Pearson BTEC

Pearson BTEC Level 3 National Diploma in Building Services Engineering

Specification

First teaching from September 2017

First certification from 2019

Issue 7

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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 schools, colleges and universities, as well as professional and vocational education to learners to help increase their skills and lifelong employability prospects. We believe that wherever learning flourishes so do people.

This specification is Issue 7. 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. We do 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.)

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Welcome

With a track record built over 30 years of learner success, BTEC Nationals are widely recognised by industry and higher education as the signature vocational qualification at Level 3. They provide progression to the workplace either directly or via study at a higher level. Proof comes from YouGov research, which shows that 62% of large companies have recruited employees with BTEC qualifications. What's more, well over 100,000 BTEC students apply to UK universities every year and their BTEC Nationals are accepted by over 150 UK universities and higher education institutes for relevant degree programmes either on their own or in combination with A Levels.

Why are BTECs so successful?

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

When creating the BTEC Nationals in this suite, we worked with many employers, higher education providers, colleges and schools to ensure that their needs are met. Employers are looking for recruits with a thorough grounding in the latest industry requirements and work-ready skills such as teamwork. Higher education needs students who have experience of research, extended writing and meeting deadlines.

We have addressed these requirements with:

- a range of BTEC sizes, each with a clear purpose, so there is something to suit each learner's choice of study programme and progression plans
- refreshed content that is closely aligned with employers' and higher education needs for a skilled future workforce
- assessments and projects chosen to help learners progress to the next stage. This means some are set by you to meet local needs, while others are set and marked by Pearson so that there is a core of skills and understanding that is common to all learners. For example, a written test can be used to check that learners are confident in using technical knowledge to carry out a certain job.

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

A word to learners

Today's BTEC Nationals are demanding, as you would expect of the most respected applied learning qualification in the UK. You will have to choose and complete a range of units, be organised, take some assessments that we will set and mark, and keep a portfolio of your assignments. But you can feel proud to achieve a BTEC because, whatever your plans in life – whether you decide to study further, go on to work or an apprenticeship, or set up your own business – your BTEC National will be your passport to success in the next stage of your life.

Good luck, and we hope you enjoy your course.

Collaborative development

Students completing their BTEC Nationals in Building Services Engineering will be aiming 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. To ensure that the content meets providers' needs and provides high-quality preparation for progression, we engaged experts. We are very 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.

Professional bodies and businesses have provided letters of support confirming that these qualifications meet their entry requirements. These letters can be viewed on our website.

Summary of Pearson BTEC Level 3 National Diploma in Building Services Engineering specification Issue 7 changes

Summary of changes made between the previous issue and this current issue	**Page number**
Change made to *Structures of the qualifications at a glance* section to remove incorrect indication that *Unit 3: Tendering and Estimating* is a mandatory unit in the Diploma (720 GLH) in Civil Engineering.	Page 6

Summary of Pearson BTEC Level 3 National Diploma in Building Services Engineering specification Issue 6 changes

Summary of changes made between Issue 5 and Issue 6	**Page number**
The number of mandatory units for the Extended Diploma in Construction and the Built Environment and the Extended Diploma in Building Services Engineering in the *Qualification, sizes and purpose at a glance* section has been corrected to 15.	Page 5
Changes made to *Unit 1: Construction Principles Essential content* under A2 and A3 for clarity.	Pages 25 and 26
Changes made to *Unit 2: Construction Design Essential content* under A1, A2, B1, B4 and C1 for clarity.	Pages 37-41
Changes made for clarity to *Unit 18: Building Information Modelling* wording in sections *Unit in brief* and *Unit introduction*. The rider statements in the *Content* section for A1, A2, A3, Learning aim B, B2, B3, B4, C1, C2, D1, D2, D3 and D5 have been amended for clarity. D4 has been removed to eliminate duplication with D3. A new paragraph on access to industry resource was added under *Employer involvement* section.	Pages 129-134, 138
Removal of references to MyBTEC, as that service is retiring.	Pages 246, 251, 256, 271, 272

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 BTEC National qualifications for the construction and the built environment sector

This specification contains the information you need to deliver the Pearson BTEC Level 3 National Diploma in Building Services Engineering. The specification signposts you to additional handbooks and policies. It includes all the units for this qualification.

This qualification is part of the suite of Construction and the Built Environment qualifications offered by Pearson. In the suite there are qualifications that focus on different progression routes, allowing learners to choose the one best suited to their aspirations.

All qualifications in the suite share some common units and assessments, allowing learners some flexibility in moving between qualifications where they wish to select a more specific progression route. The qualification titles are given below.

Within this suite are BTEC National qualifications for post-16 learners wishing to specialise in a specific industry, occupation or occupational group. The qualifications give learners specialist knowledge and technical skills, enabling entry to an Apprenticeship or other employment, or progression to related higher education courses. Learners taking these qualifications must have a significant level of employer involvement in their programmes.

In the construction and the built environment sector these are:

Pearson BTEC Level 3 National Extended Certificate in Construction and the Built Environment (603/0862/X)

Pearson BTEC Level 3 National Foundation Diploma in Construction and the Built Environment (603/0863/1)

Pearson BTEC Level 3 National Diploma in Construction and the Built Environment (603/0864/3)

Pearson BTEC Level 3 National Diploma in Building Services Engineering (603/1218/X)

Pearson BTEC Level 3 National Diploma in Civil Engineering (603/1217/8)

Pearson BTEC Level 3 National Extended Diploma in Construction and the Built Environment (603/0861/8)

Pearson BTEC Level 3 National Extended Diploma in Building Services Engineering (603/1219/1)

Pearson BTEC Level 3 National Extended Diploma in Civil Engineering (603/1216/6).

Other BTEC National qualifications in this sector provide a broad introduction that gives learners transferable knowledge and skills. These qualifications are for post-16 learners who want to continue their education through applied learning. The qualifications prepare learners for a range of higher education courses either by meeting entry requirements in their own right or by being accepted alongside other qualifications at the same level and adding value to them. Learners may progress to one of the qualifications in this specification having completed a smaller qualification that provides suitable fundamental knowledge and skills.

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

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

Total Qualification Time

For all regulated qualifications, Pearson specifies a total number of hours that it is estimated learners will require to complete and show achievement for the qualification: this is the Total Qualification Time (TQT). Within TQT, Pearson identifies the number of Guided Learning Hours (GLH) that we estimate a centre delivering the qualification might provide. Guided learning means activities, such as lessons, tutorials, online instruction, supervised study and giving feedback on performance, that directly involve teachers and assessors in teaching, supervising and invigilating learners. Guided learning includes the time required for learners to complete external assessment under examination or supervised conditions.

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

BTEC Nationals have been designed around the number of hours of guided learning expected. Each unit in the qualification has a GLH value of 60, 90 or 120. There is then a total GLH value for the qualification.

Each qualification has a TQT value. This may vary within sectors and across the suite depending on the nature of the units in each qualification and the expected time for other required learning.

The following table show all the qualifications in this sector and their GLH and TQT values.

Qualifications, sizes and purposes at a glance

Title	Size and structure	Summary purpose
Pearson BTEC Level 3 National Extended Certificate in Construction and the Built Environment	360 GLH (490 TQT) Equivalent in size to one A Level. 4 units of which 4 are mandatory and 2 are external. Mandatory content (100%). External assessment (66%).	The Extended Certificate is for learners who are interested in learning about the construction sector alongside other fields of study, with a view to progressing to a wide range of higher education courses, not necessarily in construction-related subjects. It is designed to be taken as part of a programme of study that includes other appropriate BTEC Nationals or A Levels.
Pearson BTEC Level 3 National Foundation Diploma in Construction and the Built Environment	540 GLH (725 TQT) Equivalent in size to 1.5 A Levels. 7 units of which 4 are mandatory and 2 are external. Mandatory content (66%). External assessment (44%).	The Foundation Diploma is for learners looking to study construction as a one-year, full-time course, or for those wishing to take it alongside another area of contrasting or complementary study, as part of a two-year, full-time study programme. It supports progression to higher education, if taken as part of a programme of study that includes other BTEC Nationals or A Levels. It also supports progression to an Apprenticeship in the construction sector or to a further year of study at Level 3.
Pearson BTEC Level 3 National Diploma in Construction and the Built Environment	720 GLH (985 TQT) Equivalent in size to two A Levels. 10 units of which 7 are mandatory and 2 are external. Mandatory content (75%) External assessment (33%).	The Diploma is designed to be the substantive part of a 16–19 study programme for learners who want a strong core of sector study. This programme may include other BTEC Nationals or A Levels to support progression to higher education courses in construction areas before entering employment. The additional qualification(s) studied allow learners either to give breadth to their study programme by choosing a contrasting subject, or to give it more focus by choosing a complementary subject. This qualification can also be used to progress to Higher Apprenticeships.

