efficiency:
  - increased insulation
  - photovoltaic
  - solar panels
  - ground-source heat pumps
  - smart energy monitoring
  - building management systems.

- Increased human comfort requirements:
  - air conditioning
  - comfort cooling
  - efficient heating systems.

A2 Levels of intervention

Different levels of intervention and determination of when they would be suitable for adapting or converting a building.

- Preservation to halt the general deterioration in the fabric – general maintenance.
- Upgrade of a specific element or space, e.g. new roof, bathroom.
- Refurbishment of the whole property.
- Internal alterations, e.g. to alter the space internally, removing or adding walls etc.
- Retaining a facade and elevation, with a new building behind it.
- Extension to add more space.
- Restoration to put the property back into the original condition.

Learning aim B: Develop a maintenance plan for a property

B1 Need for maintenance

Consideration of the reasons why properties need ongoing maintenance to preserve their fabric and ensure their longevity.

- Material failure.
- Inappropriate specification, detailing and design.
- Poorly constructed.
- Climatic impact.
- Structural failure.
- Thermal movement.
- Lack of or inappropriate maintenance.
- Human impact.
- Regular cyclical requirements.

B2 Maintenance approaches

Maintenance approaches and their advantages and disadvantages in maintaining and extending the life of a property.

- Emergency (unplanned):
  - reactive to issues as they arise
  - often exacerbates ongoing issues
  - availability of appropriate resource(s).
- Planned:
  - regular maintenance to agreed timescales and relevant to specific materials and plant
  - asset management plans.
- Scheduled:
  - maintenance after a specified time/number of uses
  - maintenance schedules.
- Condition-based:
  - preventative at predetermined periods or intervals
  - legislative compliance inspections, e.g. compliance with fire regulations etc.

B3 Levels of maintenance intervention and repair

The scope, scale and resource requirements for intervention.

- Emergency repairs to stop the immediate problem and prevent further issues.
- Temporary or short repairs to stop or prevent problems.
- Targeted repairs.
- Planned/cyclical repairs.
- Renewal/replacement.

Learning aim C: Develop a scheme design and specification for the conversion and adaptation of a property

The methods for undertaking a conversion and adaptation project, detailing the processes and legislative consideration for a project.

C1 Process of conversion and adaptation

Process for undertaking a conversion and adaptation project.

- Initial need (strategic definition).
- Preparation and brief.
- Property inspection.
- Concept design.
- Detailed and technical design.
- Construction.
- Completion.
- Building use.

C2 Legislative requirements

Legislative requirements and their impact on a building conversion and adaptation project.

- Planning legislation in the host nation such as:
    - planning permission
    - listed building consent
    - specific planning permission for conservation areas
    - geographical sites and areas protected for their beauty and/or scientific interest.
- Building regulations in the host nation.
- Current health and safety legislation in the host nation.
- Property-related legislation in the host nation.

C3 Options for conversion and adaptation

Consideration of the options available for the conversion and adaptation of a property.

- Initial project brief, to include analysis and interpretation of the client requirements in relation to the property and feasibility.
- Structural alterations, to include internal alterations to remove or add walls, floors, doors, windows.
- Lateral adaptation, to include extensions to add space to the property.
- Vertical adaptation, to include loft conversions, additional storey, basement conversions.

C4 Proposals for conversion and adaptation schemes

Use of building survey reports and plans to determine the size and condition of a property to produce a conversion and adaptation scheme.

- Analysis and interpretation of plans, elevations and sectional details.
- Analysis and interpretation of building survey reports.
- Plans of the proposed scheme.
- Sections detailing the levels and all changes to be made.
- Specifications.
- Ongoing maintenance plans.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine the need for conversion and adaptation of a property		
A.P1 Explain why properties may need to be converted and adapted. **A.P2** Explain the intervention options for the conversion and adaptation of properties.	**A.M1** Discuss the reasons for intervention options for the conversion and adaptation of a given property.	**A.D1** Evaluate the needs and intervention options for the conversion and adaptation of a given property.
Learning aim B: Develop a maintenance plan for a property		
B.P3 Explain how the different approaches to maintenance can preserve and extend the life of properties. **B.P4** Describe the different levels of maintenance intervention. **B.P5** Produce a maintenance plan for a given property.	**B.M2** Assess how the different approaches to and levels of maintenance can preserve and extend the life of a given property. **B.M3** Produce a detailed maintenance plan for a given property.	**B.D2** Evaluate the maintenance requirements and the maintenance plan, and their impact in preserving and extending the life of a given property.
Learning aim C: Develop a scheme design and specification for the conversion and adaptation of a property		
C.P6 Explain the legislative requirements for a conversion and adaptation of buildings. **C.P7** Compare the design options for conversion and adaptation of a given property. **C.P8** Produce an outline scheme design and specification for the conversion and adaptation of a given property.	**C.M4** Produce a detailed scheme design and outline specification that meets legislative requirements for the conversion and adaptation of a given property.	**C.D3** Justify the proposed scheme design and specification, ensuring that it meets legislative requirements for a conversion and adaptation project of a given property.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.P4, B.P5, B.M2, B.M3, B.D2)

Learning aim: C (C.P6, C.P7, C.P8, C.M4, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- a range of resources, including appropriate books, internet resources, industry exemplars and example projects
- blank copies of drawings (on which learners can express their ideas)
- the built environment for exploration purposes: to analyse existing conversion and adaptation schemes in the locality, as this will enhance an understanding of options and how buildings can change to suit new demands.

There is a requirement for drawing in the unit but there is no expectation that this will be formal technical drafting: accurately scaled and annotated sketches are acceptable.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the specific needs of a given property. They will consider its suitability for conversion and adaptation, discussing the various options and levels of intervention, and concluding with a coherent, reasoned discussion on the most appropriate option for that property. The evaluation must be detailed and the analysis of the options, and the reasons for non-selection, must be justified. Learners must demonstrate a thorough understanding of the options and possibilities – a broad-brush approach is not acceptable at this level. To achieve this standard, learners must produce a detailed, referenced, annotated report.

For merit standard, learners will link their discussion to a particular property and will consider all options. However they will also have a specific focus on the suitability of the options discussed for a particular property. Learners must show a broad understanding of all the options, and take this broad narrative and apply it to a particular scenario.

For pass standard, learners will produce a wide-ranging narrative on the reasons why properties need to be converted and adapted. The discussion may not focus on any specific project and will consider a wide range of reasons, levels of intervention and the different options available. This does not need to be specific to a particular building, or link to the reasons given for the need to convert or adapt. Learners must produce a well-researched and wide-ranging consideration of the options.

Learning aim B

For distinction standard, learners will develop the discussion to include an evaluative discussion as to how and why the maintenance plan they have produced will preserve and extend the life of a given property. They will be specific to the given property and demonstrate a detailed understanding of how their specified interventions will benefit all aspects of the building. The discussion must include the relative merits of each intervention and state specifically how each one will prolong the life of the building.

For merit standard, learners will apply their discussion to the given property. They will consider all of the available options in relation to this property, assessing why they may or may not be applicable to that particular situation. In addition to the detailed and applied narrative, learners will produce a detailed maintenance plan, considering all of the options and requirements for the property, such as maintenance requirements, cyclical requirements (dates) and the different levels of intervention at each inspection. For example, it may be appropriate to inspect a roof annually from the ground, but perhaps every three years it may be more appropriate to inspect it at close quarters from a scaffold or mobile elevating work platform (MEWP).

For pass standard, learners will produce a broad explanation of the different options, methods and approaches to maintenance, culminating in a basic maintenance plan for a given property. The explanation must be detailed but it may cover a wide range of issues without specifically focusing on any one building. The maintenance plan should focus on a particular building to give learners some direction as to what to include. The plan will be sufficiently detailed to enable it to be a useful document for a typical domestic property, and will contain the works required and the dates these works would be expected to be carried out. The format is not as important as the actual content. Learners must demonstrate an understanding of the need for a plan and how it would be used in a given scenario.

Learning aim C

For distinction standard, learners will fully justify their final design solution. They will take into account all the design options and provide a detailed narrative of the relative merits and demerits of each. They will assess the impact of legislation on their thinking and conclude with a detailed analysis of their final design solution, explaining why they felt it most appropriate for the given property.

For merit standard, learners will provide an appropriate level of detail in their initial proposals, showing a deep understanding of the design process and the options available for selection of materials. Their drawings and specification will contain appropriate detail and provide a thorough understanding of the scheme and the materials used to construct it. There is no requirement to produce original drawings and learners can put specification notes onto the drawings. However, to provide sufficient evidence to demonstrate merit-level understanding, learners will produce a detailed specification of work items and a range of drawings.

For pass standard, learners will consider different design options for a given project. They must be given plans and a brief of sufficient size and scope to allow them to develop a range of design ideas and solutions, as well as legislative requirements (a small domestic extension may not provide sufficient scope). Learners will explore different options (at least three) and discuss the legislative impact, and the implications, for each design. There is no expectation that learners should produce their own plans – drawing on or tracing originals is acceptable – and there is no requirement to draw office equipment. Once learners have decided on their final proposal, they will produce a number of drawings and a specification to communicate their ideas. They do not have to produce their own drawings, and the specification can be in the form of notes on the drawing, as long as there is sufficient clarity and detail to allow the reader to be able to ascertain exactly what the final design will look like. Learners will produce plans, elevations and sections to support the specification (which must contain sufficient information to convey a clear understanding of the process). For example; if a lintel is to be inserted to form a new opening, learners are not required to produce design calculations, but would be expected to state the type, style and material, e.g. 'a new steel box lintel with minimum 200 mm bearing inserted to form a new opening' and not 'a new lintel over the opening'.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 12: Building Surveying in Construction
- Unit 21: Building Services Science

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 25: Building Services Control Systems

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of the purpose and function of building services control systems, and the operational characteristics of control components and devices.

Unit introduction

In recent years, the need for automatic control systems for use in buildings has increased significantly. The pressure to reduce energy costs and to reduce the associated environmental impact, coupled with advances in technology, has resulted in the development of sophisticated systems that can monitor and optimise plant performance to meet building and environmental requirements and legislation.

In this unit, you will investigate the development of building services control systems. This begins with an understanding of the associated principles for control systems. You will then learn about the design requirements for a control system, including the design and layout and the selection of suitable control sensors, actuators, control devices and controllers.

Control system installations are an essential feature of any building, and as such this unit gives you a valuable insight into the types of control systems. This unit will give you a good foundation for studying construction related subjects at a higher level, including degree level programmes. This unit will also help you to progress to employment supporting a site manager or quantity surveyor.

Learning aims

In this unit you will:

A Understand the principles associated with building services control systems

B Apply the principles of building services control systems and the function and operational characteristics of control systems

C Develop an appropriate specification and schematic drawings for building services control systems.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the principles associated with building services control systems	**A1** Control loops **A2** Modes of control **A3** Operational features **A4** Purpose of control systems	Analyse a client brief in terms of the modes of control and operational features.
B Apply the principles of building services control systems and the function and operational characteristics of control systems	**B1** Generic functions **B2** Safety controls and functions of safety control systems **B3** Operational characteristics of control devices and components **B4** The role of the computer technology in control systems	Develop a control system for a scenario, from a set of criteria. As part of the solution, produce a specification for all elements of the installation.
C Develop an appropriate specification and schematic drawings for building services control systems	**C1** Control functions **C2** Control strategies **C3** Drawings	

Content

Learning aim A: Understand the principles associated with building services control systems

The working principles of control systems to provide effective control of the internal environment of the building, providing appropriate comfort levels to the end user.

A1 Control loops

How control loops are used in control systems, the benefits and drawbacks of each type, including how inputs, decisions and outputs interrelate.

- Open loop.
- Closed loop.
- Single loop.
- Multi loop.

A2 Modes of control

Main modes of control and their uses, including the advantages and drawbacks for a range of situations.

- Two position.
- Proportional.
- Integral.
- Derivative.
- Proportional-integral (PI).
- Proportional-integral-derivative (PID).

A3 Operational features

The performance of control systems in terms of speed, accuracy and reliability, for different construction scenarios.

- Lag.
- Transport and transfer lag:
    - causes
    - effects
    - methods of reduction.
- Stability and accuracy.
- Causes and effects.

A4 Purpose of control systems

The use and benefits provided by building services control systems for building users and other stakeholders.

- How building services are controlled and impact on the stakeholder's comfort and use of the building.
- Consequences of poor control.
- Effects for the building owner and environment.
- Legislative requirements relevant to the local vernacular.

Learning aim B: Apply the principles of building services control systems and the function and operational characteristics of control systems

The purpose of control systems, their operational characteristics and the effects of poor control systems on the environment.

B1 Generic functions

Functions of building services control and how they are controlled with the use of automated systems.

- Functions of heating and ventilation control systems:
  - temperature
  - humidity
  - air quality
  - air flow
  - time
  - contamination/pollution
  - pressure
  - weather compensation
  - night set-back
  - zone control
  - system frost protection
  - fabric protection
  - pump exercising
  - plant sequencing.
- Functions of lighting control systems:
  - lighting levels
  - time
  - contamination/pollution
  - zone control.

B2 Safety controls and functions of safety control systems

Use of control systems to protect the building users and stakeholders from potential accidents and health issues.

- Flame failure.
- Combustion.
- Pressure relief.
- Leak detection.
- High and low warning.
- Fire and smoke.
- Carbon monoxide.

B3 Operational characteristics of control devices and components

The use of various control devices and components, including smart technology integration of sensors and control devices.

- Sensors that are linked to control systems, including their purpose, use and benefits provided:
  - temperature
  - humidity

  - flow
  - velocity
  - pressure
  - level
  - air quality
  - rotational speed
  - gas detection
  - flame
  - smoke
  - light
  - presence
  - thermal radiation.
- Actuators that are linked to control systems, including their purpose and use:
  - linear
  - rotary
  - types of power
  - drive and positional feedback.
- Control devices, including their purpose, use and benefits provided:
  - control valves, to include types, operation, associated problems
  - control valve characteristics
  - valve authority
  - applications
  - control dampers, to include types, blade action, construction, operation
  - inherent and installed characteristics
  - damper authority
  - mixing
  - other control devices, including dimmers, variable speed fans, pumps, compressors.
- Controllers, including their purpose, use and benefits provided:
  - control signal media, to include mechanical, electrical, pneumatic, hydraulic
  - analogue to digital conversion.
- Direct acting controls:
  - thermostatic radiator valves (TRVs)
  - float valves
  - thermostatic expansion valves
  - pressure relief valves
  - flame failure valves
  - thermostatic shower mixer valves
  - thermostatic hot water valves.

B4 The role of the computer technology in control systems

The role of the microprocessor and software in control systems and the use of Building Information Modelling (BIM) to produce effective and efficient building services control.

- Simple automatic.
- Direct digital control.
- Building management system.
- Integrated control systems.

- How the strategy can be improved/informed by BIM tools:
  - techniques at the control system design and specification stage
  - BIM collaboration, e.g. working with other trades to improve the project planning and efficiency in installation
  - using software to bring together models on one system
  - checking for conflicts and clashes between models using appropriate and available software
  - BIM analysis tools, e.g. IES, Autodesk internal environmental tools
  - BIM parametric design, e.g. floor-to-floor heights, structural integrity or solar gain within software to trial and test techniques before they are used using appropriate and available software.

Learning aim C: Develop an appropriate specification and schematic drawings for building services control systems

The selection of control functions, whether essential or desirable, for installations, systems and items of plant. Use of technology to manage natural resources as much as possible in heating and ventilation design.

C1 Control functions

- Desirable and essential functions for installations.
- Systems and items of plant.

C2 Control strategies

- Automatic or direct digital control strategies for building services installations and plant:
  - low pressure hot water heating systems and boiler plant
  - central ventilation
  - warm air heating
  - air-conditioning systems
  - air-handling units
  - domestic hot water installations
  - calorifiers and hot water generators
  - chilled water installations and refrigeration plant
  - package air-conditioning systems.
- Location of sensors to achieve required control functions.
- Sequence of events and scenarios.
- Functions of various sensors.
- Selection of appropriate sensor points.
- Deadbands.

C3 Drawings

- Schematic control drawings and sketches.
- Requirement to communicate detailed designs of control systems.
- Use of drawing symbols and annotation.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the principles associated with building services control systems		**A.D1** Justify the selection of a building services control system, its components and all of its operational features, for a given scenario.
A.P1 Explain the selection of a building service control system, its components and some of its operational features, for a given scenario.	**A.M1** Assess the selection of a building services control system, its components and most of its operational features, for a given scenario.	
Learning aim B: Apply the principles of building services control systems and the function and operational characteristics of control systems		**B.D2** Produce a comprehensive system design that fully meets the requirements of a building services control system, for a given scenario.
B.P2 Produce a systems diagram for a simple building services control system. **B.P3** Describe the sensors, actuators and controllers to be installed for a simple building services control system, for a given scenario.	**B.M2** Produce a detailed control system design that mostly meets the requirements of the building services control system.	
Learning aim C: Develop an appropriate specification and schematic drawings for building services control systems		**C.D3** Justify the selection of an appropriate building services control system and control components, including details of the control strategy and schematic drawings which clearly communicate the designs, for a given scenario.
C.P4 Select an appropriate building services control system for a given scenario. **C.P5** Select the appropriate control components for use within a building services control system, for a given scenario. **C.P6** Explain the behaviour of the controls selected for a simple building services control system, for a given scenario.	**C.M3** Select an appropriate building services control system and control components, including detailed control strategy and detailed schematic drawings, for a given scenario.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aims: B and C (B.P2, B.P3, C.P4, C.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners must consider a building services control system and identify all the control components and their operational features. Their work will be accompanied by justified reasons for system use that fully substantiate the findings. The evaluation should justify why the sensors, actuators, control devices and controllers were selected. In evaluating the system, learners will draw on their experience and knowledge of the factors to consider in the design of any building services control system.

For merit standard, learners must consider a building services control system and identify all the control components and their operational features. Their work will be accompanied by reasons to support the findings, relating to the appropriateness of the system. The analysis should explain why the sensors, actuators, control devices and controllers were selected. In analysing the system, learners will draw on their experience and knowledge of the factors to consider in the design of any building services control system.

For pass standard, learners must consider a building services control system and identify most of the components, explaining some of their operational features. This explanation will be accompanied by reasons to support the findings, relating to the suitability of the system. The explanation should include information about the sensors, actuators, control devices and controllers used. In explaining the system, learners will demonstrate that they comprehend the factors that need to be considered in the design of any building services control system.

Learning aims B and C

For distinction standard, learners will produce a comprehensive report that is detailed in its compilation and contains full manufacturer details and drawings, produced to a professional standard, for a given scenario. The selection of all sensors, actuators, control devices and controllers, including diagrams, needs to be evaluated. In their evaluation, learners will draw on their knowledge of control systems in order to consider the relevance and significance of key aspects for their design, and the benefits and drawbacks to the design of the building services control system for the given scenario.

For merit standard, learners will produce a design report that is detailed in its compilation and contains full manufacturer details, including justification of the control components for a system for the given scenario. Learners will draw on their knowledge of the design of control systems to prove that key aspects of their designs are correct for the given scenario.

For pass standard, learners must produce a diagram for a control system for a given scenario. This should include control components. Descriptions will be supported with diagrammatic illustrations of the system and components, and manufacturer's details, including all key elements. Learners must assess the operational function of the components using the manufacturer's published information. The control components must be selected to meet the design requirements.

Links to other units

This unit links to:

- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 26: Heating, Ventilation and Air Conditioning Design
- Unit 27: Plumbing and Fluid Behaviour in Building Services Engineering
- Unit 28: Electrical Principles and Electrical Installation Standards in Building Services Engineering.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 26: Heating, Ventilation and Air Conditioning Design

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of ventilation and air-conditioning design and installations in modern buildings.

Unit introduction

Ventilation has long been recognised as promoting healthy living. Today, ventilation and air-conditioning systems are viewed as integral parts of building design and management. Buildings are more airtight to conform to legislation, which requires them to be clean, comfortable and fresh, healthy environments in which to live and work.

In this unit, you will investigate the development of ventilation, ducted warm-air heating and air-conditioning installations. This begins with an understanding of the associated principles for ventilation and air-conditioning systems. This is followed with the design requirements for ducting and ancillary components and continues through to the layout of an air-handling plant or unit.

Ventilation and air-conditioning installations are an essential feature of any building, and as such this unit provides you with a valuable insight into the types of systems. This unit will give you a good foundation for studying construction related subjects at a higher level, including degree level programmes. This unit will also help you to progress to employment supporting a site manager or quantity surveyor.

Learning aims

In this unit you will:

A Understand the operational characteristics of ventilation and air-conditioning requirements for buildings

B Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings

C Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the operational characteristics of ventilation and air-conditioning requirements for buildings	**A1** Air-terminal devices **A2** Ductwork, jointing and systems **A3** Air-handling units	Analyse a brief in terms of the components used and their operational features.
B Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings	**B1** Requirements **B2** Design conditions **B3** Ventilation systems	Develop a ventilation and air-conditioning system for a scenario, from a set of criteria. Produce a ventilation and air-conditioning strategy and schematic drawings.
C Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment	**C1** Air flow rates and supply conditions **C2** Air-terminal devices **C3** Ductwork and fans **C4** Air-conditioning plant	

Content

Learning aim A: Understand the operational characteristics of ventilation and air-conditioning requirements for buildings

The consideration and selection of appropriate ventilation and air-conditioning plant, equipment and materials.

A1 Air-terminal devices

The use of air-terminal devices to control the flow of air to ensure a comfortable environment for building users and stakeholders.

- Installation requirements and application of supply and extract air-terminal devices:
  - characteristics
  - terminology
  - operational features
  - materials.
- Control of air quality and direction of air discharge in supply and extract devices:
  - operational features
  - installation requirements
  - materials
  - suction dynamics, to include booths, canopies, hoods and other extraction devices used in commercial kitchens and industrial applications, to include grease filters, grease removal and fire prevention in kitchen canopies.

A2 Ductwork, jointing and systems

The characteristics and selection of appropriate ductwork materials and related service components.

- Ductwork shapes and materials used for heating, ventilation and air-conditioning (HVAC) systems.
- Support systems.
- Characteristics and features of jointing:
  - assembly
  - installation procedures.
- Relationship between physical properties of ductwork materials and their application.
- Flexible and fire-rated ductwork.
- Criteria for selection of materials and shape.
- Published standards and specifications for ductwork relevant to respective National standards.
- Ancillary components:
  - characteristics
  - operational features and selection criteria of various types of ductwork items, to include volume-control dampers, fire and smoke dampers, access doors, flexible connectors, test points.

A3 Air-handling units

The different elements of air-handling units and plant, including reasons for their use, and the benefits that they provide for the building users and stakeholders.

- Air-handling plant:
  - types of fan, to include characteristics, operational features and applications of fans, types of drive
  - installation requirements and ductwork connections.
- Heater/cooler batteries:
  - types, material characteristics, operational features and applications of heater batteries
  - chilled water and direct expansion (DX) cooling coils, to include installation requirements and ductwork connections.
- Heat-recovery devices:
  - types of heat-recovery device
  - characteristics, operational features and application of heat-recovery devices, to include installation requirements and ductwork connections.
- Air-cleaning devices:
  - terminology and definitions associated with filters and air-cleaning devices
  - group and class of filters
  - filter testing methods
  - type, characteristics, operational features and applications of filters and dust collection/removal devices for air-handling systems, to include installation requirements and ductwork connections.
- Humidifiers:
  - types of humidifier
  - characteristics, operational features and applications of humidifiers, to include installation requirements and ductwork connections
  - water supply
  - maintenance
  - health and safety implications of humidifiers.
- Refrigeration plant:
  - principles, components and application of vapour-compression refrigeration systems
  - application of refrigeration in air-conditioning systems
  - operation, features and applications of heat pumps.
- Air-handling units:
  - configuration and features of simple units, to include composite air-handling units (AHUs), local exhaust ventilation systems, dust collection, packaged air-conditioning systems
  - control requirement and arrangements for ventilation and warm-air handling installations.

Learning aim B: Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings

The consideration of appropriate systems for heating and cooling that support the needs of the user and building.

B1 Requirements

Key considerations when designing heating, ventilation and air-conditioning systems.

- Reasons for providing ventilation.
- Client, user and environmental requirements and considerations.
- Health and safety and other statutory requirements relevant to respective National standards.
- Identification of locations with specific ventilation requirements and conditions.
- Sources of heat gain to buildings.
- Identification of locations requiring air conditioning.
- Advantages and disadvantages of warm-air heating as an alternative to low temperature hot water (LTHW) and other heating distribution media.
- Identifying zones and locations suitable for warm-air heating.
- Establishing performance requirements for proposed installations.

B2 Design conditions

Performance requirements to consider when designing heating, ventilation and air-conditioning systems to meet the needs of and provide comfort for building users and stakeholders.

- Methods of specifying ventilation rates.
- Selection of ventilation rates for specific locations.
- Occupational exposure limits (OEL) for single specific contaminants.
- Workplace exposure limits (WEL) for single specific contaminants.
- Maximum exposure limits (MEL) for single specific contaminants.
- Selection of internal and external design conditions for warm-air heated and air-conditioned rooms.
- Impact of room velocity and temperature on comfort.
- Estimation of heat gains and cooling loads using tabulated data and established ‘rules of thumb’.

B3 Ventilation systems

Types of ventilation systems, methodologies and their use, including benefits and drawbacks.

- Operating principles.
- Applications of key performance characteristics of natural ventilation and passive stack ventilation.
- Mechanical ventilation.
- Comfort cooling/warm-air heating/air-conditioning and mixed-mode ventilation systems.
- Energy and environmental implications of ventilation and air-conditioning installations.
- Energy implications of alternative systems.

- Selecting ventilation and air-conditioning strategies.
- Local exhaust ventilation (LEV).

Learning aim C: Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment

The consideration of relative flow rates and associated components, ducting, fans and plant.

C1 Air flow rates and supply conditions

The design and determination of appropriate air flow within heating, ventilation and air-conditioning systems to ensure efficient, effective and safe air supply for building users and stakeholders.

- Calculations of air flow rates for mechanical supply and extract ventilation systems.
- Supply air conditions:
  - mass and volumetric flow rates to maintain room conditions for warm-air heating and single-zone air-conditioning application.
- Plotting summer and winter psychrometric cycles for simple air-conditioning applications.
- Balance between fresh air and thermal requirements in warm-air heating and air-conditioning installations.
- Determining re-circulation rates.
- Layout of supply air devices to achieve good air distribution.
- Location of extract devices for effective operation.
- Relationship between supply and extract devices in balanced supply and extract systems.
- Design of simple local exhaust ventilation and other industrial/commercial ventilation.
- Warm-air heating and air-conditioning installations.
- Criteria and methods for zoning installations.

C2 Air-terminal devices

The selection and specifications of air-terminal devices to meet the performance requirements of the system.

- Selection of supply air-terminal devices and booths, canopy hoods and other extract devices, using manufacturers' information to suit specification requirements.
- Throw, resistance and noise characteristics.
- Production of air-terminal device specifications and schedules.

C3 Ductwork and fans

The design and specification of ductwork and fans, to meet the performance requirements of the system and provide comfort for the building users and stakeholders.

- Selection and parameters for ductwork design.
- Use of manual calculations and computer software to determine duct sizes by use of constant pressure drop and/or constant velocity methods, total static and velocity pressure in ductwork.

- Total resistance of index circuits.
- Methods of producing balanced systems and absorbing excess pressure at branches.
- Establishing commissioning data for ductwork distribution networks.
- Applications of fans:
  - applications of margins
  - determining fan capacity
  - selection of fans from manufacturers' data
  - efficiency and operational features
  - production of fan schedules
  - establishing commissioning data.
- Ductwork systems and arrangements for comfort/process ventilation.
- Features of good ductwork.
- Prevention of noise problems.
- Accommodation of ductwork within buildings.
- Ductwork supports.
- Use of ductwork design and installation standards and codes.
- Provision for maintenance and testing ductwork.

C4 Air-conditioning plant

The provision and specification of air conditioning in plant, to meet the cooling and thermal demands required to provide comfort for building users and stakeholders at extremes of temperature.

- Space requirements.
- Types of accommodation for air-handling devices.
- Refrigeration/chiller plant and fans.
- Location of air intake and discharge points.
- Structural and building work requirements to accommodate air-handling plant and ductwork.
- Use of psychrometric cycles to determine cooler coil, heater battery, frost coil and humidifier duties.
- Selection of plant and components from manufacturers' data.
- Production of plant specifications and schedules.
- Provision for maintenance and commissioning:
  - reasons for commissioning duct networks
  - location of flow-regulation devices.
- Design drawings:
  - communication of detailed drawings
  - use of drawing symbols and annotation
  - production of appropriate drawings and sketches.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the operational characteristics of ventilation and air-conditioning requirements for buildings		**A.D1** Justify the ventilation and air-conditioning system, including all the component parts and their respective operational features.
A.P1 Explain the operational characteristics of the ventilation and air-conditioning system.	**A.M1** Assess the elements of the ventilation and air-conditioning system.	
Learning aim B: Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings		**B.D2** Produce a comprehensive design for a detailed ventilation and air-conditioning system that fully meets the requirements of the scenario.
B.P2 Produce a systems diagram for a basic air-conditioning and ventilation system. **B.P3** Assess the system to be installed in terms of ductwork, jointing and related ancillary components for a simple single-zone installation. **B.P4** Assess the air flow rates and supply conditions.	**B.M2** Produce a design for a detailed ventilation and air-conditioning system that mostly meets the requirements of the scenario.	
Learning aim C: Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment		**C.D3** Evaluate the selection of an appropriate ventilation and air-conditioning system and components, including details of the strategy and schematic drawings for the given scenario.
C.P5 Select an appropriate ventilation and air-conditioning system for use in a given scenario. **C.P6** Select appropriate ductwork, plant and equipment for use within a given scenario.	**C.M3** Justify the selection of an appropriate ventilation and air-conditioning system that meets most of the needs of the given scenario.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.

The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aims: B and C (B.P2, B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners must consider the features, benefits and drawbacks of a ventilation and air-conditioning system, including the identification of all the individual components and their operational features. The justification will be accompanied by specific reasons that fully substantiate the findings. The evaluation should also justify why the plant and equipment was selected. In evaluating the system, learners will draw on their experience and knowledge of the factors to consider in the design of any ventilation and air-conditioning system.

For merit standard, learners must consider a ventilation and air-conditioning system and analyse all the individual components and their operational features. The analysis will be accompanied by reasons to support the findings. The analysis should also explain why the plant and equipment was selected. In analysing the system, learners will draw on their experience and knowledge of the factors to consider in the design of any ventilation and air-conditioning system.

For pass standard, learners must consider a ventilation and air-conditioning system and identify most of the components, including an explanation of some of their operational features. This explanation will be accompanied by reasons that support the findings. The explanation should also include information about the plant and equipment used. In explaining the system, learners will demonstrate that they comprehend the factors that need to be considered in the design of any ventilation and air-conditioning system.

Learning aims B and C

For distinction standard, learners will produce a comprehensive report that is detailed in its compilation and contains full manufacturer's details and drawings, produced to a professional standard, for a given scenario. The selection of air-terminal devices, ducting and associated ancillary components, including diagrams, needs to be evaluated. In their evaluation, learners will draw on their knowledge of ventilation and air-conditioning systems in order to consider the relevance and significance of key aspects for their design, and the benefits and drawbacks of the design of the ventilation and air-conditioning system for the given scenario.

For merit standard, learners will produce a design report that is detailed in its compilation and contains full manufacturer's details, including the air-terminal devices, ducting and associated ancillary components for the given scenario. Learners will draw on their knowledge of the design of ventilation and air-conditioning systems to prove that key aspects of their designs are correct for the given scenario.

For pass standard, learners must produce a diagram for a ventilation and air-conditioning system for a given scenario. This should include some of the required components. Descriptions will be supported with diagrammatic illustrations of the system, components and manufacturer's details, including all key elements. Learners must assess the operational function of the components using the manufacturer's published information. The components must be selected to meet the design requirements.

Links to other units

This unit links to:

- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 15: Measurement Techniques in Construction
- Unit 20: Quantity Surveying
- Unit 21: Building Services Science
- Unit 25: Building Services Control Systems
- Unit 27: Plumbing and Fluid Behaviour in Building Services Engineering.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 27: Plumbing and Fluid Behaviour in Building Services Engineering

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of the properties and behaviour of fluids, both at rest and when flowing through pipe and ductwork, and the design of fluid flow systems.

Unit introduction

Water has been used for thousands of years to power systems, from waterwheels to the pressurised systems used to produce steam for driving turbines. To be able to put fluids to good use, it is necessary to control their flow under various conditions. An understanding of the properties and behaviour of fluids is fundamental to the successful design of services installations.

In this unit, you will investigate building services systems. You will begin by understanding the principles associated with the behaviour of fluids and their physical properties. This will be followed with the principles of dynamic fluid flow in pipes and ducts, and continues through to the selection of suitable pumps, fans and compressors.

Fluid system installations are an essential feature of any building and this unit gives you a valuable insight into the types of systems available and how appropriate they are for use in a modern building. The unit will give you a good foundation for studying construction-related subjects at a higher level, including degree-level programmes. The unit will also help you to progress to employment where you support a site manager or a quantity surveyor.

Learning aims

In this unit, you will:

A Understand the properties, behaviour of water and how it is sourced, cleansed to the required standards and distributed

B Undertake the design of plumbing and above-ground drainage installation for a property

C Develop and apply the principles of dynamic fluid flow in pipes and ducts

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the properties, behaviour of water and how it is sourced, cleansed to the required standards and distributed	**A1** Physical properties and behaviour of water **A2** Sources of cold water **A3** Cleansing process **A4** Standards **A5** Distribution	Analyse a client brief in terms of current regulations and requirements.
B Undertake the design of plumbing and above-ground drainage installation for a property	**B1** Appliances and components **B2** Materials and components **B3** Hot and cold water systems **B4** Types of drainage **B5** Drainage systems, materials and testing	Develop a system for a domestic installation from a set of criteria and produce a specification for all the elements of the installation.
C Develop and apply the principles of dynamic fluid flow in pipes and ducts	**C1** Dynamic fluid flow **C2** Pipes and ductwork **C3** Energy loss **C4** Losses in pipes and ductwork	

Content

Learning aim A: Understand the properties, behaviour of water and how it is sourced, cleansed to the required standards and distributed

A1 Physical properties and behaviour of water

The general definitions and associated units and notation when considering the physical properties and behaviour of fluids.

- Ideal fluids.
- Real fluids.
- Viscosity.
- Flow:
  - uniform
  - non-uniform
  - steady
  - unsteady
  - laminar
  - turbulent.
- Boundary layers.
- Variation of density with temperature.
- Pressure.
- Units of pressure.
- Measurement of pressure:
  - absolute
  - atmospheric
  - gauge.
- The behaviour of fluids in building services systems:
  - static
  - flowing
  - fluid flow behaviour
  - use of the Reynolds number to predict flow type.

A2 Sources of cold water

The source, types and quality of cold water supplied to buildings.

- Water cycle.
- Sources of water:
  - reservoirs
  - lakes
  - shallow and deep wells
  - boreholes
  - artisan wells
  - springs.
- Types of water:
  - soft
  - hard.
- Effects of soft and hard water on plumbing systems.

A3 Cleansing process

The methods of cleansing water before it is deemed clean and fit to drink.

- Levels and types of water filters.
- Filtration medium used.
- Addition of chemicals to water supplies.
- Cleansing and filtering of private water supplies.

A4 Standards

The standards that must be met before water is deemed safe and clean to drink.

- World Health Organization (WHO) standards.
- Supply of water regulations, to include the Water Supply (Water Fittings) Regulations 1999, relevant to the local vernacular.
- Effects of contaminated water supplies on an area.

A5 Distribution

How water is distributed in appropriate quantities and pressures, for use by consumers.

- Mains supply.
- Service pipes.
- Communication and supply pipes.
- Applicable water regulations.
- Responsibility of water supplier and householder.
- Water pressure:
  - static head requirements
  - means of achieving appropriate pressure.
- Flow rates to meet demand:
  - supply pipe sizing
  - size reduction to meet demand.

Learning aim B: Undertake the design of plumbing and above-ground drainage installation for a property

Consideration of the supply of hot and cold water, gas and associated drainage systems requirements to be safely met according to current regulations.

B1 Appliances and components

The selection of appropriate appliances and components to meet the needs of building users and stakeholders.

- Connections for various appliances, depending on pressure, temperature and water-supply requirements:
  - washbasins
  - WCs
  - baths
  - bidets
  - shower valve arrangements
  - sinks
  - washing machines
  - dishwashers
  - fridges with water and ice dispensers
  - water boilers.

- Requirements for, and means of, temperature control on showers and sanitary appliances.
- Luxury and lifestyle appliances:
  - spas
  - hot tubs
  - steam rooms
  - whirlpool baths
  - pumped shower variations.
- Production of sanitary schedules, including ancillary components:
  - handles
  - brackets
  - fixings
  - sealants
  - decor
  - mounting panels
  - wall board
  - seats.
- Characteristics and operational features:
  - stopcocks
  - isolation points
  - drain-off valves.
- Filters.
- Water conditioners.
- Devices to prevent excessive urinal flushing.
- Water-minimisation fittings and devices.

B2 Materials and components

Materials and components used in pipework systems, methods of fixing and their appropriate use.

- Copper tube.
- Capillary fittings.
- Compression fittings.
- Push-fit fittings.
- Crimped fittings.
- Brazed fittings.
- Galvanised low-carbon steel (threaded and compression).
- Polyethylene and other acceptable plastic pipes.
- Fusion and solvent welding.

B3 Hot and cold water systems

The various systems that can be employed for hot and cold water systems, and their benefits and drawbacks for building users and stakeholders.

- Direct and indirect systems for cold water.
- Instantaneous single- and multi-point water heaters.
- Atmospheric direct and indirect hot water storage vessels.
- Methods of heating hot water.
- Maximising energy efficiency in hot water generation, to include integration with green/renewable technology, e.g. solar PV systems, tankless hot water heating.
- Systems and methods for distribution of domestic hot water for single dwellings.
- Use of mains pressure, unvented domestic hot water systems in accordance with current building regulations relevant to the local vernacular.
- Prevention of bacterial growth (legionella) within systems.
- Using information from Building Information Modelling (BIM) tools in the specification of techniques and how this can enhance plumbing system design and specification:
  - BIM collaboration tools to avoid conflicts and clashes with other trades, to include using analysis in modelling
  - BIM parametric design, to include defining set rules, e.g. floor to floor heights, structural integrity or solar gain within software to trial and test techniques before they are used.

B4 Types of drainage

The different types of drainage systems above ground, used to ensure efficient and effective removal of effluent, waste water and surface water from the building, incorporating appropriate ventilation.

- One-pipe method.
- Two-pipe method.
- Single stack.
- Stub stack systems:
  - use of air admittance valves.
- Ventilation stacks.
- Requirements for current regulations and standards affecting the design and installation of above-ground drainage systems, relevant to the local vernacular.
- Rainwater systems.
- Provision for the disposal of rainwater:
  - gutters
  - roof arrangements
  - rainwater pipes.
- Materials used in the construction of these systems.
- Grey water, including recycling systems.
- Rainwater harvesting.

B5 Drainage systems, materials and testing

The design of above-ground drainage systems, including the installation and testing of the systems, to include:

- the need and types of traps
- causes and prevention of the loss of seal
- connections to above-ground drainage systems of domestic sanitary appliances
  - shower arrangements
  - washbasins
  - WCs
  - bidets
  - baths
  - sinks
  - washing machines
  - dishwashers
- macerators
- materials and jointing methods for above-ground drainage and rainwater systems
- procedures for testing
- need and procedures for testing of above-ground drainage to current regulations, relevant to the local vernacular
- testing of trap and seal retention
- Use Building Information Modelling (BIM) tools to enhance the plumbing system design and specification
  - use BIM collaboration tools to avoid conflicts and clashes with other trades, to include using analysis in modelling
  - BIM parametric design, to include defining set rules, e.g. floor-to-floor heights, structural integrity or solar gain in software to trial and test techniques before they are used.

Learning aim C: Develop and apply the principles of dynamic fluid flow in pipes and ducts

The need to consider energy losses in pipework and ducting as a result of flow patterns and fittings.

C1 Dynamic fluid flow

Consideration of the qualitative behaviour and fluid flow capacity in building services systems.

- Continuity of flow equation.
- Forms of energy.
- Principles of conversion of energy.
- Steady flow energy equation.
- Bernoulli's equation.
- Units and notation for potential energy.
- Pressure energy and kinetic (velocity) energy.
- Velocity of flow.
- Volume flow rate.
- Mass flow rate.
- Viscosity and its effect on flow.

C2 Pipes and ductwork

- Use of continuity flow equation to solve duct and flow problems.
- Use of steady flow energy equation to solve simple flow problems.
- Use of Bernoulli's equation to solve problems relating to continuous flow systems.
- Determination of flow arrangements through orifice contractions.
- Pipe contractions and ductwork branches.
- Application of Bernoulli's equation to orifice plate and meter, and Venturi meters.

C3 Energy loss

- Friction in straight pipes and ducts.
- Turbulence caused by fittings and changes in direction.
- Changes in direction and/or sizes of pipes/ducts.

C4 Losses in pipes and ductwork

- Energy loss in systems with laminar flow.
- Poiseuille's equation (Hagen–Poiseuille's law).
- Energy loss in systems with turbulent flow.
- Darcy's formula.
- Chézy formula.
- Use of friction coefficients.
- Energy loss due to fittings.
- Pressure-loss factors for pipe and ductwork fittings.
- Expressing fittings as equivalent lengths of pipe.
- Pressure loss due to fittings and changes in flow conditions.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the properties, behaviour of water and how it is sourced, cleansed to the required standards and distributed		**A.D1** Evaluate the effectiveness of the current regulations and consider the stakeholders' requirements when distributing water to and installing a cold-water supply for a given scenario.
A.P1 Explain the current regulations and requirements that need to be considered for delivering clean water to a property. **A.P2** Explain how water is distributed to the consumer.	**A.M1** Assess the current regulations and requirements that need to be considered for the distribution of cold water and installation for a given scenario.	
Learning aim B: Undertake the design of plumbing and above-ground drainage installation for a property		**B.D2** Produce a comprehensive system design that fully meets the requirements of the building services system for a given scenario.
B.P3 Select appliances and components for a property. **B.P4** Produce a design layout for a property. **B.P5** Explain the design requirements for plumbing, above-ground drainage and gas installations for a given scenario.	**B.M2** Produce a detailed design that meets the needs of a given scenario.	
Learning aim C: Develop and apply the principles of dynamic fluid flow in pipes and ducts		**C.D3** Demonstrate the selection of pipes and ducting, including dimensional details, flow rates and the energy losses involved, to meet all the needs of a building services system for a given scenario, justifying all the choices.
C.P6 Assess the behaviour of fluids in the building services system. **C.P7** Select appropriate pipe and ducting for the building services system.	**C.M3** Produce a pipe and duct system design that mostly meets the requirements of a given scenario.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, B.P4, B.P5, C.P6, C.P7, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

There are no special resources needed for this unit.