Title	Size and structure	Summary purpose
Pearson BTEC Level 3 National Diploma in Building Services Engineering	720 GLH (990 TQT) Equivalent in size to two A Levels. 10 units of which 6 are mandatory and 2 are external. Mandatory content (66%) External assessment (33%).	The Diploma is designed to be the substantive part of a 16–19 study programme for learners who want a strong core of sector study. This programme may include other BTEC Nationals or A Levels to support progression to higher education courses in construction areas before entering employment. The qualification is intended to meet the educational base for registration as a technician. The additional qualification(s) studied allow learners either to give breadth to their study programme by choosing a contrasting subject, or to give it more focus by choosing a complementary subject. This qualification can also be used, when studied part time, as part of an advanced technician Apprenticeship in building services engineering, or for progression to a Higher Apprenticeship in building services engineering.
Pearson BTEC Level 3 National Diploma in Civil Engineering	720 GLH (975 TQT) Equivalent in size to two A Levels. 10 units of which 7 are mandatory and 2 are external. Mandatory content (75%) External assessment (33%).	The Diploma is designed to be the substantive part of a 16–19 study programme for learners who want a strong core of sector study. This programme may include other BTEC Nationals or A Levels to support progression to higher education courses in construction areas before entering employment. The qualification is intended to meet the educational base for registration as a technician. The additional qualification(s) studied allow learners either to give breadth to their study programme by choosing a contrasting subject, or to give it more focus by choosing a complementary subject. This qualification can also be used, when studied part time, as part of an advanced technician Apprenticeship in civil engineering, or for progression to a Higher Apprenticeship in civil engineering.

Title	Size and structure	Summary purpose
Pearson BTEC Level 3 National Extended Diploma in Construction and the Built Environment	1080 GLH (1465 TQT) Equivalent in size to three A Levels. 15 units of which 9 are mandatory and 3 are external. Mandatory content (66%) External assessment (33%).	The Extended Diploma is a two-year, full-time course that meets entry requirements in its own right for learners who want to progress to higher education courses in construction areas before entering employment. It can also support learners who want to progress directly to employment in job roles in construction or a professional construction role and Higher Apprenticeships in the construction sector.
Pearson BTEC Level 3 National Extended Diploma in Building Services Engineering	1080 GLH (1480 TQT) Equivalent in size to three A Levels. 15 units of which 7 are mandatory and 3 are external. Mandatory content (55%) External assessment (33%).	The Extended Diploma is a two-year, full-time course that meets entry requirements in its own right for learners who want to progress to higher education courses in building services areas before entering employment. The qualification is intended to meet the educational base for registration as a technician. It supports learners who want to progress directly to employment in roles in building services engineering as technicians, or to a professional construction role and advanced/ Higher Apprenticeships in building services engineering.
Pearson BTEC Level 3 National Extended Diploma in Civil Engineering	1080 GLH (1450 TQT) Equivalent in size to three A Levels. 15 units of which 8 are mandatory and 3 are external. Mandatory content (66%) External assessment (33%).	The Extended Diploma is a two-year, full-time course that meets entry requirements in its own right for learners who want to progress to higher education courses in civil engineering areas before entering employment. The qualification is intended to meet the educational base for registration as a technician. It supports learners who want to progress directly to employment in roles in civil engineering as technicians, or to a professional construction role and advanced/Higher Apprenticeships in civil engineering.

Structures of the qualifications at a glance

This table shows all the units and the qualifications to which they contribute. The full structure for this Pearson BTEC Level 3 National in Construction and the Built Environment is shown in *Section 2*. **You must refer to the full structure to select units and plan your programme.**

Key

	Unit assessed externally	**M**	**Mandatory units**	**O**	**Optional units**
CBE	**Construction and the Built Environment**	**CE**	**Civil Engineering**	**BSE**	**Building Services Engineering**

Unit (number and title)	Unit size (GLH)	Extended Certificate (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
				CBE	CE	BSE	CBE	CE	BSE
1 Construction Principles	120	M	M	M	M	M	M	M	M
2 Construction Design	120	M	M	M	M	M	M	M	M
3 Tendering and Estimating	120						M	M	M
4 Construction Technology	60	M	M	M	M	M	M	M	M
5 Health and Safety in Construction	60	M	M	M	M	M	M	M	M
6 Surveying in Construction	60		O	M	O		M	O	
7 Graphical Detailing in Construction	60		O	M	O	O	M	O	O
8 Building Regulations and Control in Construction	60		O	M			M	O	
9 Management of a Construction Project	60		O	O	O	O	M	O	O
10 Building Surveying in Construction	60		O	O			O	O	
11 Site Engineering for Construction	60		O	O	M		O	M	
12 Low Temperature Hot Water Systems in Building Services	60			O		O	O		O
13 Measurement Techniques in Construction	60		O	O	O		O	O	
14 Provision of Primary Services in Construction	60		O	O		M	O		M
15 Further Mathematics for Construction	60				M	O	O	M	O
16 Work Experience in the Construction Sector	60						O	O	O
17 Projects in Construction	60			O	O	O	O	O	O
18 Building Information Modelling	60			O	O	O	O	O	O

continued overleaf

Unit (number and title)	Unit size (GLH)	Extended Certificate (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
				CBE	CE	BSE	CBE	CE	BSE
19 Quantity Surveying	60		O	O		O	O		O
20 Quality Control Management in Construction	60			O			O	O	O
21 Building Services Science	60					M	O		M
22 Economics and Finance in Construction	60						O		
23 Construction in Civil Engineering	60				M		O	M	
24 Planning Application Procedures in Construction	60						O		
25 Property Law	60						O		
26 Conversion, Adaptation and Maintenance of Buildings	60						O		
27 Building Services Control Systems	60					O			O
28 Heating, Ventilation and Air Conditioning Design	60					O			O
29 Use of Static and Dynamic Fluids in Building Services Engineering	60					O			O
30 Plumbing Technology in Building Services Engineering	60					O			O
31 Electrical Principles in Building Services Engineering	60					O			O
32 Electrical Installation Standards, Components and Design	60					O			O
33 Quantity Surveying Measurement Techniques in Building Services Engineering	60					O			O
34 Building Regulations and Control in Building Services Engineering	60					O			O
35 Principles and Applications of Structural Mechanics	60				O			O	
36 Public Health Engineering	60				O			O	
37 Specialist Civil Engineering Techniques	60				O			O	
38 Highway Construction and Maintenance in Civil Engineering	60				O			O	

Unit (number and title)	Unit size (GLH)	Extended Certificate (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
				CBE	CE	BSE	CBE	CE	BSE
39 Housing Design Project	**60**			**O**			**O**		
40 Offsite and Onsite Alternative Construction Methods	**60**			**O**			**O**		
41 Renewable Energy for Housing	**60**			**O**			**O**		
42 The Housing Industry	**60**			**O**			**O**		

Qualification and unit content

Pearson has developed the content of the new BTEC Nationals 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 attributes required in the sector.

Each qualification in the suite has its own purpose. The mandatory content provides a balance of breadth and depth ensuring that all learners have a strong basis for developing technical skills required in the sector. Learners are then offered the opportunity to develop a range of technical skills and attributes expected by employers with some opportunity to select between optional units where a degree of choice for individual learners to study content relevant to their own progression choices is appropriate. It is expected that learners will apply their learning in relevant employment and sector contexts during delivery and have opportunities to engage meaningfully with employers.

The proportion of mandatory content ensures that all learners are following a coherent programme of study and acquiring the knowledge, understanding and skills that will be recognised and valued. Learners are expected to show achievement across mandatory units as detailed in *Section 2*.

BTEC Nationals have always required applied learning that brings together knowledge and understanding (the cognitive domain) with practical and technical skills (the psychomotor domain). This is achieved through learners performing vocational tasks that encourage the development of appropriate vocational behaviours (the affective domain) and transferable skills. Transferable skills are those such as communication, teamwork, planning and completing tasks to high standards, which are valued in both the workplace and in higher education.

Our approach provides rigour and balance, and promotes the ability to apply learning immediately in new contexts. Further details can be found in *Section 2*.

Centres should ensure that delivery of content is kept up to date. Some of the units within the specification may contain references to legislation, policies, regulations and organisations, which may not be applicable in the country you deliver this qualification in (if teaching outside of England), or which may have gone out-of-date during the lifespan of the specification. In these instances, it is possible to substitute such references with ones that are current and applicable in the country you deliver subject to confirmation by your Standards Verifier.

Assessment

Assessment is specifically 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. There are three main forms of assessment that you need to be aware of: external, internal and synoptic.

Externally-assessed units

Each external assessment for a BTEC National is linked to a specific unit. All of the units developed for external assessment are of 120 GLH to allow learners to demonstrate breadth and depth of achievement. Each assessment is taken under specified conditions, then marked by Pearson and a grade awarded. Learners are permitted to resit external assessments during their programme. You should refer to our website for current policy information on permitted retakes.

The styles of external assessment used for qualifications in the Construction and the Built Environment suite are:

- examinations – all learners take the same assessment at the same time, normally with a written outcome
- set tasks – learners take the assessment during a defined window and demonstrate understanding through completion of a vocational task.

Some external assessments include a period of preparation using set information. External assessments are available once or twice a year. For detailed information on the external assessments please see the table in *Section 2*. For further information on preparing for external assessment see *Section 5*.

Internally-assessed units

Most units in the sector are internally assessed and subject to external standards verification. This means that you set and assess the assignments that provide the final summative assessment of each unit, using the examples and support that Pearson provides. 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*.

In line with the requirements and guidance for internal assessment, 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:

- demonstrate practical and technical skills using appropriate (tools/processes etc.)
- complete realistic tasks to meet specific briefs or particular purposes
- 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.

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 see *Section 6*.

Synoptic assessment

Synoptic assessment requires learners to demonstrate that they can identify and use effectively, in an integrated way, an appropriate selection of skills, techniques, concepts, theories and knowledge from across the whole sector as relevant to a key task. BTEC learning has always encouraged learners to apply their learning in realistic contexts using scenarios and realistic activities that will permit learners to draw on and apply their learning. For these qualifications we have formally identified units which contain a synoptic assessment task. Synoptic assessment must take place after the teaching and learning of other mandatory units in order for learners to be able to draw from the full range of content. The synoptic assessment gives learners an opportunity to independently select and apply learning from across their programmes in the completion of a vocational task. Synoptic tasks may be in internally or externally assessed units. The particular unit that contains the synoptic tasks for this qualification is shown in the structure in *Section 2*.

Language of assessment

Assessment of the internal and external units for these qualifications will be available in English. All learner work must be in English. A learner taking the qualifications may be assessed in British or Irish Sign Language where it is permitted for the purpose of reasonable adjustment.
For information on reasonable adjustments see *Section 7*.

Grading for units and qualifications

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

Units are assessed using a grading scale of Distinction (D), Merit (M), Pass (P), Near Pass (N) and Unclassified (U). The grade of Near Pass is used for externally-assessed units only. All mandatory and optional units contribute proportionately to the overall qualification grade, for example a unit of 120 GLH will contribute double that of a 60 GLH unit.

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* 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 qualification.

UCAS Tariff points

The BTEC Nationals attract UCAS points. Please go to the UCAS website for full details of the points allocated.

1 Qualification purpose

Pearson BTEC Level 3 National Diploma in Building Services Engineering

In this section the learner will find information on the purpose of this qualification and how its design meets that purpose through the qualification objective and structure. We publish a full 'Statement of Purpose' for each qualification on our website. These statements are designed to guide potential learners to make the most appropriate choice about the size of qualification suitable at recruitment.

The construction sector

Construction is a very important global industry and is worth £90 billion annually to the UK economy. At technician level and beyond, there is a diverse range of career pathways, with established professional entry and development routes in civil engineering, building services engineering, design/architecture and construction supervision/management. Currently, qualified construction technicians, managers and professionals are highly sought after in the UK industry, with demand for a greater number of professionals to implement and lead low-carbon and sustainable building projects in an efficient, cost-effective way.

Who is this qualification for?

The Pearson BTEC Level 3 National Diploma in Building Services Engineering is intended as a Tech Level qualification, equivalent in size to two A Levels and designed to meet two-thirds of a full-time curriculum. It allows learners to develop significant core knowledge and study in more depth an extensive range of optional areas. The qualification size allows it to be offered part time or with other qualifications, including as a core component of the Tech Bacc alongside the other mandatory components – Level 3 mathematics and the Extended Project Qualification (EPQ). Learners can also study this qualification while undertaking other formal training and work in the sector, as part of an Apprenticeship. No prior study of the sector is needed but learners should normally have a range of achievement at Level 2, in GCSEs or equivalent qualifications, including English, mathematics and science.

The qualification would also suit learners wanting to pursue a career in construction by progressing directly to employment as a building services engineering technician or to higher education. The qualification is intended to meet the educational base for registration as a technician, for example with the Chartered Institution of Building Services Engineers (CIBSE) once they are in employment. Learners who choose this route should take *Unit 15: Further Mathematics for Construction* (or take the qualification alongside an A Level in mathematics). This is likely to be a requirement for entry to many degrees.

What does the qualification cover?

The content of this qualification has been developed in consultation with employers and professional bodies to ensure that it is appropriate for those interested in working in the sector. In addition, higher education representatives have been involved to ensure that it fully supports entry to the relevant range of specialist degrees.

This qualification provides the knowledge, understanding and skills that will allow the learner to progress to further education, or directly to employment or an apprenticeship in the construction sector.

There are six core mandatory units, which cover the following aspects of construction:

- construction principles
- construction design
- health and safety in construction
- construction technology
- provision of primary services in buildings
- building services science.

The mandatory units will cover foundation mathematical and scientific principles, as applied in a construction context. They will introduce a range of technologies and their application in the industry, and how essential primary services such as heating, lighting and ICT networks are supplied to a new building project. The health and safety unit will introduce learners to their personal responsibilities for health, safety and welfare, the industry and legislative requirements for health and safety, and the application of organisational processes and risk management to ensure compliance. The building services science unit will give learners the understanding of, for example, electrical generation and thermodynamics, which will be used when designing and installing services.

Learners will be able to choose optional units focusing on their areas of preferred specialism, at least one of which must be in a specialist building services engineering context, for example in control systems, plumbing technology, ventilation and air conditioning design. Learners will gain skills and knowledge from studying these units, which will be needed as part of their wider work in building services engineering installation or design projects, or for progression to further study.

While taking this qualification, learners will be required to engage with sector employers as part of their course. This could include work experience with an employer in the sector, where learners will be given opportunities to develop practical skills in preparation for employment.

What could this qualification lead to?

This qualification will prepare learners for direct employment in the construction and built environment sector, and is ideal if they wish to enter a particular specialist area of work, such as:

- building services engineering technician
- building services engineering design technician
- construction project technician
- mechanical/electrical services technician
- building services site engineering technician.

The optional units give learners the chance to learn about a particular aspect of construction in more detail but because the mandatory content makes up two-thirds of the qualification, they will be prepared for all these roles, whichever optional units they choose.

After this qualification, learners can also progress directly into employment, however it is likely that many will do so via higher study. Areas of employment include specialist roles, such as building services engineering technician, building services engineering design technician, construction project technician, mechanical/electrical services technician, building services site engineering technician.

As part of their higher study choices, learners may also choose to progress to a BTEC Higher National (HN) qualification. HNs are widely supported by higher education and industry as the principal vocational qualifications at Levels 4 and 5 and are designed to reflect the increasing need for high quality professional and technical education at Levels 4 and 5. They provide learners with a clear line of sight to employment and to a degree at Level 6 if they choose. The Pearson BTEC Level 3 National Diploma in Building Services Engineering meets the admission requirements for:

- Pearson BTEC Level 4 Higher National Certificate in Construction and the Built Environment (Building Services Engineering)
- Pearson BTEC Level 5 Higher National Diploma in Construction and the Built Environment (Building Services Engineering – Heating, Ventilation and Air Conditioning).

Will the qualification lead to further learning?

There are many roles in this sector where recruitment is at graduate level. The qualification, if taken with an additional Level 3 qualification such as A Level in mathematics or science, is recognised by higher education providers as contributing to meeting the admission requirements for many relevant courses, for example:

- BSc (Hons) in Construction Management
- BSc (Hons) in Building Services Engineering, if taken in combination with subjects such as science and mathematics
- HNC/D in Building Services Engineering
- HND in Construction and the Built Environment.

Teachers and learners should always check the entry requirements for degree programmes with specific higher education providers.

How does the qualification provide employability and technical skills?