Essential information for assessment decisions

Learning aims A

For Distinction standard, learners must consider a building services system and identify all the influences on fluid flow within the system, while also covering the current regulations and standards when considering how cold water is sourced, cleansed and delivered to a given building. Learners' will evaluate the effectiveness of the regulations and standards. Their evaluation should relate to fluid behaviour and the requirements of all the stakeholders in the project. Learners comments should include consideration of the cold water supply, design conditions and building restrictions in the design of a building services system.

For Merit standard, learners must analyse a building services system and identify most of the influences on fluid flow in the system. They should assess the helpfulness of the current regulations and standards when considering how cold water is sourced, cleansed and delivered to a given building. Learners will include stakeholder requirements, design conditions and building restrictions, and will consider the interrelationships between design needs and regulatory requirements.

For Pass standard, learners must consider a building services system, identify some of the components and explain some of their operational features. They must also explain the factors relating to the current regulations and standards that need to be considered when supplying clean cold water. The explanation will be supported with reasons for the findings. The explanation should also include information on the laws of fluids, along with stakeholder requirements and design conditions covering how water is distributed to the consumer. Learners will demonstrate that they understand the need to consider these factors when designing the system.

Learning aims B and C

For Distinction standard, learners will produce a comprehensive design and report that is detailed in its compilation and which contains full manufacturers' details and drawings, produced to a professional design standard, for a given building. The selection of all equipment and materials needs to be evaluated in meeting the requirements and current regulations and standards of the scenario for the given property. In their evaluation, learners will draw on their knowledge of the design of plumbing installations to consider the relevance and significance of key aspects of their designs, and the benefits and drawbacks to the design of the plumbing installation for the given building.

For Merit standard, learners will produce a design and report that is detailed in its compilation, contains full manufacturer details, including drawings, produced to a good design standard, for a given building. The selection of all other equipment needs to be justified in meeting the requirements, current regulations, standards and design needs of the scenario for the given property. Learners will draw on their knowledge of the design of plumbing installations to prove that key aspects of their designs are correct for the situation.

For Pass standard, learners must produce a pipe diagram for a domestic installation. This should show hot and cold water requirements and, in terms of human interaction, be linked to the stakeholders who will occupy the building. Descriptions will be supported with diagrammatic illustrations of the pipe layout and equipment, and manufacturers' details, including all key elements. Learners must assess the amount of heat required in each space and select appropriate fittings accordingly, using the manufacturer's published information. A schedule of materials and equipment for the plumbing installation needs to be produced, including a summary of the product information, manufacturer's references and total quantities

Links to other units

This unit links to:

- Unit 14: Low Temperature Hot Water Systems in Building Services
- Unit 25: Building Services Control Systems
- Unit 26: Heating, Ventilation and Air Conditioning Design
- Unit 28: Electrical Principles and Installation Standards in Building Services Engineering.

Opportunities to develop transferable employability skills

Learners will have the opportunity to develop the following transferable skills in the completion and assessment of this unit.

- Decision making when comparing information.
- Presentation and interpersonal skills when working with others.
- Analytical and evaluative practices when carrying out plumbing.
- Mathematical skills and knowledge when calculating costs.

Unit 28: Electrical Principles and Installations Standards in Building Services Engineering

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of electrical installations that provide power for domestic environments.

Unit introduction

In most buildings, electricity is essential for providing power and light. Modern electrical installations are expected to do much more than merely supply power. Safety is of paramount importance and systems must also be economical, functional and reliable. Electrical installation designers and electricians are responsible for the safe installation of such systems.

In this unit, you will investigate the development of electrical installations. You will begin by understanding the regulations and legislation that apply to any electrical installation and the use of appropriate methods to determine quantities associated with electricity. This will be followed by looking at agreement of the client's needs and design requirements for a system, the design of layouts, the sizing, selection and specification of components, cabling and equipment, and the commissioning and certification of the installation.

Electrical installations are a critical feature of any building. This unit gives you valuable insight into the legal requirements and legislation in relation to installations and site activities. It will support you in progressing to a higher-level construction programme, such as the Higher National in Construction and the Built Environment with a Building Services Engineering pathway, or to a general construction or building services degree. This unit will also help you to progress to employment in supporting a site manager or quantity surveyor.

Learning aims

In this unit, you will:

A Understand the regulations and legislation applicable to electrical installations

B Undertake the design of an electrical installation for a property

C Develop a specification for materials, components and ancillary equipment for an electrical installation.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the regulations and legislation applicable to electrical installations	**A1** Regulations and legislation **A2** Earthing, bonding and circuit protection **A3** Units and calculations **A4** Terminology, principles and calculations	Analyse a client brief in terms of all legal and electrical requirements.
B Undertake the design of an electrical installation for a property	**B1** Power requirements **B2** Wiring methods and techniques **B3** Electrical lighting **B4** Data, security and fire protection	Develop a system for an electrical installation from a set of given design parameters. As part of the design, produce a specification for all the elements of the electrical installation.
C Develop a specification for materials, components and ancillary equipment for an electrical installation	**C1** Materials and components **C2** Consumer units **C3** Security and fire **C4** Drawings	

Content

Learning aim A: Understand the regulations and legislation applicable to electrical installations

A1 Regulations and legislation

The statutory measures that must be met and implemented in the design of electrical installations, and their benefits and drawbacks.

- International standards relevant to the local vernacular for electrical installations.
- Special locations: where a person may have reduced body resistance or greater risk of injury from electric shock
  - bathroom
  - swimming pools
  - outdoor power and lights
  - portable and outdoor equipment.
- Site safety:
  - 110 V safety isolating transformers
  - temporary supplies.
- Construction site electricity:
  - supply incoming unit (SIU)
  - main distribution unit (MDU)
  - outlet unit (OU)
  - extension outlet unit (EOU)
  - earth monitor unit (EMU).
- Health and safety at work:
  - safe operation and maintenance of the working environment, plant and systems
  - maintenance of safe access and egress to the workplace
  - adequate training of staff to ensure health and safety
  - adequate welfare provisions for staff.
- Workplace health, safety and welfare.
- Safety in construction, design and management:
  - inspection, testing and commissioning, to include initial verification, compliance with local regulations, meeting design specifications, testing instruments.
- Test methods and requirements, including safety precautions and their purpose:
  - sequence of tests
  - precautions to be taken (safe isolation procedure)
  - continuity of circuit protective conductor (CPC)
  - insulation resistance
  - polarity (dead and live)
  - earth fault loop impedance
  - residual current device (RCD)
  - functional testing
  - results and actions to be taken.

- Certification:
  - electrical installation certificate
  - schedule of inspection
  - schedule of test results
  - periodic inspection report
  - report forms

A2 Earthing, bonding and circuit protection

The statutory measures that must be met in the design of electrical installations and their impact on electrical safety.

- Earthing principles:
  - protection against electric shock
  - principles of earthing
  - protective conductors
  - earth and ground rod.
- Equipotential bonding requirements and methods:
  - main
  - supplementary bonding
  - equipotential bonding.
- Circuit protection:
  - Fuses (cartridge, high rupturing capacity (HRC), rewireable)
  - breaker and circuit breakers (CB)
  - miniature circuit breaker (MCB)
  - residual current device (RCD)
  - residual current circuit breaker (RCCB)
  - residual current circuit breaker with overcurrent protection (RCBO).

A3 Units and calculations

The standard units and calculations used in electrical systems and what they measure, and their interrelationships for DC and AC circuits.

- Basic electrical quantities:
  - charge
  - current
  - voltage
  - resistance
  - conductance
  - frequency
  - standard symbols and their abbreviations.
- Calculation of electrical power.
- Electrical energy.
- Electrical charge.
- Quantity of energy:
  - Ohm’s law
  - Kirchoff’s laws
  - series, parallel and combination circuits.

- Determination of values of:
  - resistance
  - voltage
  - current
  - power.
- Use of material resistivity to determine the resistance of materials.

A4 Terminology, principles and calculations

The essential terms and calculations that learners need to understand when applying the principles of electricity to the behaviour of simple electrical components.

- Potential difference.
- Electromotive force (emf).
- Voltage.
- Direct current (DC).
- Alternating current (AC).
- AC waveforms:
  - average
  - peak to peak
  - root mean square (rms)
  - frequency values.
- Faraday's law.
- Lenz's law.
- Ohm's law.
- Calculations to determine:
  - magnetic flux
  - flux density
  - induced emf
  - electrostatic field strength for capacitors
  - energy stored in inductor
  - back emf
  - self-inductance
  - mutual inductance
  - inductance of a coil.

Learning aim B: Undertake the design of an electrical installation for a property

Consideration of the demand and power requirements that need to be provided and met safely.

B1 Power requirements

Key elements to consider in circuit design for construction projects.

- Location of distribution board and equipment.
- Suitable circuit arrangements.
- Cables and wiring systems for current carrying capacity.
- Cable routing.
- Number and location of socket outlets and other power loads.

- Selection of containment.
- Selection of over current protection.
- Volt drop.

B2 Wiring methods and techniques

The types of cable, wiring and electrical systems that need to be considered and specified in an electrical installation and how this is achieved.

- Cable type:
  - meter tails
  - twin (2, 3 and 4) core and earth
  - live (L)
  - neutral (N)
  - earth (E)
  - steel-wire armoured (SWA)
  - flexible cords
  - powerlines.
- Wiring systems:
  - final
  - radial and loop
  - ring final circuit (RFC)
  - floor area limits for each circuit
  - down lights
  - transformers
  - smoke and fire alarms
  - intruder alarm
  - data and communications
  - bathroom extraction isolation
  - SMART technology systems
  - central heating systems, to include boiler control panels, thermostats, underfloor heating.
- Cable protection:
  - PVC sheathed
  - trunking metal and plastic
  - conduit, metal, plastic
  - mineral insulated cables.
- Voltage drop.
- Cable capacity.
- Current capacity and cable sizing and allowing for diversity:
  - lights
  - ring main
  - showers
  - immersion heaters
  - cookers
  - night-storage heaters
  - electric bathroom towel heaters.

- Outputs of Building Information Modelling (BIM) models and techniques that enhance the process of specifying electrical installation, including:
  - BIM collaboration when working with other trades on modelling
  - BIM parametric design, to include the ability to trial and test techniques at the design stage of electrical installation, by defining set rules, e.g. floor-to-floor heights, solar gain to automatically generate optimised solutions
  - software packages.

B3 Electrical lighting

The selection of luminaires to meet user requirements and standards, including the assessment of output levels to meet design requirements and to fulfil legal parameters, to include:

- lamps and luminaires
- cables and wiring systems
- switching arrangements
  - one way
  - two way
  - intermediate
- lighting zones
- ingress protection (IP rating)
- cable routing
- illumination levels
- glare rating
- inverse square law of illumination
- cosine law of illumination
- lumen calculation for number of luminaires for artificial light installations
- spacing ratios
- glare assessment and prevention.

B4 Data, security and fire protection

The selection of appropriate circuits, sensors, detectors and outputs to meet the needs of end users and stakeholders.

- Data:
  - local area network (LAN) and wide area network (WAN)
  - cable types
  - cable routing and capability.
- Security systems:
  - access control
  - detector types
  - open- and closed-loop systems
  - alarms
  - Wi-Fi connected and enabled.

- Fire-protection systems:
  - automatic detectors
  - cabling and interconnections
  - stand-alone smoke detectors
  - heat detectors
  - carbon monoxide detectors
  - control and indicating equipment.

Learning aim C: Develop a specification for materials, components and ancillary equipment for an electrical installation

C1 Materials and components

The characteristics of the material and components that will be used to carry and distribute electricity safely.

- Materials selection.
- Earthing and bonding.
- Size of cable:
  - 1 mm^2 PVC insulated twin and earth
  - 1.5 mm^2 PVC insulated twin and earth
  - 2.5 mm^2 PVC insulated twin and earth
  - 6 mm^2 PVC insulated twin and earth
  - 10 mm^2 PVC insulated twin and earth
  - 1.5 mm^2 3-core and earth
  - 1.5 mm^2 earth
  - 25 mm^2 meter tails.
- Power outlets:
  - fused spur
  - switched fused spur
  - junction boxes
  - cooker control points
  - external sockets
  - built-in USB chargers
  - shaving points.
- Switches:
  - pull chord
  - single pole
  - switched stairway lighting
  - dimmers.
- Lighting:
  - IP ratings
  - fire protection for down lighters
  - light-emitting diode (LED) under cabinet and kickboard lighting
  - security
  - garden lighting.
- Opportunities for smart (i.e. internet-enabled) and wireless control interfaces/systems to be appropriate for greater convenience and energy efficiency for the consumer.

C2 Consumer units

Consumer unit to suit the installation, providing adequate zoning and protection, including non-combustible enclosure.

- Location of unit.
- Types of circuit.
- Types of unit:
    - multi-way high integrity dual RCD units
    - multi-way with mains isolation
    - 3- and 2-way garage units.

C3 Security and fire

The type and selection of security and fire systems in terms of capability and characteristics, including the benefits they provide and how they work together, to provide composite security solutions.

- App enabled.
- Wireless.
- Smoke.
- Heat.
- Carbon monoxide (CO).
- Intruder alarms.

C4 Drawings

Communication methods, including the use of standard symbols and the production of as-built drawings.

- Layout.
- Schematic.
- Graphical symbols.
- Distribution board.
- Schedules.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the regulations and legislation applicable to electrical installations		**A.D1** Justify the regulations and legal requirements that need to be considered when designing an electrical installation for a given scenario.
A.P1 Explain the regulations and legal factors that need to be considered in relation to electrical installations.	**A.M1** Assess the regulations and legal factors that need to be considered in relation to electrical installations for a given scenario.	
Learning aim B: Undertake the design of an electrical installation for a property		**B.D2** Produce a comprehensive electrical system design that fully meets legislative requirements and the needs of a given scenario.
B.P2 Produce a wiring diagram for a domestic electrical installation that includes the positioning and requirements of all key components. **B.P3** Assess the current power requirements for each individual room. **B.P4** Explain the consumer unit requirements for a given scenario.	**B.M2** Produce a detailed design that meets the needs of a given scenario.	
Learning aim C: Develop a specification for materials, components and ancillary equipment for an electrical installation		**C.D3** Evaluate the selection of a consumer unit, materials and fittings that fully meet the needs of a given scenario.
C.P5 Select a consumer unit to meet the needs of a given scenario. **C.P6** Produce schedules of materials and equipment that meet some of the needs of a given scenario.	**C.M3** Justify the selection of a consumer unit, materials and fittings that meet most of the needs of a given scenario.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aims: B and C (B.P2, B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- appropriate construction drawings
- examples of electrical components and fittings
- product information, catalogues and electrical standards
- the internet.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners must consider all the relevant regulations and legal factors that apply when designing an electrical installation for a given building. The legal factors given by learners will be supported and fully referenced by research. Learners must consider the stakeholder requirements of the project, linked to electrical installation, design conditions and building restrictions. In their justification, learners will draw on their knowledge of the factors to consider their relevance or significance to the design of the electrical installation for the given building.

For Merit standard, learners must consider the relevant regulations and legal factors that apply when designing an electrical installation for a given building. Their analysis will cover stakeholder requirements, design conditions and building restrictions. In assessing these factors, learners will consider the conflicting interrelationships between the factors.

For Pass standard, learners must explain the factors relating to the relevant regulations and legal factors for the design of an electrical installation. The explanation must cover stakeholder requirements, design conditions and building restrictions. Learners will demonstrate that they understand the need to consider these factors when designing the system.

Learning aims B and C

For Distinction standard, learners will produce a comprehensive, detailed design and report that contains full manufacturers' details and drawings, produced to a professional design standard, for a given building. The selection of all equipment and materials, including a consumer unit, needs to be evaluated in terms of how they meet legislative requirements and the design needs of the scenario for the given property. In their evaluation, learners will draw on their knowledge of consumer units and the design of electrical installations to consider the relevance and significance of key aspects of their designs, and the benefits and drawbacks to the design of the electrical installation for the given building.

For Merit standard, learners will produce a detailed design and report that contain full manufacturers' details, including details of consumer units, with drawings produced to a good design standard for a given building. The selection of a consumer unit, and all equipment, needs to be justified in terms of how they meet legislative requirements and the design needs of the scenario for the given property. Learners will draw on their knowledge of the design of electrical installations to prove that key aspects of their designs are correct for the scenario.

For Pass standard, learners must produce wiring diagrams for a domestic installation. This should include the consumer unit, its fuses and protective devices. Electrical requirements should be linked to the scenario and show all key elements. Learners must assess the amount of power and light required in each space and select appropriate fittings and outlets accordingly, using manufacturers' published information. The consumer unit has to be selected to meet the output and safety considerations in the building's design requirements. A schedule of materials and equipment for the electrical installation needs to be produced, including a summary detailing product information and total quantities.

Links to other units

This unit links to *Unit 25: Building Services Control Systems*.

Employer involvement

This unit would benefit from employer involvement in the form of:

- office visits to electrical installation designers
- talks from visiting electrical engineers.

Unit 29: Principles and Applications of Structural Mechanics

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners consider how structural elements behave under load and develop the skills needed to solve structural mechanics problems.

Unit introduction

It is essential for engineers, architects and contractors to understand the mechanics of structures to enable them to build safely. The structural safety of buildings is about how loads are carried and transmitted to the ground. Some loads will occur during the construction process and others will arise during the use of the building or structure following completion of a project. Civil and structural engineers often deal with large and complex structures but each beam, column, roof truss, foundation and retaining wall must be individually designed to contribute to the safety of the construction project as a whole.

In this unit, you will develop an understanding of the forces that are distributed by the building framework and the structural elements. You will learn how to design simple and safe structural units, which will include an analysis of the forces within framed structures and elements. You will carry out structural calculations to assist with this design work.

The unit will give you a sound basis for the analysis and design of more complex structures. It will also prepare you for a role as a trainee structural or civil engineer or for further study on a higher-level qualification in construction or civil engineering.

Learning aims

In this unit you will:

A Understand the principles of structural behaviour under load
B Carry out calculations to solve structural mechanics problems
C Undertake the design of structural elements
D Examine the use of computers in structural analysis and design.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand the principles of structural behaviour under load	**A1** Concepts **A2** Simple structural behaviour from given data	A presentation or written report to clearly explain, with the aid of diagrams and supporting calculations, the underpinning concepts relating to how structural elements behave under loads.
B Carry out calculations to solve structural mechanics problems	**B1** Beams **B2** Columns **B3** Frames	A report containing calculations and interpretation of results for contextualised structural element tasks subject to loading conditions.
C Undertake the design of structural elements	**C1** Beam design **C2** Column design **C3** Retaining wall design	A report containing written responses on design methods and their suitability, and production of design solutions for a given design brief. A report or presentation for a given project scenario that evaluates the measures used to protect and enhance land and buildings.
D Examine the use of computers in structural analysis and design	**D1** Computer software packages for design calculations **D2** Benefits and drawbacks of using computing software	A written review for a journal on structural design, read by structural and civil engineers, of the impact of computer software on computer structural analysis and design.

Content

Learning aim A: Understand the principles of structural behaviour under load

The application and understanding of the underpinning concepts of how structural elements behave under different loading conditions and the resulting stress within the element.

A1 Concepts

- Types of structural members:
  - beams, columns, ties, struts, walls, frames
  - behaviour under load:
    - deflection and change of shape
    - failure methods
    - impact of structural cross section, to include shape profile, slenderness and depth.
- Underpinning concepts, including their graphical representation and their impact on structural design:
  - loading types, to include dead, imposed, wind, live
  - types of forces, to include concurrent, non-concurrent, coplanar
  - loading configurations, to include point loads, uniformly distributed loads
  - stress types, to include compression, tension, bending, shear
  - sectional properties
  - materials used.

A2 Simple structural behaviour from given data

Completion of calculations to determine the structural behaviour of structural members under load, including their deflected shape.

- Structural calculations to determine:
  - stress
  - strain
  - modulus of elasticity
  - factors of safety.
- Deflected shape of structural members:
  - columns
  - beams
    - simply supported
    - overhanging simply supported
    - cantilever
  - compressive face
  - tension face.

Learning aim B: Carry out calculations to solve structural mechanics problems

B1 Beams

Completion of calculations for shear forces and bending moments, and the production of shear force and bending moment diagrams to determine the structural behaviour of beams under loading conditions.

- Types:
  - simply supported
  - overhanging simply supported
  - cantilever.
- Loading:
  - uniformly distributed
  - point.
- Calculations, to include:
  - reactions
  - shear force values
  - bending moment values
  - maximum bending moment calculations on overhanging simply supported beams.
- Sketch diagram details, to include:
  - shear force diagrams
  - bending moment diagrams.
- Relationship between shear force and bending moment:
  - point of contraflexure
  - deflected shape.

B2 Columns

Completion of calculations to determine the structural behaviour of columns under axial and eccentric loading conditions.

- Loading:
  - axially loaded
  - eccentrically loaded.
- Key terminology:
  - effective length
  - short column
  - long column
  - slenderness ratio.

B3 Frames

Using methods and techniques to determine the value and type of forces in structural frames.

- Key terminology:
  - statically determinate frame
  - pin-jointed.

- Subject to loading types:
  - dead loads
  - imposed loads
  - wind loads
  - live loads.
- Types of member:
  - strut-compressive
  - tie-tension
  - beams
  - columns.
- Methods used to determine forces in statically determinate frameworks:
  - graphical method
  - method of resolution
  - method of section.

Learning aim C: Undertake the design of structural elements

The determination of the sectional requirements of structural members under differing load conditions.

C1 Beam design

Application, characteristics and analysis of beams under load conditions for steel, reinforced concrete and timber beams.

- Limit state design.
- Design of relevant sections to appropriate design tables.

C2 Column design

Application, characteristics and analysis of columns under axial and eccentric loading conditions for steel, reinforced concrete and timber columns.

- Limit state design.
- Axial loaded.
- Design of relevant sections to appropriate design tables.
- British Standards.

C3 Retaining wall design

Application, characteristics and analysis of retaining walls under different forms of loading and stress conditions.

- Forces to be retained:
  - soil
  - water/liquid
  - level surcharge.
- Design factors to comply with appropriate factors of safety:
  - sliding
  - overturning
  - overstressing.

- Understand the key concepts of:
  - the Middle Third Rule
  - Rankin's formula.

Learning aim D: Examine the use of computers in structural analysis and design

D1 Computer software packages for design calculations

Computer software used for beam, column and retaining wall design.

- Basic software types to check calculations of:
  - reactions and bending moment values of beams
  - sketch details of shear force and bending moment calculations
  - complete check calculations for beam, column and retaining wall designs.

D2 Benefits and drawbacks of computing software

Benefits and drawbacks of using computer software in beam, column and retaining wall design.

- Main benefits:
  - automated loading of structures
  - integration of computer-aided design (CAD) drawings
  - simplicity of use
  - accuracy
  - speed of use
  - ability/flexibility to change cross sections to affect design, such as with retaining walls or beams, so that as geometric shape is changed, factors of safety and stress/loading conditions may improve
  - economics of design:
    - sections may be designed based on a most economical section
    - computer modelling providing design options.
- Drawbacks:
  - capital cost of computer equipment:
    - initial cost
    - software costs, to include regular upgrade costs
    - cost of upgrades to hardware
  - training staff to use equipment:
    - initial training
    - upgrade training
  - security of information and backups
  - systems stability
  - need to recognise computer error
  - health and safety, to include screen usage, keyboard usage.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the principles of structural behaviour under load		**A.D1** Interpret the likely behaviour, under load, of structural elements for given design conditions at the point of failure.
A.P1 Describe the behaviour of structures under loads.	**A.M1** Assess the behaviour of structures under loads for given design conditions.	
Learning aim B: Carry out calculations to solve structural mechanics problems		**BC.D2** Evaluate alternative design methods and approaches for structural elements in terms of their application for a given situation.
B.P2 Calculate reactive forces, and plot shear force and bending moment diagrams for simply supported and cantilever beams for a given situation. **B.P3** Calculate the stress conditions in a short column under axial and eccentric loads for a given situation. **B.P4** Calculate the forces acting in a determinate frame using mathematical and graphical techniques for a given situation.	**B.M2** Discuss the methods and approaches used in determining the loads and forces acting within a structure for a given situation.	
Learning aim C: Undertake the design of structural elements		
C.P5 Produce suitable section sizes for simply supported beams. **C.P6** Produce suitable section sizes for axially loaded columns. **C.P7** Produce a suitable section for a mass retaining wall that complies with design requirements.	**C.M3** Discuss the methods and approaches used in determining the sectional size and details of a structural element.	

Pass	Merit	Distinction
Learning aim D: Examine the use of computers in structural analysis and design		**D.D3** Evaluate the use of computers on structural analysis and design in civil engineering projects.
D.P8 Explain how computers are used in structural analysis and design.	**D.M4** Discuss the benefits and drawbacks of using computers in structural analysis and design.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.M1, A.D1)

Learning aims: B and C (B.P2, B.P3, B.P4, C.P5, C.P6, C.P7, B.M2, C.M3, BC.D2)

Learning aim: D (D.P8, D.M4, D.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will interpret the important concepts associated with forces acting on structural members at the point of failure. This should include the interpretation of the behaviour of structural elements under given loading conditions, for given design conditions, at the point of failure.

For merit standard, learners will provide a careful consideration of the varied factors that affect the behaviour of structures under loads for given design considerations. This will include an assessment of the key factors and concepts that underpin the structural behaviour of design elements.

For pass standard, learners will demonstrate a clear understanding of the concepts of structural behaviour under different loading conditions. This will cover the range of structural members of beams, columns, ties, struts, walls and frames. Learners must differentiate between compressive, tensile, shear and bending stresses, and must demonstrate an awareness of how stresses can alter the shape of members and how excessive stresses may lead to failure. Learners should describe the difference between point and uniformly distributed loading and the deflected shape of structural members under load. Learners will include calculations, illustrations and sketches to help describe how structural elements behave under different loading conditions.

Learning aims B and C

For distinction standard, learners will evaluate alternative design methods in terms of their application for a given scenario. Learners should be given a design brief outlining serviceability requirements and other relevant details. This can be set as an extension to the activity planned to meet B.M2 and C.M3.

For merit standard, learners will discuss the relationship between forces acting within a structure from a given scenario. They will analyse alternative methods of designing structural elements. Decisions and commentary must be supported by reference to the properties and materials and required performance for their particular application.

For pass standard, learners will calculate reactive forces and plot shear force and bending moment diagrams for two simply supported beams carrying a combination of point and uniformly distributed loads. Learners will determine the stress conditions of two short columns under loading conditions, one axially loaded and one eccentrically loaded. Learners will calculate the forces acting on a pin-jointed framework with loads at nodal points, by using either the method of sections or method of resolution. This should then be checked using a graphical method. Learners will produce suitable section sizes for a simply supported beam for two different materials (timber, steel or reinforced concrete). Learners will produce a suitable section for a mass retaining wall, retaining either soil or water, applying suitable checks that will involve the resulting factors of safety for overturning, sliding and bearing capacity. Emphasis should be on the accurate presentation of calculations and results.

Learning aim D

For distinction standard, learners will evaluate the impact of computer software on structural analysis and design. They will support this with evidence from all stages of the use and application of computer software in the design of structural elements to meet the requirements of learning aim C. In addition, the centre could also request that learners evaluate the design of structural elements for a given scenario, from which further evaluative commentary of the impact of the use of computer software could be drawn.

For merit standard, learners will discuss the use and implementation of new computer software in structural analysis and design. They will discuss how computer software has been applied to design structural components. Learners will discuss the principles of computer software structural analysis to show how variation in process outcomes may be achieved.

For pass standard, learners will explain how computer software is used in the structural analysis of beams, columns and retaining walls.

Links to other units

It is strongly recommended that learners should take *Unit 17: Further Mathematics for Construction*, before they attempt this unit.

This unit links to:

- Unit 3: Construction Science
- Unit 17: Further Mathematics for Construction.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 30: Public Health Engineering

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop an understanding of below ground drainage systems, and examine the methods used to treat and dispose of both sewerage and domestic waste, and the processes that are used to produce drinking water.

Unit introduction

Public health engineering is an aspect of civil engineering that allows us to live in communities without the worries associated with ill health and disease that result from inadequate or unhealthy disposal of waste materials.

In this unit, you will examine a range of areas related to public health engineering which are, to some extent, often found in civil engineering projects. You will understand how waste water is drained from both buildings and surfaces using below ground drainage systems, including the design, installation and maintenance of these systems. You will examine methods of treating sewerage before developing an understanding of ways to dispose of solid domestic waste. Finally, you will examine sources of drinking water, the methods used to treat water and then the distribution to users.

This unit provides progression opportunities to civil engineering sector roles, including public health design engineer, water engineer, process engineer, or progression to degrees in construction specialisms, including civil engineering.

Learning aims

In this unit you will:

A Understand below ground drainage systems and methods for treating sewerage

B Examine methods for disposing of solid domestic waste

C Examine the processes used to produce and distribute drinking water.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Understand below ground drainage systems and methods for treating sewerage	**A1** Introduction to below ground drainage systems **A2** Installation, testing and maintenance of below ground drainage systems **A3** Methods of treating domestic sewerage	A report that investigates below ground drainage systems and methods of treating domestic sewerage.
B Examine methods for disposing of solid domestic waste	**B1** Types and forms of solid domestic waste **B2** Methods of disposal of solid waste **B3** Requirements and constraints relating to the disposal of solid waste	A report that investigates and evaluates the disposal of solid domestic waste produced within a given domestic development.
C Examine the processes used to produce and distribute drinking water	**C1** Sources of drinking water **C2** Treatment of drinking water **C3** Storage and distribution of drinking water	A report that examines a range of sources of drinking water, methods used to purify water and the subsequent storage and distribution of drinking water.

Content

Learning aim A: Understand below ground drainage systems and methods for treating sewerage

A1 Introduction to below ground drainage systems

The requirements and characteristics of below ground drainage systems and their impact on design.

- Disposal of:
  - foul water
  - surface water.
- Types of system:
  - combined systems
  - totally separate systems
  - partially separate systems
  - sustainable urban drainage systems (SUDS):
    - filter strips
    - swales
    - infiltration and attenuation basins
    - wet ponds
    - porous and permeable surfaces
    - infiltration systems
    - underground storage tanks
  - grey water systems
  - systems for different building types, to include:
    - domestic dwellings
    - small commercial and industrial buildings
    - small housing developments
    - small industrial/commercial trading estates.
- Design requirements:
  - ventilation of below ground drainage systems:
    - ventilation stacks
  - access to below ground drainage systems
  - rainwater storage and use
  - grey water storage and use.
- Design calculations:
  - size of drain
  - depth of flow
  - maximum depth of flow
  - methods of determining drain/sewer loadings
  - self-cleansing velocity and inclination of sewers from given data
  - Chezy equation
  - Chezy-Manning equation
  - continuity equation.

A2 Installation, testing and maintenance of below ground drainage systems

How characteristics and methods of installing, testing and maintaining below ground drainage systems impact on the design of systems.

- Materials and installation techniques:
  - common materials used for below ground drainage systems:
    - vitrified clay
    - concrete
    - cast iron
    - uPVC
    - polypropylene
    - structured wall plastic pipes
    - brick
  - methods of jointing different below ground drainage materials
  - bedding and backfilling of drains
  - surrounds to drains
  - depth of cover
  - gradient requirements
  - arrangements for drains passing through building structures.
- Tests for soundness and performance:
  - tests to below ground drainage systems:
    - air tests
    - water tests
    - visual inspections
  - alignment tests
  - mirror and torch tests
  - obstruction test, to include:
    - visual inspection
    - Mandrel tests
    - CCTV inspection
  - rolling ball test
  - soundness tests
  - hydraulic and pneumatic tests.
- Servicing and maintenance:
  - access points and manholes
  - health, safety and welfare
  - personal hygiene and protective clothing and equipment
  - tools and equipment required for servicing and maintenance
  - work sequences and methods of carrying out servicing and maintenance tasks
  - testing of drains and sewers for toxic or explosive gases.

A3 Methods of treating domestic sewerage

The relationships between the different methods of treating sewerage and the specific requirements of a development that are influential in decisions relating to the selection of suitable methods of treatment.

- Different methods of treating sewerage:
  - sewerage treatment plants:
    - via mains drainage
    - small-scale localised treatment plants
  - cesspits and cesspools
  - septic tanks.
- Requirements for different methods of treating sewerage:
  - location and building type
  - design requirements
  - method of operation
  - sizing based on population
  - disposal of sludge
  - disposal of water after treatment
  - vehicle access.

Learning aim B: Examine methods for disposing of solid domestic waste

B1 Types and forms of solid domestic waste

The nature and characteristics of different types of solid domestic waste and why these characteristics require a range of different methods of disposal.

- Organic waste:
  - food
  - garden waste.
- Combustible waste:
  - paper
  - wood
  - dried leaves
  - packaging.
- Non-combustibles:
  - metals
  - glass
  - ceramics.
- Ashes and dust.
- Hazardous materials:
  - batteries
  - bandages and sticking plasters
  - disposable nappies.

B2 Methods of disposal of solid waste

- Methods that can be used to dispose of domestic solid waste:
  - refuse chutes
  - sorting, disposal and recycling of solid waste
  - biological reuse:
    - composting
    - anaerobic digestion
  - disposal:
    - landfill
    - incineration
    - compaction.

B3 Requirements and constraints relating to the disposal of solid waste

Legal requirements applied to waste materials and approved methods of disposal:

- Health, safety and welfare.
- Damage to the environment.
- Cost implications.

Learning aim C: Examine the processes used to produce and distribute drinking water

The relationships between sources of water, methods of treating water and the storing and distribution of drinking water, their relative costs, health and safety issues, and how this varies depending on the specific requirements of a location.

C1 Sources of drinking water

- Rainfall:
  - hydrological cycle:
    - evaporation
    - condensation
    - precipitation
  - absorption of carbon dioxide, sulphur dioxide and oxides of nitrogen.
- Sources of supply:
  - rivers and streams
  - shallow wells and deep wells
  - boreholes
  - desalination of salt water
  - impounding reservoirs.
- River management:
  - weirs
  - floodplains.

C2 Treatment of drinking water

- Hardness:
  - hard and soft water
  - temporary hardness and permanent hardness
  - pH values
  - removal of temporary hardness
  - removal of permanent hardness by the base-exchange process
  - hardening of acidic water to prevent corrosion
  - plumbosolvency and cuprosolvency
  - palatability.
- Purification for drinking:
  - properties of potable water supplies, to include:
    - colour
    - turbidity
    - taste
    - odour
  - protection of the gathering grounds
  - effects of livestock, cultivation, nitrates and landfill
  - storage, impounding and storage/settlement in reservoirs
  - filtration, to include:
    - slow sand filters
    - rapid sand filters
    - microstraining
    - sterilisation and chlorination of water supplies.

C3 Storage and distribution of drinking water

- Storage and distribution:
  - service reservoirs
  - pumping stations
  - use of water towers or expansion/pressure vessels
  - minimum pressure
  - methods of isolation
  - materials and jointing methods used
  - disinfection
  - diagrammatic layouts of each method, highlighting the components for:
    - installations
    - distribution systems
    - water-main grid systems.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand below ground drainage systems and methods for treating sewerage		**A.D1** Justify the suitability of alternative approaches to below ground water drainage and domestic sewerage treatment, including reference to calculations, maintenance requirements and testing for a given situation.
A.P1 Explain design requirements for below ground drainage systems for surface water and foul water from buildings. **A.P2** Explain methods of treating domestic sewerage in a given situation.	**A.M1** Assess the design requirements for below ground drainage systems and treatment of domestic sewerage, using calculations to support decisions for a given situation.	
Learning aim B: Examine methods for disposing of solid domestic waste		**B.D2** Evaluate how requirements and constraints impact on the selection of methods for the sorting and disposal of solid domestic waste for a given situation.
B.P3 Explain the benefits associated with the separating of different types of solid domestic waste. **B.P4** Explain how different requirements and constraints impact on the methods used for the disposal of solid domestic waste.	**B.M2** Discuss methods of disposal of solid domestic waste, including the benefits of separating materials and how decisions are influenced by requirements and constraints for a given situation.	
Learning aim C: Examine the processes used to produce and distribute drinking water		**C.D3** Evaluate how availability of sources, purification, storage and distribution requirements impact on the supply of drinking water in a given situation.
C.P5 Explain the relationships between factors that influence the water purification process. **C.P6** Explain the factors that contribute towards the use of different approaches to remove hardness from water.	**C.M3** Discuss the influence of design factors in the selection of methods to purify and distribute drinking water in a given situation.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aim: B (B.P3, B.P4, B.M2, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- opportunities to develop understanding of how systems interact with buildings for each of the three learning aims by experiencing site visits, by seeing some elements of drainage within existing buildings (if site visits are not possible) and by using video or DVD materials
- copies of drawings and utility records to exemplify the different types of drainage systems and water distribution networks
- copies of legislation, standards, design charts and tables.

  NB Health, safety and welfare issues must be considered at all times and risk assessments should be undertaken for visits and practical investigations.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will justify the suitability of below ground drainage systems for a given construction development. They will consider the suitability of at least two systems for the given scenario, including the effectiveness of testing to ensure compliance with health and safety requirements. Learners must use calculations to support decisions that they have made, for example related to the materials used for pipework and connectors or regarding the type of system that is to be installed. Learners must also consider the need for maintenance in the systems and the requirements for access to pipelines. Learners must justify alternative methods of treating sewerage from the development, including the disposal of sludge, with reference to costs, legal requirements and issues relating to health and safety and the environment.

For merit standard, learners will assess the design requirements for below ground drainage systems in a given situation. They will consider the need for drainage of both foul water from buildings and also from surface water. Learners will assess the relative merits of different materials and consider alternative systems such as combined, separate and partially separate systems. They will also assess the requirements for domestic sewerage systems and the relative benefits and constraints of on-site methods. In their assessment, learners will consider the different aspects of each system, using calculations to support decisions related to the given situation.

For pass standard, learners will explain design requirements for both foul water systems and surface water drainage systems. They must explain the different types of system that can be used, including separate, combined and partially combined systems. Additionally, learners will explain the reasons why different materials are used, the methods employed for laying systems and the considerations to be made for maintenance. They will also explain at least two methods of treating domestic sewerage, including information about sizing, operation and maintenance. In their explanations, learners will show that they comprehend the function and operation of systems, making effective use of diagrams.

Learning aim B

For distinction standard, learners will evaluate methods of disposal of solid waste materials for a given domestic situation. They will evaluate the methods that can be used to initially dispose of waste materials and the reasons why materials need to be sorted into different types, for example metals, combustibles or ceramics. Learners will evaluate the different methods used to dispose of materials, considering how decisions are affected by constraints such as legislation, health and safety, environmental impacts and also the relative costs of methods of disposal.

For merit standard, learners will discuss the various methods that can be used to dispose of solid domestic waste in a given situation. They will consider the differences between the methods that could be used for the situation, and will take into account constraints relating to factors such as health and safety or the environment. The discussion will consider the need for sorting materials and make reference to the benefits and disadvantages of different methods of disposing of solid waste.

For pass standard, learners will explain the different types of solid material, including organic, combustible, non-combustible and hazardous waste, and dust and ashes. They will provide examples of each, explaining why materials need to be separated and sorted. Learners will also explain the methods that can be used for the disposal of solid domestic waste, including reference to the requirements and constraints associated with each.

Learning aim C

For distinction standard, learners will evaluate the provision of drinking water for a given scenario. They will evaluate at least two potential sources of water and alternative methods of treating and purifying the water so that it is suitable for drinking. They will consider alternative methods of storing the drinking water and the factors relating to the distribution of drinking water. Learners will evaluate the choices that have been made, including the appropriateness of alternatives for the given scenario, and making reference to a range of factors, including legal requirements, the environment, cost, and health and safety.

For merit standard, learners will discuss the various methods that can be used to provide drinking water in a given situation. They will consider the differences between the methods that could be used for the situation and will take into account constraints relating to factors such as health and safety or the environment. Learners will consider the need for treatment, storage and distribution, providing the relative costs of different approaches as opposed to absolute costs.

For pass standard, learners will explain the differences between hard and soft water, including the methods to remove hardness either temporarily or permanently. They will also explain the various stages of water purification, from source through to distribution, representing them through the use of diagrams that consider the source of the water, treatment, storage and distribution. Learners will explain alternative approaches that are appropriate for the given situation.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 7: Graphical Detailing
- Unit 23: Construction in Civil Engineering.

Employer involvement

This unit would benefit from employer involvement in the form of:

- visits to solid waste disposal facilities and water treatment installations
- visits to construction sites to view drainage installations
- opportunities to observe the testing, inspection and maintenance of drainage systems.

Unit 31: Specialist Civil Engineering Techniques

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners study the specialist civil engineering techniques used in the design and construction of bridges and tunnels as well as those used in marine applications.

Unit introduction

Civil engineering projects require a range of skills that are unique to the sector, such as those for designing and constructing bridges, tunnels and marine features. Many of the techniques draw on underpinning construction principles, including the types of materials used and a structural analysis.

In this unit, you will learn how different forms of bridges can be used for differing applications, from small single-span footbridges across a river through to multi-span cable-stayed viaducts that carry motorways across deep valleys. You will gain a good understanding of the factors that influence the methods of construction for tunnels. You will investigate the methods used for providing coastal protection and also learn how coffer dams and caissons allow construction to take place in bodies of water.

This unit provides progression opportunities to specialist civil engineering sector job roles. It can also provide the skills for progression to degrees in construction specialisms, including civil engineering.

Learning aims

In this unit you will:

A Examine different types of bridges and construction techniques

B Examine the principles of tunnelling

C Examine marine applications of civil engineering.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine different types of bridges and construction techniques	**A1** Bridge design **A2** Materials used in the construction of bridges **A3** Applications of bridges	A proposal for a type of bridge that will meet design criteria for a given scenario, including alternatives.
B Examine the principles of tunnelling	**B1** Design considerations for tunnels **B2** Construction methods for tunnels	A report that investigates alternative approaches that could be used to construct a tunnel for a given scenario.
C Examine marine applications of civil engineering	**C1** Coastal protection and sea walls **C2** Cofferdams and caissons **C3** Harbour works and breakwaters	An investigation into the approaches that can be used for coastal defences in a given situation that includes alternative solutions for the scenario.

Content

Learning aim A: Examine different types of bridges and construction techniques

A1 Bridge design

The types of bridge used in civil engineering projects, including construction methods, their design considerations and benefits and drawbacks for different situations, heights and spans.