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

- **cognitive and problem-solving skills:** use critical thinking, approach non-routine problems applying expert and creative solutions, use systems and technology
- **intrapersonal skills:** communicating, working collaboratively, negotiating and influencing, self-presentation
- **interpersonal 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.

Many of the mandatory and specified optional units encourage learners to develop the specific practical skills that employers are looking for.

How does the qualification provide transferable knowledge and skills for higher education?

All BTEC Nationals provide transferable knowledge and skills that prepare learners for progression to university or other higher study either immediately or for career progression. The transferable skills that universities value include:

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

BTEC learners can also benefit from opportunities for deep learning where they are able to make connections among units and select areas of interest for detailed study. BTEC Nationals provide a vocational context in which learners can become prepared for life-long learning through:

- reading technical texts
- analytical skills.

2 Structure

Qualification structure

Pearson BTEC Level 3 National Diploma in Building Services Engineering

Mandatory units

There are six mandatory units, two external and four internal. Learners must complete and achieve at Near Pass grade or above in all mandatory external units and achieve a Pass or above in all mandatory internal units in group A. Learners must complete all units in group B.

Optional units

Learners must complete four optional units.

Pearson BTEC Level 3 National Diploma in Building Services Engineering				
Unit number	**Unit title**	**GLH**	**Type**	**How assessed**
	Mandatory units group A – learners complete and achieve all units			
1	Construction Principles	**120**	**Mandatory**	External
2	Construction Design	**120**	**Mandatory and Synoptic**	External
4	Construction Technology	**60**	**Mandatory**	Internal
	Mandatory units group B – learners complete all units			
5	Health and Safety in Construction	**60**	**Mandatory**	Internal
14	Provision of Primary Services in Construction	**60**	**Mandatory**	Internal
21	Building Services Science	**60**	**Mandatory**	Internal
	Optional units group C – learners complete up to 3 units			
7	Graphical Detailing in Construction	**60**	**Optional**	Internal
9	Management of a Construction Project	**60**	**Optional**	Internal
12	Low Temperature Hot Water Systems in Building Services	**60**	**Optional**	Internal
15	Further Mathematics for Construction	**60**	**Optional**	Internal
17	Projects in Construction	**60**	**Optional**	Internal
18	Building Information Modelling	**60**	**Optional**	Internal
19	Quantity Surveying	**60**	**Optional**	Internal
	Optional units group D – learners complete at least 1 unit			
27	Building Services Control Systems	**60**	**Optional**	Internal
28	Heating, Ventilation and Air Conditioning Design	**60**	**Optional**	Internal
29	Use of Static and Dynamic Fluids in Building Services Engineering	**60**	**Optional**	Internal
30	Plumbing Technology in Building Services Engineering	**60**	**Optional**	Internal
31	Electrical Principles in Building Services Engineering	**60**	**Optional**	Internal
32	Electrical Installation Standards, Components and Design	**60**	**Optional**	Internal

Unit number	Unit title	GLH	Type	How assessed
	Optional units group D *(cont'd)* – learners complete at least 1 unit			
33	Quantity Surveying Measurement Techniques in Building Services Engineering	**60**	**Optional**	Internal
34	Building Regulations and Control in Building Services Engineering	**60**	**Optional**	Internal

External assessment

This is a summary of the type and availability of external assessment, which is of units making up 33% of the total qualification GLH. See *Section 5* and the units and sample assessment materials for more information.

Unit	Type	Availability
Unit 1: Construction Principles	• Written exam. • 1 hour 30 minutes. • Written submission. • 75 marks.	**Jan and May/June** **First assessment May/June 2018**
Unit 2: Construction Design	• A task set and marked by Pearson and completed under supervised conditions. • Before the supervised assessment, learners will be given three hours for research in a two-week period. • The supervised assessment is 12 hours in a two-week period timetabled by Pearson. • Written submission of evidence. • 63 marks.	**May/June** **First assessment May/June 2018**

Synoptic assessment

The mandatory synoptic assessment requires learners to apply learning from across the qualification to the completion of a defined vocational task. Within the assessment for *Unit 2: Construction Design* learners complete a task to demonstrate the application of skills involved in the design and construction of low- and medium-rise buildings and structures, evaluating the effectiveness of a design solution against client requirements and external constraints, including the requirements for installing a building services system. This draws together underpinning knowledge of how to go through clear design processes, along with practical knowledge of how to use different manual and computer-aided methods. Learners complete the task using knowledge and understanding from their studies of the sector and apply both transferable and specialist knowledge and skills.

In delivering the unit you need to encourage learners to draw on their broader learning so they will be prepared for the assessment.

Employer involvement in assessment and delivery

You need to ensure that learners on this qualification have a significant level of employer involvement in programme delivery or assessment. See *Section 4* for more information.

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. There are two types of unit format:

- internal units
- external units.

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.

Internal units

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 and it appears on certificates.
Level	All units are at Level 3 on the national framework.
Unit type	This shows if the unit is internal or external only. See structure information in *Section 2* for full details.
GLH	Units may have a GLH value of 120, 90 or 60 GLH. 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	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 designed with learners in mind. It indicates why the unit is important, how learning is structured, and how learning might be applied when progressing to employment or higher education.
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 2*.
Summary of unit	This new section helps teachers to see at a glance the main content areas against the learning aims and the structure of the assessment. The content areas and structure of assessment are required. The forms of evidence given are suitable to fulfil the requirements.
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.

Section	Explanation
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 2*. 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.
Further information for teachers and assessors	The section gives you information to support the implementation of assessment. It is important that this is used carefully alongside the assessment criteria.
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*.
Essential information for assessment decisions	This information gives guidance for each learning aim or assignment of the expectations for Pass, Merit and Distinction standard. This section contains examples and essential clarification.
Links to other units	This section shows you the main relationship among units. This section can help you to structure your programme and make best use of materials and resources.
Employer involvement	This section gives you information on the units that can be used to give learners involvement with employers. It will help you to identify the kind of involvement that is likely to be successful.

External units

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 and it appears on certificates.
Level	All units are at Level 3 on the national framework.
Unit type	This shows if the unit is internal or external only. See structure information in *Section 2* for full details.
GLH	Units may have a GLH value of 120, 90 or 60 GLH. 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	A brief formal statement on the content of the unit.
Unit introduction	This is designed with learners in mind. It indicates why the unit is important, how learning is structured, and how learning might be applied when progressing to employment or higher education.
Summary of assessment	This sets out the type of external assessment used and the way in which it is used to assess achievement.
Assessment outcomes	These show the hierarchy of knowledge, understanding, skills and behaviours that are assessed. Includes information on how this hierarchy relates to command terms in sample assessment materials (SAMs).
Essential content	For external units all the content is obligatory, the depth of content is indicated in the assessment outcomes and sample assessment materials (SAMs). The content will be sampled through the external assessment over time, using the variety of questions or tasks shown.
Grade descriptors	We use grading descriptors when making judgements on grade boundaries. You can use them to understand what we expect to see from learners at particular grades.
Key terms typically used in assessment	These definitions will help you analyse requirements and prepare learners for assessment.
Resources	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*.
Links to other units	This section shows the main relationship among units. This section can help you to structure your programme and make best use of materials and resources.
Employer involvement	This section gives you information on the units that can be used to give learners involvement with employers. It will help you to identify the kind of involvement that is likely to be successful.

Index of units

This section contains all the units developed for this qualification. Please refer to *pages 6–7* to check which units are available in all qualifications in the construction and the built environment sector.

Unit 1: Construction Principles

Level: **3**

Unit type: **External**

Guided learning hours: **120**

Unit in brief

Learners demonstrate an understanding of the underlying 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, 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 scientific knowledge and carrying out mathematical and statistical techniques. You will learn about the science underpinning 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 technician, and Higher Level Apprenticeships.

Summary of assessment

This unit is assessed through a written examination set and marked by Pearson.

The examination is 1 hour and 30 minutes. During the supervised assessment period, learners will be assessed on their knowledge of construction materials and their properties, application of mathematics in construction contexts, and the provision of human comfort in buildings. The number of marks for the paper is 75.

The assessment availability is January and May/June each year. The first assessment availability is May/June 2018.

Sample assessment materials will be available to help centres prepare learners for assessment.