- Cable-stayed.
- Suspension.
- Arch.
- Beam.
- Truss.
- Cantilever.
- Swing.
- Opening.
- Bascule.
- The methods used to provide support for bridges, including design considerations, applications, benefits and drawbacks:
  - abutments
  - bearings:
    - elastomeric
    - roller
    - plane sliding
  - footings and foundations:
    - strip footings
    - piled foundations
  - piers
  - wing walls and retaining walls
  - joints
  - parapets.

A2 Materials used in the construction of bridges

The materials used in the construction of bridges, including reasons for selection, applications, benefits and drawbacks.

- Reinforced concrete.
- Steel.
- Brick.
- Stone.
- Timber.

A3 Applications of bridges

Applications of bridges, including design requirements, traffic levels, loadings, benefits and drawbacks.

- Highways:
  - motorways and dual carriageways
  - local distributor roads
  - public spaces and car parks.
- Railways:
  - viaducts
  - river and road crossings.
- Pedestrian and cycle.

Learning aim B: Examine the principles of tunnelling

B1 Design considerations for tunnels

The factors that influence and impact on the design and construction of tunnels.

- Ground conditions:
  - hard rock
  - soft ground
  - sand
  - groundwater
  - gases in rocks
  - underground obstructions.
- Ground support and ground improvement methods.

B2 Construction methods for tunnels

The methods used to construct tunnels, including design considerations, applications, benefits and drawbacks.

- Construction methods:
  - cut and cover
  - drill and blast
  - pipe and box jacking
  - mini-tunnelling
  - tunnel-boring machines
  - immersed tube tunnel.
- Lining methods for tunnels:
  - segmental linings
  - jacked pipe linings
  - sprayed concrete/shotcrete.
- Approaches to shaft construction:
  - secant piling
  - sheet piling
  - diaphragm walls
  - ground freezing
  - caissons.

Learning aim C: Examine marine applications of civil engineering

C1 Coastal protection and sea walls

The methods used to construct coastal protection and sea walls, including design considerations, applications, benefits and drawbacks.

- Coastal protection methods:
  - gabions
  - groins
  - jetties.
- Sea walls:
  - bulkheads
  - revetments
  - levees and dikes
  - sheet steel pile.

C2 Cofferdams and caissons

The methods used to construct cofferdams and caissons, including design considerations, applications, benefits and drawbacks.

- Types of cofferdam:
  - braced
  - double-walled sheet pile
  - cellular
  - water-filled.
- Piling methods.
- Methods to prevent water seepage.
- Types of caissons:
  - box
  - open
  - pneumatic.

C3 Harbour works and breakwaters

The factors that influence the design of breakwaters, including applications, benefits and drawbacks.

- Types of breakwaters:
  - submerged
  - emerged
  - floating
  - offshore
  - coastal
  - beach
  - single
  - multiple.
- Types of harbour:
  - semi-natural
  - artificial.

- Features of harbours:
  - pontoons
  - jetties
  - rafts
  - landing stages
  - moorings
  - piers.
- Design parameters:
  - geology of the sea bed
  - intended purpose
  - tidal conditions
  - materials.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine different types of bridges and construction techniques		
A.P1 Explain the principles that underpin the design of different types of bridges. **A.P2** Explain the impact that material choice can have on the design of bridges. **A.P3** Explain the impact of different traffic levels on the design of a bridge.	**A.M1** Discuss the benefits and drawbacks of different approaches to bridge construction in a given situation. **A.M2** Discuss the impact of the traffic levels on bridge design in a given situation.	**A.D1** Evaluate the interaction between design considerations for a bridge in a given situation.
Learning aim B: Examine the principles of tunnelling		
B.P4 Explain the methods that can be used to construct tunnels. **B.P5** Explain the impact of ground conditions on the design of tunnels.	**B.M3** Discuss the suitability of alternative types of tunnel for a given situation.	**B.D2** Evaluate the different approaches that can be taken to construct a tunnel for a given situation.
Learning aim C: Examine marine applications of civil engineering		
C.P6 Explain the approaches used to provide coastal protection. **C.P7** Describe the reasons why cofferdams and caissons are used in civil engineering projects.	**C.M4** Discuss the suitability of alternative approaches to coastal protection for a given situation.	**C.D3** Evaluate the interaction between design parameters, methods of construction and approaches to coastal protection for a given situation.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of three summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.P3, A.M1, A.M2, A.D1)

Learning aim: B (B.P4, B.P5, B.M3, B.D2)

Learning aim: C (C.P6, C.P7, C.M4, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional resource requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will evaluate the design options that are appropriate solutions to the problem in the given scenario. They will consider alternative, appropriate approaches, justifying their proposals against the criteria given in the scenario. They will also consider the type of bridge to be used along with materials to be used. Learners' decisions must be based on the design considerations given in the scenario, for example linking the type of bridge to the location, span and expected types of traffic that will use the bridge. Learners will consider the design of the bridge, including supports, bearings, parapets and joints, and how these are affected by the design considerations of the given scenario. In their evaluation, learners will consider the interaction between design considerations and alternative proposals, justifying their decisions based on how effective they are at providing an appropriate solution.

For merit standard, learners will discuss the benefits and drawbacks of different approaches to bridge construction in relation to the given scenario. They will consider different approaches to meet the needs of the scenario, with each being suitable for the given criteria. They will also consider how different traffic levels and types of traffic will impact on designs. In their discussion, learners will consider the relationship between the intended use of the bridge and the suitability of designs.

For pass standard, learners will explain the principles that underpin the design of different types of bridge, including reference to typical applications of each. They will also explain how the design of a bridge can be affected by the choice of materials, for example lengths of span or thicknesses of decks. Learners will also explain how the design of a bridge differs depending on intended traffic levels. In their explanation, learners will show that they comprehend the principles of bridge design, the impact of material choices and the effects of different traffic levels on design.

Learning aim B

For distinction standard, learners will evaluate different, suitable tunnelling methods for a given scenario. They will consider the ground conditions that will influence and impact on the design and construction of the tunnel, and will suggest suitable approaches to construct the tunnel, taking into account the design considerations stated in the scenario, the intended use of the tunnel, along with the benefits and drawbacks of each approach. They will consider appropriate lining methods for the tunnels and propose alternative methods of shaft construction. In their evaluation, learners will consider the benefits and drawbacks of each suggested approach in meeting the needs of the given scenario.

For merit standard, learners will discuss the benefits and drawbacks of different approaches to constructing a tunnel in relation to the given scenario. They will consider different tunnelling methods that can be used, along with lining methods and shaft construction, each being assessed against the design criteria. In their discussion, learners will consider the relative merits of approaches in comparison with each other.

For pass standard, learners will explain the range of methods that can be used to construct tunnels, including examples of where each approach could be used. They will also explain how the design of a tunnel can be affected by different ground conditions. In their explanation, learners will show that they comprehend the principles of tunnelling and the impact that ground conditions can have on the selection of tunnelling methods.

Learning aim C

For distinction standard, learners will evaluate how a range of factors interact when providing coastal protections. They will consider different approaches that can be taken, for example the use of breakwaters, sea walls and harbours, and evaluate them against the design parameters given in a scenario. Learners will take into account aspects such as sea conditions, the intended purpose and the application of the coastal defences, along with different tunnelling methods that are suitable for a given scenario. They will include considerations of the methods of construction, evaluating the relative merits and disadvantages of caissons and cofferdams in relation to the given scenario. In their evaluation, learners will consider the benefits and drawbacks of each suggested approach in meeting the needs of the given scenario.

For merit standard, learners will discuss the benefits and drawbacks of different approaches to providing coastal protection for the given scenario. They will consider different methods of coastal protection that could be used, including breakwaters, sea walls and harbours, along with how caissons and coffer dams would be used in the construction of coastal protection. In their discussion, learners will consider the relative merits of the approaches in comparison with each other.

For pass standard, learners will explain the range of methods that can be used to provide coastal protection, including examples of where each approach could be used. They will also explain the reasons why coffer dams and caissons are used in the construction of coastal protection. In their explanation, learners will show that they comprehend the principles of marine civil engineering works and the impact that external factors can have on approaches taken.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 4: Safe Working Practice
- Unit 10: Surveying in Construction
- Unit 15: Measurement Techniques in Construction
- Unit 18: Work Experience
- Unit 23: Construction in Civil Engineering
- Unit 30: Public Health Engineering
- Unit 32: Highway Construction and Maintenance in Civil Engineering.

Employer involvement

This unit would benefit from employer involvement in the form of site visits.

Unit 32: Highway Construction and Maintenance in Civil Engineering

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners develop skills and understanding in highway planning, the processes involved with constructing earthworks, the methods used to provide drainage for highways, and highway maintenance.

Unit introduction

For the majority of people, highways contribute to the way in which they live. As such, civil engineers play a vital role in the planning, building and maintenance of roads and highways both in the United Kingdom and around the world. Road building has been at the centre of the civil engineering profession throughout history and can trace its heritage back both to ancient Egypt and the Romans.

In this unit, you will look at the processes that are involved in the planning and preparation of new highways, such as deciding on the location, the route that needs to be taken and the methods of construction that can be used to meet the design requirements. You will look at earthworks and how these are developed, along with different types of pavement and ways in which highways can be drained.

You will examine the methods of maintaining highways, taking into account structural and environmental issues, and apply this understanding to suggest solutions to well-defined complex and non-routine highways projects.

This unit provides progression opportunities to civil engineering sector job roles, including those related to highways, traffic and geotechnics. It can also provide the skills for progression to degrees in construction specialisms, including civil engineering.

Learning aims

In this unit you will:

A Undertake the planning and preparation works required for highway construction

B Undertake the production of plans for highway construction

C Examine maintenance procedures for highways.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Undertake the planning and preparation works required for highway construction	**A1** Introduction to planning a new highway **A2** Earthwork construction for new highways	A set of proposals for a new highway based on a given scenario, including information about preparatory activities, design of earthworks, pavement details and drainage.
B Undertake the production of plans for highway construction	**B1** Forms and methods of highway construction **B2** Drainage of highways **B3** Drainage of land and subsoils **B4** Quality control	
C Examine maintenance procedures for highways	**C1** Introduction to highway maintenance **C2** Highway maintenance processes	A report that investigates and evaluates the need for highway maintenance and approaches that can be taken to rectify defects.

Content

Learning aim A: Undertake the planning and preparation works required for highway construction

A1 Introduction to planning a new highway

Activities and responsibilities related to the planning of a new highway to ensure the route is appropriate when considered against budget, route requirements, and the line and level of the highway.

The activities relating to the planning of a new highway.

- Land acquisition:
  - procedures to acquire land
  - potential problems.
- Route location:
  - assessment of traffic volumes
  - environmental impact
  - potential earthwork problems
  - choice of alignment
  - procedures to consult public.
- Allocation of resources:
  - funding of new highways
  - private and/or public funding.
- Design of line and level:
  - factors that affect vertical alignment (level):
    - type of terrain
    - type of highway to be constructed
    - environmental features
  - factors that affect horizontal alignment (line):
    - type of terrain
    - lines of sight
    - drainage.

A2 Earthwork construction for new highways

How existing land use and conditions impact on the processes involved with the construction of earthworks for new highways.

- Site clearance:
  - advance fencing contracts
  - grubbing out
  - stripping topsoil.
- Cut and fill:
  - setting out embankments and cuttings
  - plant used
  - mass haul curves
  - computer applications.
- Embankment construction:
  - end product or method specification.

- Control of line and level:
  - suitable and unsuitable materials for fill
  - procedures and testing as work proceeds.
- Treatment of weak areas:
  - replacement
  - stabilisation
  - drainage techniques.

Learning aim B: Undertake the production of plans for highway construction

B1 Forms and methods of highway construction

The relationship between different forms of highway, the construction methods that are suitable and materials specifications for highways with a range of traffic requirements.

- Different forms of construction:
  - flexible pavements:
    - Hot Rolled Asphalt (HRA)
    - Stone Mastic Asphalt (SMA)
    - Dense Heavy Duty Macadam or Heavy Duty Macadam (HDM)
  - rigid pavements:
    - continuously reinforced concrete pavement (CRCP)
    - continuously reinforced concrete base (CRCB)
    - jointed reinforced concrete slab (JRC)
    - unreinforced jointed concrete (URC)
    - modular paved surfacing
  - tactile surfacing.
- Methods of construction:
  - paving machines
  - slip form and fixed form pavers
  - manual and semi-manual methods of constructing elements
  - use of site profiles and automatic paver guidance techniques
  - compaction procedures to include the use of different rollers and their effects.
- Material specification:
  - bituminous materials
  - concrete and cement-bound materials (CBM)
  - California bearing ratio (CBR).

B2 Drainage of highways

The relationship between methods of providing drainage for highways and the requirements of different methods of collecting run-off from paved highway surfaces.

- Surface water drains:
  - conventional kerb and gully
  - side filter drains
  - grips and ditches
  - combined kerb/main drain
  - gully spacing
  - gully construction.

- Collection of run-off from paved surfaces:
  - camber
  - crossfall
  - longitudinal fall
  - crowned channels.

B3 Drainage of land and subsoils

The relationship between methods of providing drainage of land and subsoils, the need for maintenance and the requirement to provide disposal methods for collected water.

- Land and subsoil drains:
  - arrangement of patterns
  - types of pipe
  - typical cross sections.
- Pipework:
  - connections to main drain
  - laying methods
  - support and protection
  - backfill.
- Manholes:
  - purposes
  - forms of construction
  - materials used
  - typical cross sections.
- Disposal of collected water:
  - soakaways
  - water courses
  - catchpits
  - sustainable urban drainage schemes: swales, attenuation ponds
  - associated calculations.

B4 Quality control

Use and application of quality control methods to facilitate the effective construction of highways and the benefits and drawbacks of their use.

Methods of quality control for highway construction.

- Quality control related to highways construction:
  - sampling of materials
  - temperature checks
  - analysis and testing of materials, to include cube, slump, lab based, e.g. penetration test, Softening Point Test for Bitumen
  - checks on the finished road surface.

Learning aim C: Examine maintenance procedures for highways

Use and application of maintenance to ensure defects in highways are resolved, and the benefits and drawbacks of alternative approaches.

C1 Introduction to highway maintenance

Types of maintenance, the reasons for maintenance and the processes that can be carried out.

- Different types of maintenance:
  - structural
  - routine
  - winter.
- Defects in highways:
  - structural defects
  - identification by inspection and testing
  - typical results
  - application of maintenance standards
  - selection of remedial treatments from examination and collected and established data.

C2 Highway maintenance processes

Maintenance processes:

- patching
- resurfacing
- reconstruction
- surface dressing
- use of sealants
- resetting kerbs and flags
- slurry sealing and retreading
- maintenance of setts and cobbles.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Undertake the planning and preparation works required for highway construction		**A.D1** Produce accurate and comprehensive proposals for a new highway, justifying decisions made for route location and earthwork design against resources and constraints.
A.P1 Produce proposals for methods of site preparation and earthworks required to control the line and level of a new highway. **A.P2** Explain the procedures used to plan new highways, including location, land acquisition and funding.	**A.M1** Produce accurate proposals for the activities that need to be carried out when preparing to construct a new highway, taking into account planning procedures and constraints.	
Learning aim B: Undertake the production of plans for highway construction		**B.D2** Produce accurate and comprehensive plans for highway designs, justifying decisions made for pavement and drainage.
B.P3 Produce plans for highway construction that include different forms of construction. **B.P4** Explain methods for providing surface water drainage, including land and subsoil drainage.	**B.M2** Produce accurate plans for highway designs, taking into account drainage requirements.	
Learning aim C: Examine maintenance procedures for highways		**C.D3** Justify the effectiveness of maintenance processes to resolve highway defects, with reference to own proposals and plans.
C.P5 Explain the reasons for different types of maintenance that are required for highways. **C.P6** Explain maintenance processes to resolve given highway defects.	**C.M3** Assess maintenance requirements and processes to resolve given highway defects.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, A.D1, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- maps and plans for sites and locations
- detail drawings and plans of existing and proposed highways (beneficial), including sections and profiles.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, learners will produce accurate and comprehensive proposals for the design of a new highway. They will provide justification for their decisions, referring to the route of the highway that they select and considering planning constraints, land acquisitions, availability and sources of funding. The justification will also make reference to requirements for the line and level of the proposed highway when considering the selection of earthworks. Justifications will be supported by diagrams and sketches, along with calculations, as appropriate. Learners will also justify their plans for the highway pavement in comparison to alternatives, considering all relevant factors, and use calculations and test data to support material selection and drainage requirements.

For merit standard, learners will produce accurate proposals for a highway based on given information. The proposals will consider the activities that are carried out when preparing to construct a new highway, including planning constraints and the availability of land for the proposed route. Learners will produce accurate plans for achieving the required line and level of the highway, and will specify appropriate materials and processes for the construction of the highway pavement. Learners will use calculations to support their plans for drainage through the use of calculations.

For pass standard, learners will produce proposals for a new highway, including explanations of the earthworks that will be required. Learners will explain how the earthworks will be developed, including the plant and equipment required, and the constraints associated with planning a new highway, including location, land acquisition and funding. Learners will also produce sketches and plans for the construction of the highway pavement, considering alternative approaches that could be taken, different forms of construction and also methods of providing drainage.

Learning aim C

For distinction standard, learners will use given information relating to highway defects in order to suggest and justify the effectiveness of alternative approaches. Learners will justify the effectiveness of the use of structural, routine and winter maintenance with regard to ensuring the integrity of highways. They will also interpret and justify given data from a structural survey of a highway in order to recommend appropriate remedial measures based on the levels of wear, traffic levels and resistance to abrasion. Learners will justify maintenance processes with reference to the requirements of the highway in question and their own proposals and plans.

For merit standard, learners will interpret information from a structural survey of a highway to identify defects. They will assess the maintenance requirements of the highway and suggest appropriate methods and processes to resolve defects based on the provided information. Learners will also assess the differences between structural, routine and winter maintenance, and the reasons why each is carried out.

For pass standard, learners will explain the reasons why structural, routine and winter maintenance activities are carried out on highways. The explanations will include information about how the different maintenance activities are carried out. Learners will interpret given data and explain the maintenance processes that are suitable to resolve specific defects, such as those associated with wear or weather, in highway pavements.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 7: Graphical Detailing.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

Unit 33: Offsite and Onsite Construction Methods

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners will develop skills in selecting suitable construction methods to meet local needs and wider changes in the international construction industry.

Unit introduction

New and innovative technologies, processes and materials are enabling new forms of construction that are more efficient, safer and more sustainable. There is pressure to modernise aspects of the industry, from working practices to inefficient business models and supply chains, which these new methods help to address.

In this unit, you will explore the range of methods used for offsite and onsite construction that are changing in the construction industry. You will consider how and why these changes are taking place, looking at the different types of driver that are internal and external to the construction industry. Your exploration will inform an investigation of opportunities for the use of alternative construction methods in relation to a construction project.

This unit will give you knowledge that complements other units in the qualification and also a good understanding of modern home building and design. This unit also provides a good foundation for studying construction-related subjects at a higher level, including degree-level programmes, or for starting employment as a trainee in a construction company.

Learning aims

In this unit, you will:

A Examine the different forms of construction available in industry

B Explore the drivers for different forms of construction

C Investigate the potential benefits of a specific method of construction for a given project.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Examine the different forms of construction available in industry	**A1** Offsite construction **A2** Onsite construction **A3** Renovation and adaptation **A4** Advantages and disadvantages	A report on offsite and onsite construction methods, and how they address drivers.
B Explore the drivers for different forms of construction	**B1** Construction-related drivers **B2** Non-construction drivers	
C Investigate the potential benefits of a specific method of construction for a given project	**C1** Project parameters	A research portfolio on methods of construction and their suitability for a given construction project.

Content

Learning aim A: Examine the different forms of construction available in industry

A1 Offsite construction

- Non-volumetric pre-assembly:
  - pre-assembled units/elements
  - precast concrete sections
  - pre-assembled structural steelwork
  - Steel Framing Systems (SFS).
- Volumetric pre-assembly:
  - complete unit
  - modular units.
- Panelised offsite construction:
  - framed panels (timber, steel)
  - sandwich panel systems
  - concrete panels/sections.
- Automated:
  - 3D printing
  - robotics.

A2 Onsite construction

- Green oak.
- Container.
- Straw bale.
- Cob.
- Adobe.
- Rammed earth.
- Earthship.
- Earthbag.
- Cross-laminated timber (CLT).
- Stone.
- Onsite robotics.

A3 Renovation and adaptation

- Type of change:
  - structural
  - cosmetic
  - service, e.g. electrical, heating, ventilation.
- Energy saving:
  - glazing upgrade
  - insulation
  - renewables integration.
- Cost-benefit analysis.

A4 Advantages and disadvantages

- Learners will consider different types of construction in terms of:
  - cost
  - environmental impact
  - speed and efficiency
  - quality
  - safety
  - durability.

Learning aim B: Explore the drivers for different forms of construction

B1 Construction-related drivers

- Local regulations and legislation.
- Quality control.
- Working conditions.
- New technologies and materials.
- Skills availability and shortages.
- Materials shortages.
- Speed and efficiency of assembly.
- Cost.
- Health and safety.
- Economies of scale, e.g. labour, plant hire, material, purchasing.
- Automation.
- Delivery.

B2 Non-construction drivers

- Sustainability:
  - availability of materials
  - waste
  - impact on others
  - local requirements and traditions
  - local climate
  - changes in cultural influence
  - carbon emissions
  - transport.
- Local and regional policy:
  - housing
  - economic
  - industrial
  - education.
- Population:
  - demographic
  - lifestyle
  - wealth.

Learning aim C: Investigate the potential benefits of a specific method of construction for a given project

C1 Project parameters

- Stakeholder:
  - client/developer
  - user:
    - demographics
  - contractor.
- Stakeholder needs:
  - type of project
  - spatial needs
  - quality
  - maintenance
  - finance availability.
- Local context:
  - site access
  - material availability
  - material transport
  - impact:
    - environmental
    - community.
- Sustainability:
  - quantity of material
  - sustainability of material, e.g. embodied energy, finite resources, processing requirements
  - waste.
- Legislation:
  - local planning regulations
  - applicable building regulations or legislation
  - health and safety.
- Cost:
  - budget
  - material
  - construction
  - operational
  - maintenance over lifespan.
- Time for development.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Examine the different forms of construction available in industry		**A.D1** Evaluate a selected onsite and offsite construction for application in a given project type.
A.P1 Describe onsite construction methods. **A.P2** Describe offsite construction methods.	**A.M1** Compare onsite and offsite construction methods.	
Learning aim B: Explore the drivers for different forms of construction		**B.D2** Evaluate the influence that policy, sustainability and population change have on the choice of forms of construction.
B.P3 Define the construction-based drivers that influence moves toward different forms of construction methods. **B.P4** Explain the influence of policy, sustainability and population on construction.	**B.M2** Assess the relationship between construction- and non-construction drivers for different forms of construction.	
Learning aim C: Investigate the potential benefits of a specific method of construction for a given project		**C.D3** Justify how the selection of a method of construction meets the needs and constraints of the brief.
C.P5 Outline the drivers that influence a given construction project. **C.P6** Explain the potential benefits of construction methods for a given project, based on project parameters.	**C.M3** Assess the ways in which a selected method of construction addresses project parameters.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary, along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is also further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aims: A and B (A.P1, A.P2, B.P3, B.P4, A.M1, B.M2, A.D1, B.D2)

Learning aim: C (C.P5, C.P6, C.M3, C.D3)

Further information for teachers and assessors

Resource requirements

There are no specific additional resource requirements for this unit.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, learners will consider how a range of onsite and offsite methods of construction respond to the influences of construction drivers, both generally for the industry and in relation to a given project type and location. They will also consider wider, non-construction drivers and carry out a detailed investigation of them, to include sustainability, policy and population changes. They will make clear judgements on the suitability of different alternative methods of construction in meeting the needs of the construction industry and wider social needs in a sustainable way.

For merit standard, learners will highlight key points that differentiate onsite and off-site construction methods, making relevant arguments. They will show clear understanding of the different opportunities available, how and why they are used and some of the benefits they provide, and clearly define their suitability for different types of projects. Learners will provide sound examples of how forms of construction are being used in response to policy, sustainability and population change; some points will be obvious or partially developed. They will be able to provide an outline of the construction drivers and draw conclusions as to how these drivers have an impact on moves toward selection of suitable methods of construction.

For pass standard, learners will give a general outline of alternative onsite and offsite construction methods, covering basic processes and materials used. They will have some knowledge of their benefits, including their suitability for different construction projects and localities. They will be able to provide a basic outline of the construction drivers and draw basic conclusions as to how these drivers have an impact on moves toward selection of suitable methods of construction. Learners will give general examples of how policy, sustainability and population influence construction decisions, using limited examples or illustrations to demonstrate their points.

Learning aim C

For distinction standard, learners will accurately consider all of the relevant project parameters and a range of suitable types of construction available for the project. They will consider the options and select a method that meets the broad needs of the brief, including non-construction influences. Learners will communicate their choice of a specific method of construction, justifying their choice based on clearly illustrated and valid supporting arguments.

For merit standard, learners will select an appropriate method of construction based on an in-depth evaluation of its suitability for project parameters. They will show a sound understanding of the potential to use a range of methods of construction and will align the benefits with the constraints of the brief.

For pass standard, learners will select a range of relevant methods of construction to consider for the project. They will outline how each method meets the different project parameters and will explore the potential benefits that each method provides.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 6: Construction Maths
- Unit 7: Graphical Detailing
- Unit 18: Work Experience.

Unit 34: Planning the Built Environment

Level: **3**
Unit type: **Internal**
Guided learning hours: **60**

Unit in brief

Learners will gain an understanding of the planning process, including the principles of urban planning and landscape design.

Unit introduction

The favelas of Sao Paulo, Brazil, represent an urban landscape that has sprung up organically without consideration for planning because of the need for shelter for people in extreme poverty. These unplanned environments suffer from many infrastructure problems, including, for example, the provision of adequate sanitation. The favelas highlight the importance of adequate urban and landscape design and the need to maintain the appropriate planning controls.

In this unit, you will be introduced to the factors that need to be considered when planning the built environment, and you will learn about planning control processes and procedures. You will gain an appreciation of landscape design and the importance of landscaped areas in a built environment. You will understand the principles of urban planning and renewal by studying cities across the world that have been improved by regeneration projects.

The content of this unit can be directly applied to the role of construction manager, and to aspects of the roles of commercial manager and civil engineer as they are involved in planning infrastructure and housing. The unit gives you a good foundation to study construction management and housing design subjects at a higher level, including degree-level programmes.

Learning aims

In this unit, you will:

A Explore best practice for obtaining statutory approval for the built environment

B Understand the significance of landscape design when planning the built environment

C Understand the principles of urban planning.

Summary of unit

Learning aim	Key content areas	Assessment approach
A Explore best practice for obtaining statutory approval for the built environment	**A1** Planning considerations **A2** Planning process	A presentation covering planning considerations and processes for a given proposal.
B Understand the significance of landscape design when planning the built environment	**B1** Importance of landscape design **B2** Types of landscaping	A report evaluating the importance of urban planning and landscape design for city regeneration.
C Understand the principles of urban planning	**C1** Principles of urban planning **C2** Principles of urban renewal **C3** Case study of an urban regeneration project	

Content

Learning aim A: Explore best practice for obtaining statutory approval for the built environment

A1 Planning considerations

Understand the factors considered when planning the built environment.

- Material considerations:
  - o overlooking/loss of privacy
  - o loss of daylight/sunlight or overshadowing
  - o scale and dominance
  - o layout and density of buildings
  - o appearance and design of development and materials proposed
  - o access for people with disabilities
  - o highway safety
  - o traffic and parking issues.
- Environmental consideration:
  - o noise, dust, fumes
  - o impact on character or appearance of an area
  - o effect on trees and wildlife/nature conservation
  - o sustainability
  - o biodiversity
  - o landscape design
  - o air quality
  - o water quality
  - o waste planning
  - o light pollution
  - o managing existing heritage
  - o conservation areas
  - o monuments and archaeology.
- Economic considerations:
  - o job generation
  - o impact on community
  - o regeneration.

A2 Planning process

Understand planning procedures and processes:

- scope of planning controls
- planning applications
- policies – local and government
- laws and legislations
- planning codes
- planning permission and conditions
- planning appeals
- enforcement of planning
- control of advertising
- planning for major infrastructure projects
- compulsory purchases.

Learning aim B: Understand the significance of landscape design when planning the built environment

B1 Importance of landscape design

Understand the impact and importance of landscape design.

- Ecological benefits:
  - concept of ecosystem
  - ecological balance
  - prevention of environmental degradation
  - prevention of deterioration of natural resources.
- Role of landscape design in architecture.
- Amenities

B2 Types of landscaping

Explore the different applications for landscaping:

- road landscaping
- waterfront development
- landscaping of residential areas
- industrial landscaping
- paving and street-furniture designs
- planting designs
- using form in the landscape
- colour theory in landscapes.

Learning aim C: Understand the principles of urban planning

C1 Principles of urban planning

- Urban scale.
- Mass and space.
- The component of the urban fabric.
- Types of urban space in a city and their hierarchy:
  - residential
  - commercial
  - recreational
  - industrial
  - streets.
- Quality of the built form.
- Spaces in the public domain.

C2 Principles of urban renewal

- Catalyst and drivers for urban renewal.
- Challenge of urban renewal:
  - urban sprawl.
- Implementing urban renewal:
  - public participation
  - townscape polices
  - urban design guidelines for new development.

C3 Case study of an urban regeneration project

Review case study examples of an urban regeneration project such as:

- Port Maravilha, Rio de Janeiro, Brazil
- Singapore
- Shenzhen, China
- Salford Quays, Manchester, United Kingdom
- Cheonggyecheon, Seoul, Republic of Korea
- Ahmedabad, India.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Explore best practice for obtaining statutory approval for the built environment		**A.D1** Evaluate the effectiveness of planning considerations and processes for a given proposal.
A.P1 Describe the factors that are considered when planning the built environment. **A.P2** Describe the stages of the planning process.	**A.M1** Assess the planning considerations and processes for a given proposal.	
Learning aim B: Understand the significance of landscape design when planning the built environment		**B.D2** Evaluate the effectiveness of landscape design for a given city-regeneration project.
B.P3 Explore the impact and importance of landscape design **B.P4** Describe the different applications for landscaping.	**B.M2** Assess the importance and impact of landscape design for a given city.	
Learning aim C: Understand the principles of urban planning		**C.D3** Evaluate the effectiveness of urban planning for a given regeneration project.
C.P5 Describe the principles of urban planning. **C.P6** Describe the principles of urban renewal.	**C.M3** Assess the importance of urban planning for a given city.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6 Internal assessment* gives information on setting assignments and there is further information on our website.

There is a maximum number of two summative assignments for this unit.
The relationship of the learning aims and criteria is:

Learning aim: A (A.P1, A.P2, A.M1, A.D1)

Learning aims: B and C (B.P3, B.P4, C.P5, C.P6, B.M2, C.M3, B.D2, C.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- planning control and legislation materials
- videos of urban regeneration projects across the world.

Essential information for assessment decisions

Learning aim A

For Distinction standard, learners will consider the effectiveness of a given planning proposal. They will provide a detailed evaluation of the planning process and the types of planning consideration required to achieve effective planning and development of the built environment.

For Merit standard, learners will show careful consideration of the different stages of the planning process for a given proposal. They will apply the standards and best practice planning consideration to the given proposal.

For Pass standard, learners will provide some detail of, reasons for and explanation of the different stages of the planning process, showing that they appreciate the factors considered when planning a project in the built environment. Learners will be able to describe the standards and best practice that apply to their location and include the sharing of appropriate planning information and material.

Learning aims B and C

For Distinction standard, learners will evaluate the effectiveness of landscape design and urban planning for the regeneration of part of a given city. They will consider how successful the regeneration has been in terms of the environment and economy, making clear links to urban and landscape design principles.

For Merit standard, learners will assess the importance of landscape design and urban planning for a given city. They will comment on the way the principles of landscape design and urban planning have impacted and influenced new development in the city. Learners could assess massing, the urban scale, the quality of the built forms or the public realm space.

For Pass standard, learners will explore the impact and importance of landscaped areas situated in the built environment. They will consider the ecological benefits, amenities and the impact on public realm spaces. Learners will consider the different types of areas that can be landscaped in a city, ranging from the introduction of street furniture to landscaping for development. Learners will consider landscape design in the context of the overall principles of urban planning, such as massing and space. They will study how urban planning and landscape design can be applied to encourage regeneration, reviewing case-study examples from around the world.

Links to other units

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 7: Graphical Detailing
- Unit 8: Sustainability in Construction.

Employer involvement

Centres can involve employers in the delivery of this unit if there are local opportunities to do so. There is no specific guidance related to this unit.

4 Planning your programme

How do I choose the right BTEC International Level 3 qualification for my learners?

BTEC International Level 3 qualifications come in a range of sizes, each with a specific purpose. You will need to recruit learners very carefully to ensure that they start on the right size of qualification to fit into their study programme and that they take the right pathways or optional units to allow them to progress to the next stage.

Some learners may want to take a number of complementary qualifications or keep their progression options open. These learners may be suited to taking a BTEC International Level 3 Certificate or Subsidiary Diploma. Learners who then decide to continue with a fuller vocational programme can transfer to a BTEC International Level 3 Diploma or Extended Diploma.

Some learners are sure of the sector in which they wish to work and are aiming for progression into that sector via higher education. These learners should be directed to the two-year BTEC International Level 3 Extended Diploma as the most suitable qualification.

Is there a learner entry requirement?

As a centre, it is your responsibility to ensure that the learners you recruit have a reasonable expectation of success on the programme. There are no formal entry requirements but we expect learners to have qualifications at or equivalent to Level 2.

Learners are most likely to succeed if they have:

- five International GCSEs at good grades and/or
- BTEC qualification(s) at Level 2
- other appropriate qualifications or achievement at year 11 or age 16 in core subjects.

Learners may demonstrate the ability to succeed in various ways. For example, they may have relevant work experience or specific aptitude shown through diagnostic tests or non-educational experience.

If learners are studying in English we recommend that they have attained at least Level B2 in the Common European Framework of Reference for Languages or Pearson Global Scale of English 51. Please see resources available from Pearson at www.pearson.com/english

What is involved in becoming an approved centre?

All centres must be approved before they can offer these qualifications – so that they are ready to assess learners and so that we can provide the support that is needed. Further information is given in *Section 8 Quality assurance*.

What level of sector knowledge is needed to teach these qualifications?

We do not set any requirements for teachers but recommend that centres assess the overall skills and knowledge of the teaching team to ensure that they are relevant and up to date. This will give learners a rich programme to prepare them for employment in the sector.

What resources are required to deliver these qualifications?

As part of your centre approval, you will need to show that the necessary material resources and work spaces are available to deliver BTEC International Level 3 qualifications. For some units, specific resources are required.

How can Pearson Progress help with planning for these qualifications?

Pearson Progress is a digital support system that supports the delivery, assessment and quality assurance of BTECs in centres. It supports teachers with activities such as course creation, creating and verifying assignments and creating assessment plans and recording assessment decisions.

For further information, see *Section 10 Resources and support*.

Which modes of delivery can be used for these qualifications?

You are free to deliver BTEC International Level 3 qualifications using any form of delivery that meets the needs of your learners. We recommend making use of a wide variety of modes, including direct instruction in classrooms or work environments, investigative and practical work, group and peer work, private study and e-learning.

What are the recommendations for employer involvement?

BTEC International Level 3 qualifications are vocational qualifications and, as an approved centre, you are encouraged to work with employers on design, delivery and assessment to ensure that it is engaging and relevant, and that it equips learners for progression. There are suggestions in many of the units about how employers could become involved in delivery and/or assessment but these are not intended to be exhaustive and there will be other possibilities at local level.

What support is available?

We provide a wealth of support materials, including curriculum plans, delivery guides, sample Pearson Set Assignments, authorised assignment briefs and examples of marked learner work.

You will be allocated a Standards Verifier early on in the planning stage to support you with planning your assessments. There will be extensive training programmes as well as support from our Subject Advisor team.

For further details see *Section 10 Resources and support*.

Meeting local needs

Centres should note that the qualifications set out in this specification have been developed in consultation with centres and employers for the relevant sector. Centres should make maximum use of the choice available to them within the optional units to meet the needs of their learners, and local skills and training needs.

In certain circumstances, units in this specification might not allow centres to meet a local need. In this situation, Pearson will allow centres to either make use of units from other BTEC specifications in this suite, or commission new units to meet the need. Centre developed units will need to be quality assured by Pearson at a cost. Centres are required to ensure that the coherence and purpose of the qualification is retained and to ensure that the vocational focus is not diluted.

The proportion of imported, or locally developed units that can be used are as follows. These units cannot be used at the expense of the mandatory units in any qualification.

Qualification	Meeting local needs allowance	Unit equivalence
Certificate (180 GLH)	No MLN allowed	0 units
Subsidiary Diploma (360 GLH)	60 GLH MLN allowed	1 * 60 GLH unit
Foundation Diploma (540 GLH)	120 GLH MLN allowed	e.g. 2 * 60 GLH units
Diploma (720 GLH)	180 GLH MLN allowed	e.g. 3 * 60 GLH units
Extended Diploma (1080 GLH)	240 GLH MLN allowed	e.g. 4 * 60 GLH units

How will my learners become more employable through these qualifications?

BTEC International Level 3 qualifications are mapped to relevant occupational standards, please see *Appendix 1*: *Links to industry standards*.

Employability skills, such as teamworking and entrepreneurialism, and practical, hands-on skills have been built into the design of the learning aims and content. This gives you the opportunity to use relevant contexts, scenarios and materials to enable learners to develop a portfolio of evidence that demonstrates the breadth of their skills and knowledge in a way that equips them for employment.

5 Assessment structure

Introduction

BTEC International Level 3 qualifications are assessed using a combination of *internal assessments*, which are set and marked by teachers, and *Pearson Set Assignments*, which are set by Pearson and marked by teachers.

- Mandatory units have a combination of internal and Pearson Set Assignments.
- All optional units are internally assessed.

In developing an overall plan for delivery and assessment for the programme, you will need to consider the order in which you deliver units, whether delivery is over short- or long periods and when assessment can take place.

We have addressed the need to ensure that the time allocated to final assessment of units is reasonable so that there is sufficient time for teaching and learning, formative assessment and development of transferable skills.

In administering an internal assignment or a Pearson Set Assignment, the centre needs to be aware of the specific procedures and policies that apply, for example to registration, entries and results. An overview, with signposting to relevant documents, is given in *Section 7 Administrative arrangements*.

Internal assessment

Our approach to internal assessment for these qualifications will be broadly familiar to experienced centres. It offers flexibility in how and when you assess learners, provided that you meet assessment and quality assurance requirements. You will need to take account of the requirements of the unit format, which we explain in *Section 3 Units*, and the requirements for delivering assessment given in *Section 6 Internal assessment*.

Pearson Set Assignment units

A summary of the set assignments for this qualification is given in *Section 2 Structure*. You should check this information carefully, together with the details of the unit being assessed, so that you can timetable learning and assessment periods appropriately.

Learners must take the authorised Pearson Set Assignment for the set assignment unit. Teachers are not permitted to create their own assessments for set assignment units. Some assignments may need to be taken in controlled conditions. These are described in each unit.

Please see *Section 6* for resubmission and retaking regulations.

6 Internal assessment

This section gives an overview of the key features of internal assessment and how you, as an approved centre, can offer it effectively. The full requirements and operational information are given in the *BTEC International Quality Assurance Handbook*. All members of the assessment team need to refer to this document.

For BTEC International Level 3 qualifications, it is important that you can meet the expectations of stakeholders and the needs of learners by providing a programme that is practical and applied. Centres can tailor programmes to meet local needs and use links with local employers and the wider vocational sector.

When internal assessment is operated effectively, it is challenging, engaging, practical and up to date. It must also be fair to all learners and meet international standards.

All units in these qualifications are internally assessed but Pearson sets assignments for some units.

Principles of internal assessment (applies to all units)

Assessment through assignments

For all units, the format of assessment is an assignment taken after the content of the unit, or part of the unit if several assignments are used, has been delivered. An assignment may take a variety of forms, including practical and written types. An assignment is a distinct activity, completed independently by learners, that is separate from teaching, practice, exploration and other activities that learners complete with direction from teachers.

An assignment is issued to learners as an assignment brief with a defined start date, a completion date and clear requirements for the evidence that they need to provide. There may be specific observed practical components during the assignment period. Assignments can be divided into tasks and may require several forms of evidence. A valid assignment will enable a clear and formal assessment outcome, based on the assessment criteria. For most units, teachers will set the assignments. For Pearson Set Assignment units, Pearson will set the assignment.

Assessment decisions through applying unit-based criteria

Assessment decisions for BTEC International Level 3 qualifications are based on the specific criteria given in each unit and set at each grade level. To ensure that standards are consistent in the qualification and across the suite as a whole, the criteria for each unit have been defined according to a framework. The way in which individual units are written provides a balance of assessment of understanding, practical skills and vocational attributes appropriate to the purpose of qualifications.

The assessment criteria for a unit are hierarchical and holistic. For example, if an M criterion requires the learner to show 'analysis' and the related P criterion requires the learner to 'explain', then to satisfy the M criterion, a learner will need to cover both 'explain' and 'analyse'. The unit assessment grid shows the relationships between the criteria so that assessors can apply all the criteria to the learner's evidence at the same time. In *Appendix 4: Glossary of terms used*, we have set out a definition of terms that assessors need to understand.

Assessors must show how they have reached their decisions using the criteria in the assessment records. When a learner has completed all the assessment for a unit, then the assessment team will give a grade for the unit. This is given according to the highest level for which the learner is judged to have met all the criteria. Therefore:

- to achieve a Distinction, a learner must have satisfied all the Distinction criteria (and therefore the Pass and Merit criteria); these define outstanding performance across the unit as a whole
- to achieve a Merit, a learner must have satisfied all the Merit criteria (and therefore the Pass criteria) through high performance in each learning aim
- to achieve a Pass, a learner must have satisfied all the Pass criteria for the learning aims, showing coverage of the unit content and therefore attainment at Level 3 of the qualification.

The award of a Pass is a defined level of performance and cannot be given solely on the basis of a learner completing assignments. Learners who do not satisfy the Pass criteria should be reported as Unclassified.

The assessment team

It is important that there is an effective team for internal assessment. There are three key roles involved in implementing assessment processes in your centre, each with different interrelated responsibilities; the roles are listed below. There is detailed information in the *BTEC International Quality Assurance Handbook*.

- The Lead Internal Verifier (the Lead IV) has overall responsibility for the programme, its assessment and internal verification, record keeping and liaison with the Standards Verifier, ensuring our requirements are met. The Lead IV acts as an assessor, standardises and supports the rest of the assessment team, making sure that they have the information they need about our assessment requirements and organises training, making use of our standardisation, guidance and support materials.
- Internal Verifiers (IVs) oversee all assessment activities in consultation with the Lead IV. They check that assignments and assessment decisions are valid and that they meet our requirements. IVs will be standardised by working with the Lead IV. Normally, IVs are also assessors but they do not verify their own assessments.
- Assessors set or use assignments to assess learners. Before making any assessment decisions, assessors participate in standardisation activities led by the Lead IV. They work with the Lead IV and IVs to ensure that the assessment is planned and carried out in line with our requirements.