Assessment outcomes

AO1 Demonstrate knowledge of construction terms, standards, concepts, methods and processes

Command words: calculate, describe, explain, identify, state/give

Marks: ranges from 1 to 4 marks

AO2 Demonstrate understanding of construction standards, concepts, methods and processes in context, in order to find solutions to real-life construction problems

Command words: calculate, describe, discuss, draw, explain, find

Marks: ranges from 1 to 8 marks

AO3 Analyse and evaluate information in order to recommend and justify the use of technologies and methodologies to solve construction problems in context

Command words: analyse, discuss, evaluate

Marks: ranges from 6 to 12 marks

AO4 Make connections between information, technologies and methodologies to resolve construction problems

Command words: analyse, discuss, evaluate

Marks: ranges from 8 to 12 marks

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Essential content

The essential content is set out under content areas. Learners must cover all specified content before the assessment.

A Construction materials

The use of materials in construction, including their manufacture, the properties of materials linked to their use, the degradation of materials, the effects of temperature change on materials and the behaviour of materials under different loading conditions.

A1 Properties of materials

Material properties, 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 on 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, new mixes using additives, smart concrete, hempcrete, 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 – structural, 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, green/living roofs, smart roofing materials, coverings with built-in PV cells.
- Engineered timber – SIPS (Structural Insulated Panels), glulam beams, engineered joists.
- Steel – mild, stainless, high strength.
- Aluminium alloys.

A3 Manufacturing and processing of construction materials

The manufacturing, processing and technology of construction materials and how this impacts on properties and fitness for purpose.

- Materials:
  - cements – ordinary Portland and sulphate-resisting cement
  - steels – mild and stainless
  - concrete – including modern concretes, fedcrete, hempcrete, admixtures, FEB
  - bricks – engineering and facing bricks
  - concrete blocks – aerated, high density, insulated
  - aluminium alloys
  - glass – laminated, tempered, float, smart and structural glass.
- Technologies:
  - 3D printing
  - CNC to manufacture structural elements
  - on-site robotics to perform repetitive tasks in construction.

A4 Degradation of construction materials

The impact of the 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.
- Material failure:
  - concrete and reinforced concrete
  - brickwork
  - timber – external and internal applications
  - steel
  - mortars.

A5 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.

A6 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 and fixed.
- Effects of structural failure on structural members.

B Solving practical construction problems

B1 Application of mathematical and statistical methods and techniques used in practical construction contexts

Recall, perform procedures, demonstrate an understanding of and analyse information in a variety of construction contexts by applying mathematical and statistical techniques, including the following.

- Algebraic techniques:
  - 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 $a(x + y)$, $a(x + 2) + b(x + 2)$
    - by grouping $ax - ay + bx - by$
    - quadratic expressions $a^2 + 2ab + b^2$
    - roots of an equation, including quadratic equations with real roots by factorisation, use of quadratic formula, completing the square
  - rearranging formulae to change subject of formulae, complex formulae involving exponents, roots and trigonometric identities
  - substituting values into and evaluating formulae.
- Accuracy of calculations:
  - use of significant figures
  - use of approximation to check a calculation
  - effects of rounding-off errors.
- Trigonometric techniques:
  - trigonometric functions: sine, cosine, tangent ratios
  - application of trigonometry to determine dimensions in 2D and 3D:
    - in surveying
    - in setting out
    - other practical contexts.
- Circular measure:
  - radian measure
  - conversion of degree measure to radian measure and vice versa
  - arc length $s = r\theta$
  - area of sector $A = \frac{1}{2} r^2\theta$
- Geometric techniques:
  - properties of points, lines, angles, circles
  - Pythagoras' theorem.

- Graphical techniques:
  - Cartesian coordinates
  - intersections of graph lines with axes
  - gradients of straight lines
  - equations of graphs: straight line
  - areas under graphs: straight line
  - interpolation and extrapolation.
- Mensuration techniques for quantity surveying and buying:
  - calculation of perimeters, centre lines, areas, surface areas and volumes of:
    - rectangles, squares, triangles, circles, trapeziums
    - prisms, spheres, pyramids, cones, cylinders
    - compound and irregular shapes and objects.
- Statistical techniques:
  - types of data: discrete data, continuous data, ungrouped data, grouped data
  - methods of visual presentation of statistics and data, interpretation and production of: line graphs, bar charts, scatter diagrams, pie charts, histograms, distribution curve, Venn diagrams, tables
  - processing large groups of data to achieve mean, median, mode
  - statistical methods to present data and make decisions based on them
  - interpretation of climate maps.
- Application of mathematical techniques used in structural analysis:
  - concurrent and non-concurrent coplanar forces
  - relationship between force (load), mass and acceleration due to gravity
  - forces: tension, compression, shear
  - application of Hooke's law $F = -kx$ and $F = kx$
  - stress, strain and modulus of elasticity
  - loading as the result of gravitational attraction
  - shear force and bending moment in a beam and its effect on the beam cross section
  - equilibrium conditions to ensure stability of a beam
  - determination of support reactions for simply supported beams with point and distributed loads.
- Application of mathematical techniques involving the human comfort effect of temperature on construction materials while in situ:
  - calculating the effect of temperature change on materials
  - coefficients of thermal expansion application and its significance for selecting fit-for-purpose construction materials and details
  - calculation of U-value
  - calculating required insulation thickness
  - calculation of structural temperature profiles
  - calculation of dew-point temperature profiles.
- Calculation of sound absorption coefficients, reverberation, actual and optimum reverberation times.
- Application of mathematical techniques to determine lighting requirements:
  - inverse square law of illumination:

    $$E = \frac{I}{r^2}$$

  - cosine law of illumination:

    $$E = \frac{I}{d^2}\cos\theta$$

  - lumen method of design
  - daylight factor.
- Application of the desktop method to determine daylight factor.

C Human comfort

The impact of heat, light and sound on human comfort in the built environment.

C1 Heat

The impact of the natural and built environment on human comfort and the provision of comfortable living and working environments.

- 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.
- Acceptable thermal comfort parameters according to:
  - current building regulations
  - combination of personal factors and thermal comfort requirements:
    - age
    - gender
    - clothing
    - state of health
    - level of activity
    - metabolic rate.
- Principles of heat losses and gains in buildings and methods to control them to provide human comfort 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 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.
- The source and causes of condensation, the consequences of its occurrence and potential impact on the building fabric and methods of control to provide human comfort in buildings:
  - 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.

C2 Acoustics

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
    - 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.

C3 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).

Grade descriptors

To achieve a grade learners are expected to demonstrate these attributes across the essential content of the unit. The principle of best fit will apply in awarding grades.

Level 3 Pass

Learners will be able to apply their understanding of construction principles to develop a solution to given situations and information in context. Learners are able to use and apply basic construction, human factors and mathematics to solve simple and familiar construction problems directly. They can provide responses showing understanding and analysis of basic and familiar construction problems. They can interpret and analyse drawings, diagrams, graphical information and meteorological information, and use their knowledge and understanding to solve basic and familiar problems. They are able to use their knowledge of construction to deconstruct given scenarios to produce solutions with interpretation. They often use appropriate construction and human comfort terminology in their responses. Learners will apply their knowledge and understanding of basic construction, human comfort and applied mathematical principles to make recommendations and propose evolutionary or analytical solutions to construction problems.

Level 3 Distinction

Learners will be able to use and apply advanced construction, human factors and mathematical principles to solve complex and unfamiliar construction problems directly, indirectly and synoptically. They can provide balanced responses showing developed understanding and evaluation of complex familiar and unfamiliar construction problems. They can interpret and evaluate drawings, diagrams, graphical information and meteorological information, and use their knowledge and understanding to solve complex, familiar and unfamiliar problems. They use appropriate and technically accurate construction and human factors terminology consistently. They are able to synthesise knowledge and understanding of construction to deconstruct given scenarios, drawing on various sources of information to develop effective solutions with justification. Learners can propose justified synoptic solutions to problems, drawing on their knowledge and understanding of construction, human comfort and applied mathematical principles to make recommendations and propose evolutionary or analytical solutions to construction problems. Learners are able to evaluate the effectiveness of solutions to make justified recommendations on their development and future actions that can be taken.

Key words typically used in assessment

The following table shows the key words that will be used consistently by Pearson in our assessments to ensure learners are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Command or term	Definition
Analyse	Learners examine in detail a scenario or problem to discover its meaning or essential features. Learners will break down the problem into its parts and show how they interrelate. This may include the analysis of graphs to solve construction problems. There is no requirement for any conclusion.
Calculate	Learners apply some form of mathematical process to give an answer. Learners judge the number or amount of something by using the information they already have and add, subtract, multiply, or divide numbers, and apply formula to solve mathematical problems.
Describe	Learners give a clear, objective account in their own words, or highlight a number of key features of a given topic to show recall and/or application of relevant features and information about a subject.
Discuss	Learners investigate a problem or scenario, showing reasoning or argument. There is no requirement for any conclusion.
Draw	Learners produce hand-drawn graphical information or a drawing to show their understanding of and/or solve a construction problem.
Evaluate	Learners review and synthesise information to provide a supported judgement about the topic or problem. Typically a conclusion will be required.
Explain	Learners make a series of linked points and/or justify or expand on an identified point.
Find	Learners discover the facts or truth about something, typically from information contained in a diagram, graph or chart.
Identify	Learners assess factual information, typically when making use of given stimuli. Requires a single word or short-sentence answer.
State/Give	Learners assess factual information. Learners declare definitely or specifically in a single word or short-sentence answer.

Links to other units

This unit has links to all other units in the qualification.

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 2: Construction Design

Level: **3**

Unit type: **External**

Guided learning hours: **120**

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.

This unit will give you the knowledge and understanding of design and construction that will support your progression to employment as an apprentice or trainee construction professional, or entry to a construction-related higher education programme.

Summary of assessment

This unit is assessed under supervised conditions. Learners will be given a scenario two weeks before a supervised assessment period in order to carry out research.

The supervised assessment period is a maximum of 12 hours and can be arranged over a number of sessions. During the supervised assessment period, learners will be given a set task that will assess their ability to produce designs to meet client requirements. Pearson sets and marks the task.

The number of marks for the unit is 63.

The assessment availability is May/June each year. The first assessment availability is May/June 2018.

Sample assessment materials will be available to help centres prepare learners for assessment.

Assessment outcomes

AO1 Demonstrate knowledge and understanding of construction design and build concepts and processes

AO2 Apply knowledge and understanding of construction design and build concepts and processes to design a building to meet an initial project brief

AO3 Analyse site, client and construction information to make decisions in order to produce a building design to meet an initial project brief

AO4 Be able to develop a reasoned design solution for a building to meet an initial project brief

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Essential content

The essential content is set out under content areas. Learners must cover all specified content before the assessment.

A The construction design process

A1 Stages and tasks involved in the design process

The application of Stages 1-7 of the Royal Institute of British Architects (RIBA) Plan of Work 2020 to the tasks associated with the design of low- and medium-rise domestic, commercial and industrial buildings.

- Preparation and brief.
- Concept Design including information modeling and coding.
- 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, cultural 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
  - interaction and compatibility between traditional and modern materials for retrofit
  - 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, Areas of Outstanding Natural Beauty (AONB), Site of Special Scientific Interest (SSSI)
  - tree preservation orders (TPO), contaminated land, flood risk areas.
- Statutory constraints and their requirements, including subsequent updates:
  - Construction (Design and Management) Regulations 2015
  - building regulations approval
  - Party Wall etc. Act 1996
  - Disability Discrimination Acts 1995 and 2005
  - Equality Act 2010
  - Landlord and Tenant Act 1985
  - restrictive covenants on land and property
  - legislation and restrictions relating to outcomes of the Hackitt report, including restrictions on the architect on specifying cladding.
- Environmental constraints:
  - avoidance of air, water and noise pollution
  - National Planning Policy Framework (NPPF) 2012 with reference to:
    - Part 6 Delivering a wide choice of high quality homes
    - Part 7 Requiring good design
    - Part 9 Protecting Green Belt land
    - Part 10 Meeting the challenge of climate change, flooding and coastal change
    - Part 11 Conserving and enhancing the natural environment
    - Part 12 Conserving and enhancing the historic environment
  - Part 1 of the Wildlife and Countryside Act 1981, with reference to protected species and habitat conservation
  - the findings of Environmental Impact Assessments (EIAs) and their use in developing designs for a project.
- Social constraints:
  - neighbour's rights
  - local community objections
  - green space requirements
  - environmental requirements
  - mixed and balanced development.
- Project budget and economic constraints:
  - cost planning
  - available funds
  - source of additional funding for business premises – grants, government incentives, European funding
  - local land prices
  - first-time buyer residential accommodation – borrowing potential, shared-ownership schemes, Help to Buy scheme, government incentives for developers
  - life cycle costs.
- Design for Manufacture and Assembly:
  - logistics for offsite including just in time concepts and transport from factory to site
  - site preparation including the ability to receive prefabricated products
  - the importance of communications and accuracy of data
  - site personnel and roles required.

B Project information and building design production

B1 Project information

Information used in the production of building designs.

- Information requirements of offsite construction.
- Client requirements.
- Site constraints.
- Planning constraints.
- Statutory constraints.
- Environmental constraints.
- 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 Digital design competencies

- Use of Digital Design software, including 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 include 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 Digital Technologies to produce virtual models:
  - New technologies:
    - BIM software
    - coding
    - coordination
    - VR, AR, holoLens
  - 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.

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:
  - offsite manufacturing, including panels, pods, volumetric with services/with finishes
  - traditional construction
  - timber frame construction
  - steel frame construction
  - light steel frame construction
  - concrete frame construction
  - modern methods of construction (MMC)
  - 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.
- Building Research Establishment Environmental Assessment Method (BREEAM):
  - benefits of
  - ratings and percentage of UK buildings in each category.

Grade descriptors

To achieve a grade learners are expected to demonstrate these attributes across the essential content of the unit. The principle of best fit will apply in awarding grades.

Level 3 Pass

Learners will demonstrate 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. They will be able to select, use and interpret relevant information in the context of a scenario to produce an initial project brief. 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.

Level 3 Distinction

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. They will be able to select, use and interpret most of the relevant information in the context of a scenario, showing a balanced consideration of this information to produce an initial project brief with minimal errors or omissions. They will be able to analyse the spatial requirements of a project and provide detailed consideration 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.

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Key words typically used in assessment

The following table shows the key words that will be used consistently by Pearson in our assessments to ensure learners are rewarded for demonstrating the necessary skills.

Please note: the list below will not necessarily be used in every paper/session and is provided for guidance only.

Command or term	Definition
Borehole report	A report that provides information on the soil types and depths within the various strata underneath the surface of the site.
Client details	Information about the client and their requirements.
External envelope	The walls and roof forming the external surfaces of a building, including features such as the windows and external doors.
Ground conditions	Soil type, composition, contamination, level of compaction, water table level, level of saturation.
Ground water table	The depth below ground level of water contained in the ground.
Initial project brief	A document providing information relating to the spatial requirements, desired project outcomes, context of the site and budget.
Internal views	3D internal views of the building.
Medium rise	A building of three- to eight storeys in height.
Sketch	A freehand drawing/hand drawn with annotations, using pens and pencils.
Specification	Details of the building fabric that will achieve the required outcomes.
Sub-soil	The soil below the topsoil.
Virtual model	A 3D computer-generated image of a CAD design that can be rotated and viewed from any angle and can be used to generate rendered images of a project.

Links to other units

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

- Unit 1: Construction Principles
- Unit 4: Construction Technology
- Unit 5: Health and Safety in Construction
- Unit 6: Surveying in Construction
- Unit 7: Graphical Detailing in Construction
- Unit 8: Building Regulations in Construction
- Unit 11: Site Engineering for Construction
- Unit 14: Provision of Primary Services in Construction
- Unit 15: Further Mathematics for Construction
- Unit 21: Building Services Science
- Unit 23: Construction in Civil Engineering.

This unit would relate to the teaching of:

- Unit 19: Quantity Surveying.

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 4: Construction Technology

Level: **3**

Unit type: **Internal**

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 UK, and 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.

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	Recommended assessment approach
A Understand common forms of low-rise construction	**A1** Forms of low-rise construction	A report to a client that covers the use of different structural forms for the proposed project, considering the effectiveness of each structural form.
B Examine foundation design and construction	**B1** Subsoil investigation **B2** Subsoil improvement **B3** Design principles **B4** Types of foundation	A report for a given project scenario that covers the foundation design and different methods that can be used for the design and construction of the foundations, superstructures and external works.
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	A report for a given project scenario that covers the design and construction of the external works, including the incorporation of sustainable drainage systems.

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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 2010, Part A – 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, 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, 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, advantages and disadvantages of the following roof types.

- Pitched, including mono pitch, double pitch, gable ended and hipped:
  - trussed rafter construction
  - traditional 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:
  - traditional two-coat plasterwork
  - dry lining
  - ceramic tiling
  - wood paneling
  - 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, 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>
<tr><td colspan="2">Learning aim D: Examine external works associated with construction projects</td><td rowspan="2">D.D3 Analyse the design and construction of external works for new construction projects, including the incorporation of a sustainable urban drainage system.</td></tr>
<tr><td>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.</td><td>D.M4 Discuss the design and construction of external works for new construction projects, including the incorporation of a sustainable urban drainage system.</td></tr>
</table>

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 aims: B and C (B.P2, B.P3, B.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

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.