Effective organisation

Internal assessment needs to be well organised so that the progress of learners can be tracked and so that we can monitor that assessment is being carried out. We support you through, for example, providing training materials and sample documentation. Our online Pearson Progress service can help support you in planning and record keeping. Further information on using Pearson Progress can be found in *Section 10 Resources and support*, and on our website.

It is particularly important that you manage the overall assignment programme and deadlines to make sure that learners are able to complete assignments on time.

Learner preparation

To ensure that you provide effective assessment for your learners, you need to make sure that they understand their responsibilities for assessment and the centre's arrangements.

From induction onwards, you will want to ensure that learners are motivated to work consistently and independently to achieve the requirements of the qualifications. Learners need to understand how assignments are used, the importance of meeting assignment deadlines and that all the work submitted for assessment must be their own.

You will need to give learners a guide that explains how assignments are used for assessment, how assignments relate to the teaching programme and how learners should use and reference source materials, including what would constitute plagiarism. The guide should also set out your approach to operating assessment, such as how learners must submit work and request extensions.

Making valid assessment decisions

Authenticity of learner work

Once an assessment has begun, learners must not be given feedback on progress towards fulfilling the targeted criteria.

An assessor must assess only learner work that is authentic, i.e. learners' own independent work. Learners must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work.

Assessors must ensure that evidence is authentic to a learner through setting valid assignments and supervising them during the assessment period. Assessors must take care not to provide direct input, instructions or specific feedback that may compromise authenticity.

Assessors must complete a declaration that:

- to the best of their knowledge 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.

Centres can use Pearson templates or their own templates to document authentication.

During assessment, an assessor may suspect that some or all of the evidence from a learner is not authentic. The assessor must then take appropriate action using the centre's policies for malpractice. Further information is given in *Section 7 Administrative arrangements*.

Making assessment decisions using criteria

Assessors make judgements using the criteria. The evidence from a learner can be judged using all the relevant criteria at the same time. The assessor needs to make a judgement against each criterion that evidence is present and sufficiently comprehensive. For example, the inclusion of a concluding section may be insufficient to satisfy a criterion requiring 'evaluation'.

Assessors should use the following information and support in reaching assessment decisions:

- the *Essential information for assessment decisions* section in each unit gives examples and definitions related to terms used in the criteria
- the explanation of key terms in *Appendix 4: Glossary of terms used*
- examples of assessed work provided by Pearson
- your Lead IV and assessment team's collective experience.

Pass and Merit criteria relate to individual learning aims. The Distinction criteria as a whole relate to outstanding evidence across the unit. Therefore, criteria may relate to more than one learning aim (for example A.D1) or to several learning aims (for example DE.D3). Distinction criteria make sure that learners have shown that they can perform consistently at an outstanding level across the unit and/or that they are able to draw learning together across learning aims.

Issuing assessment decisions and feedback

Once the assessment team has completed the assessment process for an assignment, the outcome is a formal assessment decision. This is recorded formally and reported to learners.

The information given to the learner:

- must show the formal decision and how it has been reached, indicating how or where criteria have been met
- may show why attainment against criteria has not been demonstrated
- must not provide feedback on how to improve evidence
- must be validated by an IV before it is given to the learner.

Planning and record keeping

For internal processes to be effective, an assessment team needs to be well organised and keep effective records. The centre will work closely with us so that we can ensure that standards are being satisfied and achieved. This process gives stakeholders confidence in the assessment approach.

The programme must have an assessment plan validated by the Lead IV, produced as a spreadsheet. When producing a plan, the assessment team needs to consider:

- the time required for training and standardisation of the assessment team
- the time available to undertake teaching and carry out assessment, taking account of when learners may complete assessments and when quality assurance will take place
- the completion dates for different assignments and the name of each Assessor
- who is acting as the Internal Verifier for each assignment and the date by which the assignment needs to be internally verified

- setting an approach to sampling assessor decisions though internal verification that covers all assignments, assessors and a range of assessment decisions
- how to manage the assessment and verification of learners' work so that they can be given formal decisions promptly
- how resubmission opportunities can be scheduled.

The Lead IV will also maintain records of assessment undertaken. The key records are:

- internal verification of assignment briefs
- learner authentication declarations
- assessor decisions on assignments, with feedback given to learners
- internal verification of assessment decisions
- assessment tracking for the unit.

There are examples of records and further information in the *BTEC International Quality Assurance Handbook*.

Setting effective assignments (applies to all units without Pearson set assignments)

Setting the number and structure of assignments

This section does not apply to set assignment units. In setting your assignments, you need to work with the structure of assignments shown in the *Essential information for assignments* section of a unit. This shows the structure of the learning aims and criteria that you must follow and the recommended number of assignments that you should use. For these units we provide sample authorised assignment briefs and we give you suggestions on how to create suitable assignments. You can find these materials on our website. In designing your own assignment briefs, you should bear in mind the following points.

- The number of assignments for a unit must not exceed the number shown in *Essential information for assignments*. However, you may choose to combine assignments, for example to create a single assignment for the whole unit.
- You may also choose to combine all or parts of different units into single assignments, provided that all units and all their associated learning aims are fully addressed in the programme overall. If you choose to take this approach, you need to make sure that learners are fully prepared so that they can provide all the required evidence for assessment and that you are able to track achievement in the records.
- A learning aim must always be assessed as a whole and must not be split into two or more assignments.
- The assignment must be targeted to the learning aims but the learning aims and their associated criteria are not tasks in themselves. Criteria are expressed in terms of the outcome shown in the evidence.
- You do not have to follow the order of the learning aims of a unit in setting assignments but later learning aims often require learners to apply the content of earlier learning aims and they may require learners to draw their learning together.

- Assignments must be structured to allow learners to demonstrate the full range of achievement at all grade levels. Learners need to be treated fairly by being given the opportunity to achieve a higher grade if they have the ability.
- As assignments provide a final assessment, they will draw on the specified range of teaching content for the learning aims. The specified content is compulsory. The evidence for assessment need not cover every aspect of the teaching content as learners will normally be given particular examples, case studies or contexts in their assignments. For example, if a learner is carrying out one practical performance, or an investigation of one organisation, then they will address all the relevant range of content that applies in that instance.

Providing an assignment brief

A good assignment brief is one that, through providing challenging and realistic tasks, motivates learners to provide appropriate evidence of what they have learned.

An assignment brief should have:

- a vocational scenario, this could be a simple situation or a full, detailed set of vocational requirements that motivates the learner to apply their learning through the assignment
- clear instructions to the learner about what they are required to do, normally set out through a series of tasks
- an audience or purpose for which the evidence is being provided
- an explanation of how the assignment relates to the unit(s) being assessed.

Forms of evidence

BTECs have always allowed for a variety of forms of evidence to be used – provided that they are suited to the type of learning aim being assessed. For many units, the practical demonstration of skills is necessary and, for others, learners will need to carry out their own research and analysis. The units give you information on what would be suitable forms of evidence to give learners the opportunity to apply a range of employability or transferable skills. Centres may choose to use different suitable forms of evidence to those proposed. Overall, learners should be assessed using varied forms of evidence.

Full definitions of types of assessment are given in *Appendix 4: Glossary of terms used*. These are some of the main types of assessment:

- written reports
- projects
- time-constrained practical assessments with observation records and supporting evidence
- recordings of performance
- sketchbooks, working logbooks, reflective journals
- presentations with assessor questioning.

The form(s) of evidence selected must:

- allow the learner to provide all the evidence required for the learning aim(s) and the associated assessment criteria at all grade levels
- allow the learner to produce evidence that is their own independent work
- allow a verifier to independently reassess the learner to check the assessor's decisions.

For example, when you are using performance evidence, you need to think about how supporting evidence can be captured through recordings, photographs or task sheets.

Centres need to take particular care that learners are enabled to produce independent work. For example, if learners are asked to use real examples, then best practice would be to encourage them to use their own or to give the group a number of examples that can be used in varied combinations.

Late completion, resubmission and retakes (applies to all units including Pearson set assignment units)

Dealing with late completion of assignments for internally-assessed units

Learners must have a clear understanding of the centre policy on completing assignments by the deadlines that you give them. Learners may be given authorised extensions for legitimate reasons, such as illness at the time of submission, in line with your centre policies.

For assessment to be fair, it is important that learners are all assessed in the same way and that some learners are not advantaged by having additional time or the opportunity to learn from others. Therefore, learners who do not complete assignments by your planned deadline or by the authorised extension deadline may not have the opportunity to subsequently resubmit.

If you accept a late completion by a learner, then the assignment should be assessed normally when it is submitted, using the relevant assessment criteria.

Resubmission of improved evidence for internally-assessed units

An assignment provides the final assessment for the relevant learning aims and is normally a final assessment decision, except where the Lead IV approves one opportunity to resubmit improved evidence based on the completed assignment brief.

The Lead IV has the responsibility to make sure that resubmission is operated fairly. This means:

- checking that a learner can be reasonably expected to perform better through a second submission, for example that the learner has not performed as expected
- making sure that giving a further opportunity can be done in such a way that it does not give an unfair advantage over other learners, for example through the opportunity to take account of feedback given to other learners
- checking that the assessor considers that the learner will be able to provide improved evidence without further guidance and that the original evidence submitted has been authenticated by both the learner and assessor and remains valid.

Once an assessment decision has been given to the learner, the resubmission opportunity must have a deadline within 15 working days after the timely issue of assessment feedback to learners, which is within term time in the same academic year.

A resubmission opportunity must not be provided where learners:

- have not completed the assignment by the deadline without the centre's agreement
- have submitted work that is not authentic.

We recognise that there are circumstances where the resubmission period may fall outside of the 15-day limit owing to a lack of resources being available, for example where learners may need to access a performance space or have access to specialist equipment. Where it is practical to do so, for example evaluations, presentations, extended writing, resubmission must remain within the normal 15-day period.

Retake of internal assessment

A learner who has not achieved the level of performance required to pass the relevant learning aims after resubmission of an assignment may be offered a single retake opportunity using a new assignment. The retake may be achieved at a Pass only.

The Lead Internal Verifier must authorise a retake of an assignment only in exceptional circumstances where they believe it is necessary, appropriate and fair to do so. The retake is not timebound and the assignment can be attempted by the learner on a date agreed between the Lead IV and assessor within the same academic year.

For further information on offering a retake opportunity, you should refer to the *BTEC Centre Guide to Internal Assessment*.

7 Administrative arrangements

Introduction

This section focuses on the administrative requirements for delivering a BTEC qualification. It is of particular value to Quality Nominees, Lead IVs, Programme Leaders and Examinations Officers.

Learner registration and entry

Shortly after learners start the programme of learning, you need to make sure that they are registered for the qualification and that appropriate arrangements are made for internal assessment. You need to refer to relevant section for BTEC International in the *Information Manual* for information on making registrations for the qualification.

Learners can be formally assessed only for a qualification on which they are registered. If learners' intended qualifications change, for example if a learner decides to choose a different pathway specialism, then the centre must transfer the learner appropriately.

Access to assessment

Assessments need to be administered carefully to ensure that all learners are treated fairly, and that results and certification are issued on time to allow learners to progress to their chosen progression opportunities.

Our equality policy requires that all learners should 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 are not, when they are undertaking one of our qualifications, disadvantaged in comparison to 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 document *Supplementary guidance for reasonable adjustments and special consideration*.

Administrative arrangements for assessment

Records

You are required to retain records of assessment for each learner. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information can be found in the relevant section for BTEC International in the *Information Manual*. We may ask to audit your records, so they must be retained as specified.

Reasonable adjustments to assessment

To ensure that learners have fair access to demonstrate the requirements of the assessments, a reasonable adjustment is one that is made before a learner takes an assessment. You are able to make adjustments to internal assessments to take account of the needs of individual learners. In most cases, this can be achieved through a defined time extension or by adjusting the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. You need to plan for time to make adjustments if necessary.

Further details on how to make adjustments for learners with protected characteristics are given on our website, in the document *Supplementary guidance for reasonable adjustments and special consideration*.

Special consideration

Special consideration is given after an assessment has taken place for learners who have been affected by adverse circumstances, such as illness. You must operate special consideration in line with our policy (see above). You can give special consideration related to the period of 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 if they are in line with the policy.

Appeals against assessment

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 could be a consideration of the evidence by a Lead IV 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. Learners have a final right of appeal to Pearson but only if the procedures that you have put in place have not been followed. Further details are given in the document *Enquiries and appeals about Pearson vocational qualifications and end point assessment policy*.

Conducting set assignments

Centres must make arrangements for the secure delivery of Pearson Set Assignments.

At least one Pearson Set Assignment will be available each year for each unit with an additional one provided for resit. Centres must not select an assignment that learners have attempted already.

Each set assignment has a defined degree of control under which it must take place. We define degrees of control as follows.

Medium control

This is completion of assessment, usually over a longer period of time, which may include a period of controlled conditions. The controlled conditions may allow learners to access resources, prepared notes or the internet to help them complete the assignment.

Low control

These are activities completed without direct supervision. They may include research, preparation of materials and practice.

Each set assignment unit will contain instructions in the *Essential information for assignments* section on how to conduct the assessment of that unit.

Some set assignments will need to be taken with limited controls. Limited controls are described in each unit and may include the following conditions:

- Time: each assignment has a recommended time period. This is for advice only and can be adjusted depending on the needs of learners.
- Supervision: you should be confident of the authenticity of learner's work. This may mean that learners be supervised.
- Resources: all learners should have access to the same types of resources to complete the assignment.
- Research: learners should be given the opportunity to carry out research outside of the learning context if required for the assignment.

Schools and colleges must be able to confirm that learner evidence is authentic.

Dealing with malpractice in assessment

Malpractice means acts that undermine the integrity and validity of assessment, the certification of qualifications, and/or that may damage the authority of those responsible for delivering the assessment and certification.

Pearson does not tolerate actions (or attempted actions) of malpractice by learners, centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on learners, centre staff or centres where incidents (or attempted incidents) of malpractice have been proven.

Malpractice may arise or be suspected in relation to any unit or type of assessment within the qualification. For further details regarding malpractice and advice on preventing malpractice by learners, please see Pearson's *Centre guidance: Dealing with malpractice and maladministration*, available on our website.

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Learners must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. The *Centre Guidance: Dealing with malpractice and maladministration* document gives comprehensive information on the actions we expect you to take.

Pearson may conduct investigations if we believe that a centre is failing to conduct internal assessment according to our policies. The above document gives further information and examples, and details the penalties and sanctions that may be imposed.

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

Learner malpractice

Learner malpractice refers to any act by a learner that compromises or which seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Learner malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form should be emailed to candidatemalpractice@pearson.com. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with learner malpractice, staff and centre malpractice is any act that compromises or which seeks to compromise the process of assessment, or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2* (available at www.jcq.org.uk/exams-office/malpractice).

The form, supporting documentation and as much information as possible should be emailed to pqsmalpractice@pearson.com. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More detailed guidance on malpractice can be found in the latest version of the document *JCQ Suspected Malpractice Policies and Procedures*, available at www.jcq.org.uk/exams-office/malpractice.

Sanctions and appeals

Where malpractice is proven, we may impose sanctions or penalties.

Where learner malpractice is evidenced, penalties may be imposed such as:

- disqualification from the qualification
- being barred from registration for Pearson qualifications for a period of time.

If we are concerned about your centre's quality procedures, we may impose sanctions, such as:

- working with you to create an improvement action plan
- requiring staff members to receive further training
- placing temporary blocks on your certificates
- placing temporary blocks on registration of learners
- debarring staff members or the centre from delivering Pearson qualifications
- suspending or withdrawing centre approval status.

The centre will be notified if any of these apply.

Pearson has established procedures for centres that are considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from Heads of Centres (on behalf of learners and/or members of staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in our document *Internal assessment in vocational qualifications: reviews and appeals policy*, which is on our website. In the initial stage of any aspect of malpractice, please notify the Investigations Team by email via pqsmalpractice@pearson.com, who will inform you of the next steps.

Certification and results

Once a learner has completed all the required components for a qualification, the centre can claim certification for the learner, provided that quality assurance has been successfully completed. For the relevant procedures, please refer to the BTEC International section of our *Information Manual*. You can use the information provided on qualification grading to check overall qualification grades.

Changes to qualification requests

Where a learner who has taken a qualification wants to resit a unit to improve their qualification grade, you firstly need to decline their overall qualification grade. You may decline the grade before the certificate is issued.

Additional documents to support centre administration

As an approved centre, you must ensure that all staff delivering, assessing and administering the qualifications have access to the following documentation. These documents are reviewed annually and are reissued if updates are required.

- *BTEC International Quality Assurance Handbook*: this sets out how we will carry out quality assurance of standards and how you need to work with us to achieve successful outcomes.
- *Information Manual*: this gives procedures for registering learners for qualifications, transferring registrations and claiming certificates.
- *Regulatory policies*: our regulatory policies are integral to our approach and explain how we meet internal and regulatory requirements. We review the regulated policies annually to ensure that they remain fit for purpose. Policies related to this qualification include:
    - adjustments for candidates with disabilities and learning difficulties, access arrangements and reasonable adjustments for general and vocational qualifications
    - age of learners
    - centre guidance for dealing with malpractice
    - recognition of prior learning and process.

This list is not exhaustive and a full list of our regulatory policies can be found on our website.

8 Quality assurance

Centre and qualification approval

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

- Centres must have appropriate physical resources (for example equipment, IT, learning materials, teaching rooms) to support the delivery and assessment of the qualification.
- 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 qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by learners.
- Centres must deliver the qualification in accordance with current equality and diversity legislation and/or regulations.
- Centres should refer to the *Further information for teachers and assessors* section in individual units to check for any specific resources required.

Continuing quality assurance and standards verification

On an annual basis, we produce the *BTEC International Quality Assurance Handbook*. It contains 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; the centre must abide by these conditions throughout the period of delivery
- Pearson makes available to approved centres resources and processes that exemplify assessment and appropriate standards. Approved centres must use these 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 Level 3 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 delivering and quality assuring its BTEC programmes.

Centres that do not fully address and maintain rigorous approaches to delivering, assessing and quality assurance cannot seek certification for individual programmes or for all BTEC Level 3 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 comply with remedial action plans may have their approval to deliver qualifications removed.

9 Understanding the qualification grade

Awarding and reporting for the qualification

This section explains the rules that we apply in awarding a qualification and in providing an overall qualification grade for each learner. It shows how all the qualifications in this sector are graded.

Eligibility for an award

In order to be awarded a qualification, a learner must complete all units AND achieve a Pass or above in all mandatory units unless otherwise specified. Refer to the structure in *Section 2 Structure*.

To achieve any qualification grade, learners must:

- complete and have an outcome (D, M, P or U) for all units within a valid combination
- achieve the **required units at Pass or above** shown in *Section 2*, abiding by the minimum requirements in the compensation table below
- achieve the **minimum number of points** at a grade threshold.

It is the responsibility of a centre to ensure that a correct unit combination is adhered to. Learners who do not achieve the required minimum grade (P) in units shown in the structure will not achieve a qualification.

Learners who do not achieve sufficient points for a qualification or who do not achieve all the required units may be eligible to achieve a smaller qualification in the same suite, provided they have completed and achieved the correct combination of units and met the appropriate qualification grade points threshold.

Compensation table

Qualification	Compensation rule	Unit equivalence
Certificate (180 GLH)	No compensation allowed	0 units
Subsidiary Diploma (360 GLH)	Mandatory must be passed, 60 GLH only at U grade permitted from optional	1 * 60 GLH unit
Foundation Diploma (540 GLH)	Mandatory must be passed, 120 GLH only at U grade permitted from optional	2 * 60 GLH units
Diploma (720 GLH)	Mandatory must be passed, 180 GLH only at U grade permitted from optional	3 * 60 GLH units
Extended Diploma (1080 GLH)	Mandatory must be passed, 180 GLH only at U grade permitted from optional	3 * 60 GLH units

Calculation of the qualification grade

The final grade awarded for a qualification represents an aggregation of a learner's performance across the qualification. As the qualification grade is an aggregate of the total performance, there is some element of compensation in that a higher performance in some units may be balanced by a lower outcome in others.

If a learner achieves more than the required number of optional units, the mandatory units, along with the optional units with the highest grades, will be used to calculate the overall result, subject to the eligibility requirements for that particular qualification title.

BTEC International Level 3 qualifications are awarded at the grade ranges shown in the table below.

Qualification	Available grade range
Certificate, Subsidiary Diploma, Foundation Diploma	P to D*
Diploma	PP to D*D*
Extended Diploma	PPP to D*D*D*

The *Calculation of qualification grade* table, given later in this section, shows the minimum thresholds for calculating these grades. The table will be kept under review over the lifetime of the qualification. In the event of any change, centres will be informed before the start of teaching for the relevant cohort and an updated table will be issued on our website.

Learners who do not meet the minimum requirements for a qualification grade to be awarded will be recorded as Unclassified (U) and will not be certificated. They may receive a Notification of Performance for individual units. The *Information Manual* gives full information.

Points available for units

The table below shows the number of **points** available for units. For each unit, points are allocated depending on the grade awarded.

	Unit size
	60 GLH
U	0
Pass	6
Merit	10
Distinction	16

Claiming the qualification grade

Pearson will automatically calculate the qualification grade for your learners when the unit grades are submitted and the qualification claim is made. Learners will be awarded qualification grades for achieving the sufficient number of points within the ranges shown in the relevant *Calculation of qualification grade* table.