Links to other units

This unit links to:

- Unit 1: Construction Principles
- Unit 2: Construction Design
- Unit 5: Health and Safety in Construction
- Unit 7: Graphical Detailing in Construction
- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 14: 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.

Unit 5: Health and Safety in Construction

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners will carry out a safe system of work and investigate the significance of safety system reviews, understanding 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 can carry out practical activities in a safe environment that is free from hazards and risks. Safety starts in the office, with planning safe systems of work, assessing the risks in construction operations and applying control measures to reduce the risks to an acceptable level. Companies aspire to achieve the target of zero accidents in the workplace, promoting their reputation as safe constructors.

In this unit, you will examine the responsibilities of employees and employers with regard to UK legislation and regulations and the procedures used to control hazards and risks for construction operations across a range of activities. You will use relevant policies and procedures to design a safe system of work that could be instigated and maintained in a construction context. You will also investigate how all aspects of health and safety are monitored to ensure they are kept up to date, employers and employees are well informed and any changes are evaluated and controlled.

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 such as the National Examination Board in Occupational Safety and Health (NEBOSH) Certificate and Diploma qualifications or Higher Nationals in Construction and degrees in construction specialisms.

Learning aims

In this unit you will:

A Understand how health and safety legislation is applied to construction operations

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

C Understand the need for the review of safety systems for construction operations.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Understand how health and safety legislation is applied to construction operations	**A1** Health and Safety at Work etc. Act 1974 **A2** Construction (Design and Management) Regulations 2015 **A3** Management of Health and Safety at Work Regulations 1999 **A4** Work at Height Regulations 2005 **A5** Control of Substances Hazardous to Health (COSHH) Regulations 2002 **A6** Training and education	Presentations, explanatory leaflets or a formal report that references case studies, showing the impact of how legislation and regulations uphold and improve health and safety on construction sites. Reference to statistics could provide justification of legislation and regulation effectiveness.
B Carry out the development of a safe system of work for construction operations	**B1** Health and safety preparation **B2** Construction phase health and safety **B3** Health and safety file	A safety survey with completed documentation, including the production of a risk assessment and method statement.
C Understand the need for the review of safety systems for construction operations	**C1** Accident reporting procedures **C2** Reviewing safety systems **C3** Changes to systems and procedures **C4** Skills, knowledge and behaviours	A report evaluating how safe systems can be improved following the reporting of accidents, utilising review procedures.

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Content

Learning aim A: Understand how health and safety legislation is applied to construction operations

Current legislation and regulations, including any updates, and their application in construction operations.

A1 Health and Safety at Work etc. Act 1974

- The duties defined in each section of the act. The duties of:
  - employers
  - employees and self-employed
  - designers and manufacturers
  - Health and Safety Executive (HSE):
    - powers of the HSE when visiting a site or investigating an accident
    - notices for improvements and prohibition, differences between the two types.
- Penalties for non-compliance:
  - enforcement, sanctions, loss of reputation, loss of work, corporate manslaughter
  - fines, magistrates and crown court penalties, level of fines
  - imprisonment, length of detainment.

A2 Construction (Design and Management) Regulations 2015

The content of the regulations and what aspects have to be carried out in order to comply with them during the design and construction of a building project.

- Phases to be followed:
  - pre-construction information – client's health and safety file, site survey, desktop research
  - construction phase safety plan – contents required for compliance with regulations
  - content of the health and safety file:
    - meet the requirements of the regulations
    - duty holders' participation, to include designer, client, main contractor, contractors.
- Duties of parties to the contract, to include:
  - principal designer and designers
  - client
  - principal contractor.
- General requirements for all construction sites:
  - welfare facilities – Schedule 2 in the appendix to the regulations
  - general principles of prevention to be employed on site.

A3 Management of Health and Safety at Work Regulations 1999

Aspects of the regulations relevant to construction.

- Duties, to include those defined in the following sections of the regulations:
  - risk assessment requirements under Regulation 3 of the legislation
  - health and safety arrangements and assistance provided by the employer
  - cooperation and co-ordination between all parties
  - capabilities and training of all operatives
  - specific duties of employees under this regulation.

A4 Work at Height Regulations 2005

Duties, to include:

- organisation and planning required before working at height is commenced
- avoiding risks from working at height by establishing an alternative method
- work equipment requirements for operatives
- duties of persons at work with regard to safety under this regulation
- requirements for any working platform used to gain access to working at height
- requirements for personal fall protection to be provided for employees
- the use of ladders and the regulations and duties concerning this use.

A5 Control of Substances Hazardous to Health (COSHH) Regulations 2002

Relevant aspects regarding the use of substances and chemicals during construction activities on site.

- Employer's duties, to include provision of:
  - 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
  - monitoring and health surveillance of employees using substances at work
  - information, instruction and training of employees.

A6 Training and education

- On-site safety training, e.g. tool box talks.
- Construction Skills Certification Scheme (CSCS) card – classification and the different types of cards available, qualifying for a card, process, validity.
- Client Contractor National Safety Group (CCNSG) Safety Passport – requirements and use.
- Fire safety.
- Off-site training requirements and links to control measures, e.g. for working at height, COSHH, noise, confined spaces.
- Training associated with equipment.
- Provision and Use of Work Equipment Regulations (PUWER) 1998.
- Purpose and provision of safety notice boards and signage.

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 Health and safety preparation

- Notifications to HSE, the completion of the F10 documentation.
- Health and safety construction phase plan, contents and safe systems of work (SSW).
- Site induction content to be prepared, inclusions, method of delivery.
- Preparation of the site waste management plan, its content and specific requirements under the regulations for waste management.
- Safety poster provision, gate and entrance signage and notices, formal gate notifications.

B2 Construction phase health and safety

- Delivery of site inductions and retaining records of inductions.
- Identifying hazards by various methods – direct observation, checklists, audits, tool box talks, safety committees.
- Writing risk assessments and evaluating control measures – risk ratings, acceptable levels.
- Writing method statements, sequencing of statements, resources to be used.
- Delivering tool box talks – method, timing, what to cover in talk, who should be present.

- Issuing care and maintenance of personal protective equipment (PPE) and first-aid facilities.
- Preparing temporary fire and evacuation procedures.
- Instructing on waste disposal, segregation, good housekeeping.
- Managing subcontractors' safety information, site meetings.

B3 Health and safety file

- Preparing file contents in accordance with the requirements of the Construction (Design and Management) Regulations 2015:
  - a brief description of the work carried out
  - any residual hazards that remain and how they have been dealt with, e.g. information concerning asbestos, contaminated land, buried services, etc.
  - key structural information, e.g. bracing, sources of substantial stored energy – including pre- or post-tensioned members, etc.
  - safe working loads for floors and roofs, particularly where these may prohibit placing scaffolding or heavy machinery
  - hazardous materials used, to include manufacturer's data sheets, e.g. pesticides, special coatings that should not be burnt off, etc.
  - information regarding the removal or dismantling of installed plant and equipment, e.g. any special arrangements for lifting, special instructions for dismantling, etc.
  - health and safety information about equipment provided for cleaning or maintaining the structure
  - the nature, location and markings of significant services, including underground cables; gas supply equipment; fire-fighting services, etc.
  - information and as-built drawings of the structure, its plant and equipment, e.g. the means of safe access to and from service voids, fire doors and compartmentalization, etc.
- Reviewing documentation.
- File distribution.

Learning aim C: Understand the need for the review of safety systems for construction operations

Reviewing to close the safety cycle and analysing systems for any changes to processes, procedures or operations.

C1 Accident reporting procedures

- Definition of the following in accordance with reporting procedures and classification:
  - accident
  - near miss
  - minor
  - major.
- Procedures on discovering an accident:
  - first-aid actions, call for help, first aider, emergency services, individual responsibilities
  - reporting to supervisor, procedures, accident book, internal reports
  - Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 2013, over-three-day lost time injuries, reporting of a fatality
  - internal accident investigation procedures
  - fatalities and HSE investigations, documentation to produce.

C2 Reviewing safety systems

Using data to establish where unplanned events occur and to reduce incidents.