Calculation of qualification grade

Applicable for registration from 1 April 2020.

Certificate		Subsidiary Diploma		Foundation Diploma		Diploma		Extended Diploma	
180 GLH		**360 GLH**		**540 GLH**		**720 GLH**		**1080 GLH**	
Grade	**Points threshold**	**Grade**	**Points threshold**	**Grade**	**Points threshold**	**Grade**	**Points threshold**	**Grade**	**Points threshold**
U	0	U	0	U	0	U	0	U	0
Pass	18	P	36	P	54	PP	72	PPP	108
						MP	88	MPP	124
								MMP	140
Merit	26	M	52	M	78	MM	104	MMM	156
						DM	124	DMM	176
								DDM	196
Distinction	42	D	74	D	108	DD	144	DDD	218
						D*D	162	D*DD	234
								D*D*D	252
Distinction*	48	D*	90	D*	138	D*D*	180	D*D*D*	270

This table is subject to review over the lifetime of the qualification. The most up-to-date version will be issued via our website.

Examples of grade calculations based on table applicable to registrations from April 2020

Example 1: Achievement of a Certificate with a P grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Merit	10
Unit 3	60	Int Set	Pass	6
Totals	**180**		**P**	**22**

The learner has sufficient points for a P grade.

Example 2: Achievement of a Certificate with an M grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Merit	6
Unit 2	60	Int Set	Distinction	16
Unit 3	60	Int Set	Merit	10
Totals	**180**		**M**	**32**

The learner has sufficient points for an M grade.

Example 3: An Unclassified result for a Certificate

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	U	0
Unit 2	60	Int Set	Distinction	16
Unit 3	60	Int Set	Pass	6
Totals	**180**		**U**	**22**

The learner has a U in Unit 1.

The learner has sufficient points for a P grade but has not met the minimum requirement for a grade in Unit 1.

Examples of grade calculations based on table applicable to registrations from April 2020

Example 1: Achievement of a Subsidiary Diploma with a P grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Pass	6
Unit 3	60	Int Set	Merit	10
Unit 7	60	Int	Unclassified	0
Unit 9	60	Int	Merit	10
Unit 11	60	Int	Pass	6
Totals	**360**		**P**	**38**

The learner has achieved P or higher in Units 1, 2 and 3.

The learner has sufficient points for a P grade.

Example 2: Achievement of a Subsidiary Diploma with an M grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Merit	10
Unit 3	60	Int Set	Distinction	16
Unit 15	60	Int	Distinction	16
Unit 16	60	Int	Merit	10
Unit 19	60	Int	Unclassified	0
Totals	**360**		**M**	**58**

The learner has sufficient points for an M grade.

Example 3: An Unclassified Result for a Subsidiary Diploma

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Merit	10
Unit 2	60	Int Set	Unclassified	0
Unit 3	60	In Set	Distinction	16
Unit 13	60	Int	Merit	10
Unit 21	60	Int	Merit	10
Unit 22	60	Int	Pass	6
Totals	**360**		**U**	**52**

The learner has a U in Unit 2.

The learner has sufficient points for an M grade but has not met the minimum requirement for a P or higher in Units 1, 2 and 3.

Examples of grade calculations based on table applicable to registrations from April 2020

Example 1: Achievement of a Foundation Diploma with a P grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Pass	6
Unit 3	60	Int Set	Pass	6
Unit 9	60	Int	Pass	6
Unit 15	60	Int	Pass	6
Unit 17	60	Int	Unclassified	0
Unit 22	60	Int	Distinction	16
Unit 23	60	Int	Pass	6
Unit 31	60	Int	Pass	6
Totals	**540**		**P**	**58**

The learner has achieved P or higher in Units 1 to 3.

The learner has sufficient points for a P grade.

Example 2: Achievement of a Foundation Diploma with an M grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Merit	10
Unit 2	60	Int Set	Merit	10
Unit 3	60	Int Set	Pass	6
Unit 13	60	Int	Pass	6
Unit 17	60	Int	Distinction	16
Unit 18	60	Int	Merit	10
Unit 23	60	Int	Pass	10
Unit 25	60	Int	Merit	10
Unit 29	60	Int	Merit	10
Totals	**540**		**M**	**88**

The learner has sufficient points for an M grade.

Example 3: An Unclassified result for a Foundation Diploma

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Merit	10
Unit 2	60	Int Set	U	0
Unit 3	60	Int Set	Pass	6
Unit 7	60	Int	Merit	6
Unit 8	60	Int	Distinction	16
Unit 10	60	Int	Distinction	16
Unit 20	60	Int	Distinction	16
Unit 30	60	Int	Pass	6
Unit 31	60	Int	Pass	6
Totals	**540**		**U**	**82**

The learner has a U in Unit 2.

The learner has sufficient points for an M grade but has not met the minimum requirement for P or higher in Unit 2

Examples of grade calculations based on table applicable to registrations from April 2020

Example 1: Achievement of a Diploma with a PP grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Pass	6
Unit 3	60	Int Set	Pass	6
Unit 4	60	Int Set	Pass	6
Unit 5	60	Set Int	Pass	6
Unit 6	60	Int	Merit	10
Unit 7	60	Int	U	0
Unit 8	60	Int	Pass	6
Unit 9	60	Int	Pass	6
Unit 11	60	Int	Pass	6
Unit 13	60	Int	Merit	10
Unit 14	60	Int	Merit	10
Totals	**720**		**PP**	**78**

The learner has achieved P or higher in Units 1 to 6.

The learner has sufficient points for a PP grade.

Example 2: An Unclassified result for a Diploma

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	U	0
Unit 3	60	Int Set	U	0
Unit 4	60	Int Set	Pass	6
Unit 5	60	Int Set	Pass	6
Unit 6	60	Int	Merit	10
Unit 7	60	Int	Pass	6
Unit 8	60	Int	Merit	10
Unit 22	60	Int	Merit	10
Unit 25	60	Int	Pass	6
Unit 27	60	Int	Distinction	16
Unit 32	60	int	Merit	10
Totals	**720**		**U**	**86**

The learner has a U in Units 2 and 3.

Examples of grade calculations based on table applicable to registrations from April 2020

Example 1: Achievement of an Extended Diploma with a PPP grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Pass	6
Unit 3	60	Int Set	Pass	6
Unit 4	60	Int Set	Pass	6
Unit 5	60	Int	Pass	6
Unit 6	60	Int	Pass	6
Unit 7	60	Int	Distinction	16
Unit 8	60	Int	U	0
Unit 9	60	Int	Pass	6
Unit 10	60	Int	Pass	6
Unit 11	60	Int	Pass	6
Unit 12	60	Int	Pass	6
Unit 13	60	Int	Pass	6
Unit 14	60	Int	Pass	6
Unit 15	60	Int	Merit	10
Unit 16	60	Int	Merit	10
Unit 17	60	Int	Pass	6
Unit 18	60	Int	Pass	6
Totals	**1080**		**PPP**	**120**

The learner has achieved P or higher in Units 1 to 7.

The learner has sufficient points for a PPP grade.

Example 2: Achievement of an Extended Diploma with a DDM grade

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Pass	6
Unit 3	60	Int Set	Distinction	16
Unit 4	60	Int Set	Merit	10
Unit 5	60	Int Set	Distinction	16
Unit 6	60	Int Set	Distinction	16
Unit 7	60	Int Set	Merit	10
Unit 8	60	Int	Distinction	16
Unit 9	60	Int	Distinction	16
Unit 10	60	Int	Merit	10
Unit 11	60	Int	Merit	10
Unit 12	60	Int	Distinction	16
Unit 13	60	Int	Pass	6
Unit 14	60	Int	Merit	10
Unit 15	60	Int	Merit	10
Unit 16	60	Int	Pass	6
Unit 17	60	Int	Merit	10
Unit 18	60	Int	Pass	6
Totals	**1080**		**DDM**	**196**

The learner has sufficient points for a DDM grade.

Example 3: An Unclassified result for an Extended Diploma

	GLH	Type (Int/Int Set)	Grade	Unit points
Unit 1	60	Int Set	Pass	6
Unit 2	60	Int Set	Merit	10
Unit 3	60	Int Set	Pass	6
Unit 4	60	Int Set	Merit	10
Unit 5	60	Int	Pass	6
Unit 6	60	Int	Merit	10
Unit 7	60	Int	Distinction	16
Unit 8	60	Int	Merit	10
Unit 9	60	Int	Unclassified	0
Unit 10	60	Int	Merit	10
Unit 11	60	Int	Unclassified	0
Unit 12	60	Int	Unclassified	0
Unit 13	60	Int	Unclassified	0
Unit 14	60	Int	Merit	10
Unit 15	60	Int	Pass	6
Unit 16	60	Int	Pass	6
Unit 17	60	Int	Merit	10
Unit 18	60	Int	Merit	10
Totals	**1080**		**U**	**128**

The learner has 240 GLH at U.

The learner has sufficient points for an MPP and has achieved P or higher for Units 1 to 7 but has not met the minimum requirement for 900 GLH at Pass or above.

10 Resources and support

Our aim is to give you a wealth of resources and support to enable you to deliver BTEC International Level 3 qualifications with confidence. You will find a list of resources to support teaching and learning, and professional development on our website.

Support for setting up your course and preparing to teach

Specification

The specification (for teaching from April 2020) gives you details of the administration of the qualifications and information on the units for the qualifications.

Pearson Progress

Pearson Progress is a digital support system that helps you to manage the assessment and quality assurance of the Pearson BTEC International Level 3 Building Services Engineering, Civil Engineering, Construction and the Built Environment qualifications.
It supports delivery, assessment and quality assurance of BTECs in centres and supports teachers and students as follows:

- course creation
- creating and verifying assignments
- creating assessment plans and recording assessment decisions
- upload of assignment evidence
- tracking progress of every learner

The system is accessible for teachers and learners so that both teachers and learners can track their progress.

Support for teaching and learning

- Pearson Learning Services provide a range of engaging resources to enable you to start teaching BTEC International Level 3 qualifications. These may include the following free materials:
- delivery guides, which give you important advice on how to choose the right course for your learners and how to ensure you are fully prepared to deliver the course. They explain the key features of the BTEC International Level 3 Building Services Engineering, Civil Engineering, Construction and the Built Environment qualifications, for example employer involvement and employability skills. They also cover guidance on assessment and quality assurance.
- sample schemes of work are provided for each mandatory unit as well as a selection of optional units. These are available in Word™ format for ease of customisation
- slide presentations for use in your teaching to outline the key concepts of a unit
- delivery plans that help you structure delivery of a qualification.

We also provide paid for resources and courseware which may include:

- teacher resource packs developed by Pearson including materials and activities to fully support your teaching of units
- student study texts across a range of mandatory and optional units to support your students throughout their programme of study.

Support for assessment

Sample assessment materials for internally-assessed units

For internal units assessed with a Pearson Set Assignment we will provide a sample assignment as an example of the form of assessment for the unit. For the remaining internally set units, we allow you to set your own assignments, according to your learners' preferences and to link with your local employment profile.

We provide a service in the form of Authorised Assignment Briefs and sample Pearson Set Assignments, which are approved by Pearson Standards Verifiers. They are available via our website.

Pearson English

Pearson provides a full range of support for English learning including diagnostics, qualifications and learning resources. Please see www.pearson.com/english

Training and support from Pearson

People to talk to

There are many people available to support you and give you advice and guidance on delivery of your BTEC International Level 3 qualifications. They include the following.

- Subject Advisors – available for all sectors. They understand all Pearson qualifications in their sector and can answer sector-specific queries on planning, teaching, learning and assessment.
- Standards Verifiers – they can support you with preparing your assignments, ensuring that your assessment plan is set up correctly, and support you in preparing learner work and providing quality assurance through sampling.
- Regional teams – they are regionally based and have a full overview of the BTEC qualifications and of the support and resources that Pearson provides. Regions often run network events.
- Customer Services – the 'Support for You' section of our website gives the different ways in which you can contact us for general queries. For specific queries, our service operators can direct you to the relevant person or department.

Training and professional development

Pearson provides a range of training and professional development events to support the introduction, delivery, assessment and administration of BTEC International Level 3 qualifications. These sector-specific events, developed and delivered by specialists, are available both face to face and online.

'Getting Ready to Teach'

These events are designed to get teachers ready for delivery of the BTEC International Level 3 qualifications. They include an overview of qualification structures, planning and preparation for internal assessment, and quality assurance.

Teaching and learning

Beyond the 'Getting Ready to Teach' professional development events, there are opportunities for teachers to attend sector- and role-specific events. These events are designed to connect practice to theory; they provide teacher support and networking opportunities with delivery, learning and assessment methodology.

Details of our training and professional development programme can be found on our website.

Appendix 1: Links to industry standards

BTEC International Level 3 qualifications have been developed in consultation with industry and appropriate sector bodies to ensure that content and the approach to assessment align closely to the needs of employers. Where they exist, and are appropriate, National Occupational Standards (NOS) and professional body standards have been used to establish unit content.

Appendix 2: Transferable employability skills

The need for transferable skills

In recent years, higher-education institutions and employers have consistently flagged the need for learners to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.'[1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework [2] as the most evidence-based and robust skills framework, and have used this as a basis for our adapted skills framework.

The framework includes cognitive, intrapersonal skills and interpersonal skills.

The NRC framework is included alongside literacy and numeracy skills.

The skills have been interpreted for this specification to ensure that they are appropriate for the subject. All of the skills listed are evident or accessible in the teaching, learning and/or assessment of the qualifications. Some skills are directly assessed. Pearson materials will support you in identifying these skills and in developing these skills in learners.

The table overleaf sets out the framework and gives an indication of the skills that can be found in construction and built environment sectors, it indicates the interpretation of the skills in this area. A full interpretation of each skill, with mapping to show opportunities for learner development, is given on the subject pages of our website: qualifications.pearson.com

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[1] OECD – *Better Skills, Better Jobs, Better Lives* (OECD Publishing, 2012)

[2] Koenig, J. A. (2011) *Assessing 21st Century Skills: Summary of a Workshop* (National Academies Press, 2011)

Cognitive skills	Cognitive processes and strategies	Critical thinking Problem solving Analysis Reasoning/argumentation Interpretation Decision making Adaptive learning Executive function
	Creativity	Creativity Innovation
Intrapersonal skills	Intellectual openness	Adaptability Personal and social responsibility Continuous learning Intellectual interest and curiosity
	Work ethic/ conscientiousness	Initiative Self-direction Responsibility Perseverance Productivity Self-regulation (metacognition, forethought, reflection) Ethics Integrity
	Positive core self-evaluation	Self-monitoring/ self-evaluation/ self-reinforcement
Interpersonal skills	Teamwork and collaboration	Communication Collaboration Teamwork Cooperation Empathy/perspective taking Negotiation
	Leadership	Responsibility Assertive communication Self-presentation

Developing the ability to make a persuasive case in the fields of construction, civil engineering and building services, supporting one or more arguments, including the ability to create a balanced and evaluated argument.

Taking responsibility for finding and correcting errors in plumbing plans.

Advocating the position of another in an oral presentation.

Appendix 3: Sustainability

Learning for a better world

As the world's leading learning company, creating a more sustainable world is a natural part of everything we do. Learning itself is the greatest force for change in our world and helping people gain knowledge and skills is, inherently, a way to improve our planet and our society. We do that everyday by turning our products into vibrant learning experiences, focusing on our people, and protecting our planet.

Our sustainable business strategy

We are aligning with the United Nation's Sustainable Development Goals that represent the environmental, social and governance areas in which we can make the biggest positive impact.

Our sustainable business strategy focuses on:

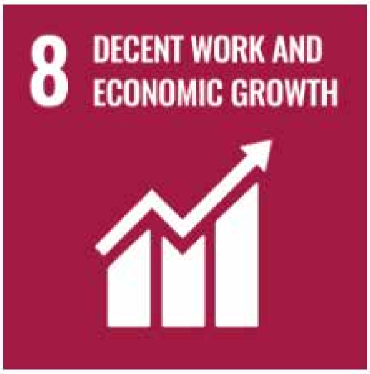
- **Products** – *driving learning for everyone with our products*

  We're widening access to learning for more people and ensuring our products have measurable outcomes.
- **People** – *empowering our people to make a difference*

  We're building a culture of belonging, along with a performance culture, so our people can make a real difference at scale.
- **Planet** – *leading responsibly for a better planet*

  We're reducing our environmental footprint and working with like-minded partners.

The United Nations' Sustainable Development Goals (SDGs) exist to achieve a better and more sustainable future for all. We contribute towards the following Sustainable Development Goals.



More detailed guidance on our sustainable business strategy and how we are contributing towards these goals, is available on our website at https://plc.pearson.com/en-GB/sustainability

Embedding sustainability into our qualifications

The United Nations Educational, Scientific and Cultural Organisation (UNESCO) has identified a series of cross-cutting sustainability and specialised SDG competencies, which is reflected in our qualifications.

We see sustainability in the context of our qualifications, assessments and teaching and learning resources, and how we can embed sustainability in a meaningful and pragmatic way, in three distinct areas: mindset, skills and practices.

Embedding sustainability mindset

Throughout the delivery of our BTEC Internationals, there are many opportunities to discuss sustainability topics with learners in the context of their qualification. A sustainability 'mindset' means that learners will ask the question of every topic, 'How is this sustainable?' or 'How does this affect people, the planet, and my future?'

Topics you could address in the 'sustainability mindset', are as follows:

- Energy usage
- Pollution
- Climate impact
- Human resources involved
- The global context.
- People – empowering our people to make a difference

Embedding sustainability skills

Any successful qualification teaches learners knowledge, skills and behaviours associated with a particular topic but often it is the cross-cutting skills that learners learn that end up having the most value in the long-term. Whilst we feel that a sustainable 'mindset' is vitally important to learners recognising and being able to think sustainably in the long-term, we feel that the embedding of sustainability skills is equally important because it means they will be able to 'do' something about the issue they identify through their new-found awareness of sustainability. The skills we are advocating are complementary to the skills they will develop as a matter of course on their BTEC International qualification but in this context, are given a new focus and importance.

Embedding sustainability practices

Less directly linked to the subject of a learner's study, sustainability practices are the actions and behaviours that we can encourage learners to take and develop that will enhance the sustainability of the course's delivery and their ability to make decisions and take actions that are more sustainable.

This may extend to the way they travel to school/college, the way they submit their assignment work, or the way resources are used and respected. In many ways, this is core of encouraging sustainability awareness because this is where the academic becomes practical as learners are encouraged to apply their learning in real-world ways. This aspect should complement the other key areas of sustainability covered in this section.

Our approach to sustainability in the Pearson BTEC International Level 3 Building Services Engineering, Civil Engineering, Construction and the Built Environment

We have considered how this qualification achieves the Sustainability Development Goals (SDGs) and Cross Cutting Skills, defined by the United Nations. Whilst acknowledging that sustainability can be approached in many ways in the design, teaching and assessment of this qualification – we have embedded sustainability by exemplifying the unit content and topic areas and provided additional guidance, with examples in the assessment guidance sections of this specification, where relevant.

In addition, the following unit(s) in the Pearson BTEC International Level 3 Building Services Engineering, Civil Engineering, Construction and the Built Environment explicitly includes learning aims which highlights the importance of sustainability and the effects it has within the industry.

- Unit 8: Sustainability in Construction.

We have also further developed our assessments, and teaching and learning resources to strengthen and support the mindset, skills and practices we want your learners to embrace when they think about sustainability in the real-world.

Delivering Sustainability through Classroom Activities

Sustainability is an area that can be addressed by all vocational subjects. Teachers should consider how they can actively address sustainability as they deliver subject content and create awareness of sustainability. Examples of this could include:

- Use of sustainability related case studies to reinforce topics delivered:
  - The use of non-fossil fuel to power cars and aircraft
  - How attitudes towards the carbon footprint of food and raw materials have affected manufacturing and logistical processes
  - Sustainable travel and tourism
  - Social entrepreneurship and sustainable practices
  - Sustainable agricultural practices
  - Sustainability in art and the portrayal of visual images and artefacts
  - Repurposing of land and buildings to reduce the release of harmful materials into the environment
  - Poverty reduction and job growth
- Considering the long-term impact on the environment and climate by the organisations and vocational sectors being studied:
  - The disposable of materials and chemicals from manufacturing processes
  - The use of solar power and green energy to heat buildings and to power machinery
  - Organisational culture and adoption of sustainable business practices

More detailed guidance about our approach, with examples of how you can embed sustainability into the qualifications you deliver, is available on our qualifications website.

Appendix 4: Glossary of terms used

This is a summary of the key terms used to define the requirements in the units.

Term	Definition
Explore	Learners apply their skills and/or knowledge to practical testing or trialling.
Examine	Learners are expected to select and apply knowledge to less familiar contexts.
Explain	Learners' work shows clear details and gives reasons and/or evidence to support an opinion, view or argument. It could show how conclusions are drawn.
Investigate	Learners' work tests the following through practical exploration: · qualities of materials · techniques · processes or contexts
Understand	Perceive the intended meaning of (words, a language, or a speaker).

This is a key summary of the types of evidence used for BTEC International Level 3 qualifications.

Type of evidence	Definition and purpose
Case study	A specific example to which all learners must select and apply knowledge. Used to show application to a realistic context where direct experience cannot be gained.
Individual project	A self-directed, large-scale activity requiring planning, research, exploration, outcome and review. Used to show self-management, project management and/or deep learning, including synopticity.
Development log	A record kept by the learner to show the process of development. Used to show method, self-management and skill development.

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