- Analysis of accident information:
  - trends in near misses and types of accidents
  - comparison with UK national averages
  - discussion with workforce, site safety meetings, interviews, safety committees
  - suggestions and recommendations for improvements, justified by statistical analysis.
- Benefits of undertaking safety reviews:
  - reduction in costs – direct and indirect
  - reputation of the company, marketing materials
  - worker morale, a better and safer place to work
  - improved performance in terms of production
  - client estimating pre-contract enquiries and getting onto employer tender lists.

C3 Changes to systems and procedures

Closing the safety cycle to ensure that any changes are reviewed, checked for compliance and monitored for effectiveness.

- Reviewing control measures, ensuring lowest possible risk achieved with reasonably practical measures, signing and dating reviews.
- Revising risk assessments in light of changes to processes, operatives and materials.
- Evaluating revised risk ratings.
- Reviewing changes and recommendations, communication to all.

C4 Skills, knowledge and behaviours

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

- Evaluating outcomes on hazards and risks to help inform high-quality justified recommendations and decisions.
- Media and communication skills, including:
  - the ability to convey intended meaning, e.g. written (risk assessment 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 how health and safety legislation is applied to construction operations		
A.P1 Explain the legislative duties of employers and employees in the current legislation. **A.P2** Explain how the application of health and safety related legislation controls health and safety in construction. **A.P3** Explain how education and training improves standards of health and safety.	**A.M1** Discuss the impact of health and safety related legislation, education and training in controlling health and safety in construction.	**A.D1** Evaluate the effectiveness of health and safety related legislation, education and training 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 with 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 the need for the review of safety systems for construction operations		
C.P6 Explain how safe systems of work are reviewed. **C.P7** Explain the procedures that follow an accident to improve future safety.	**C.M3** Discuss how safety systems are improved following the reporting of accidents and review of procedures.	**C.D3** Evaluate how safety systems are improved following the reporting of accidents and review of procedures.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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.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 specific additional resource requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners must thoroughly evaluate, in terms of advantages and disadvantages, the effectiveness of health and safety legislation and regulations in controlling risks on a construction site. Learners will make specific, relevant references to the role of safety education and training to produce a logical, coherent response. Learners' research must lead to a supported, convincing judgement of the impact of risk reduction, considering fatalities and major and minor accidents in order to come to a robust conclusion. Learners' research can also include the contribution of legislation and regulations in reducing 'near misses'. This can include making reasoned judgements where legislation and regulations have not reduced accident rates or incidents on construction sites.

For merit standard, learners must produce a clear, balanced discussion of the impact of how legislation and regulations, and associated training and education, control safety on a construction site. This should be in terms of what has to be provided legally, for example safety information and welfare facilities and how these are provided, depending on the choice of two other regulations in addition to the Health and Safety at Work etc. Act 1974. 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, the training of operatives to use harnesses to restrain falls from height, etc.

For pass standard, learners need to explain the Health and Safety at Work etc. Act 1974 in terms of the duties placed on an employer and employee under this legislation. Learners will give mostly relevant examples of the types of provision, giving accurate details and reasons for their importance in a construction working environment. Two other regulations must be explored by learners in explaining how each controls health and safety in a construction context. Examples of on-site requirements must be provided against each regulation. Learners will also provide a realistic explanation of how education and training improves standards of health and safety.

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 in a safe manner with minimal risk of accident, injury or near miss.

For merit standard, learners must produce an optimised safe system of work. In doing so, 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 these can be improved. Learners must demonstrate that they fully comprehend the methods used to ensure that construction operations can be carried out in a safe manner 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. Learners will produce a realistic risk assessment and method statement with effective control measures that supports 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 in a safe manner with minimal risk of accident, injury or near miss.

Learning aim C

For distinction standard, learners must consider an accident report and then thoroughly evaluate how safe systems of work can be improved, utilising review procedures following the reporting of accidents. 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 that they are proposing. Learners must demonstrate that they have developed a robust, in-depth understanding of the methods used to review safe systems of work following the reporting of an accident.

For merit standard, learners will adopt a balanced approach in considering an accident report and discussing how safe systems of work can be improved, utilising review procedures following the reporting of accidents. Learners will provide a relevant, balanced discussion of how different aspects of safe systems of work interrelate, in relation to the scenario. Learners must demonstrate that they fully comprehend the methods used to review safe systems of work following the reporting of an accident.

For pass standard, learners must explain how safe systems of work are reviewed, and the procedures that follow an accident to facilitate safety improvements in the future. Learners' explanations will be realistic and mostly relevant. Learners must demonstrate that they have a good understanding of the methods used to review safe systems of work following the reporting of an accident.

Links to other units

This unit links to:

- Unit 4: Construction Technology
- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 14: Provision of Primary Services in Buildings.

Employer involvement

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

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

Unit 7: Graphical Detailing in Construction

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 following British Standards 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 drawings 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	Recommended 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. Learners' construction drawings produced using manual and CAD methods, following standard conventions and practices in response to a given brief.
B Develop construction drawings for a given construction brief	**B1** Construction drawings	
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.

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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 section 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 in accordance with British Standard BS 1192:2007.

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 BS 1192:2007 standards and conventions using manual and CAD methods:

- BS 1192:2007 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 drawings 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), 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 the audience, e.g. positive and engaging tone, technical/vocational language suitable for intended audience.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Understand the resources required to produce construction drawings</td><td rowspan="4">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.
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 BS 1192:2007 standards.</td></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><td colspan="2">Learning aim B: Develop construction drawings for a given construction brief</td></tr>
<tr><td>B.P4 Produce construction drawings for a two-storey building drawn to an appropriate scale, containing some technical information following BS 1192:2007 standards.</td><td>B.M2 Produce good-quality construction drawings for a two-storey building drawn accurately to an appropriate scale, containing appropriate technical information following BS 1192:2007 standards.</td></tr>
<tr><td colspan="2">Learning aim C: Undertake production of two-dimensional and three-dimensional freehand construction sketches</td><td rowspan="2">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.</td></tr>
<tr><td>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.</td><td>C.M3 Produce good-quality, annotated 2D and 3D freehand sketches for the interior and exterior of a building with convergence to vanishing points.</td></tr>
</table>

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Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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, 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 as laid down in BS 1192:2007 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 as laid down in BS 1192:2007 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 as laid down in BS 1192:2007 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 2: Construction Design
- Unit 4: Construction Technology
- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 14: 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.

Unit 9: 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	Recommended 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	A training pack for trainee site managers joining a large national housing contractor.
C Develop a programme of activities for construction works	**C1** Production control systems	A presentation in which learners consider the methods used to plan and control a programme of work for a housing development.

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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, to include 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 on site:
  - 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
  - National House Building Council (NHBC) 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 Construction Skills Certification Scheme (CSCS) 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 on site.

- 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 on site, 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 on site.
- Measurement of progress:
  - physical progress on site, to include:
    - regular comparison of planned progress of work on site 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* 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, on site. 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 on site. 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 on site.

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 4: Construction Technology
- Unit 5: Health and Safety in Construction
- Unit 9: Management of a Construction Project
- Unit 19: 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: 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 most buildings in the UK, 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 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 so on, 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 an LTHW system

B Undertake the design of an 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	Recommended assessment approach
A Understand the design requirements for an 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 an 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	

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Content

Learning aim A: Understand the design requirements for an 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 an LTHW system for a domestic situation.

- Regulations and standards that have to be met.
- Emissions legislation.
- Building regulations.
- 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 and 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 an 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 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 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 versus 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 for Part L of the building regulations
- 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 in maintaining 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:
  - plastic
  - 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 an 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 an LTHW installation for a domestic property		**B.D2** Produce a comprehensive heating design that fully meets the needs of a given domestic property. **C.D3** Evaluate the selection of a boiler, materials and equipment 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.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* 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)

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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 an LTHW system for a given building. They will support and fully reference these factors using their research. Their evaluation should consider the requirements of all the stakeholders in the project 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 an 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 size the heat emitters accordingly, using manufacturers' published information. Learners will select the primary heat-generating plant with the 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 Principles
- Unit 2: Construction Design
- Unit 4: Construction Technology
- Unit 7: Graphical Detailing in Construction
- Unit 14: 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 14: 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	Recommended 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.

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Content

Learning aim A: Examine the practices associated with the provision of hot- and cold-water systems

The systems used to supply buildings with a supply of 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; 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 feeds 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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Examine the practices associated with the provision of hot- and cold-water systems</td><td rowspan="4">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.
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.</td></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><td colspan="2">Learning aim B: Examine the principles and approaches associated with the provision of above- and below-ground drainage systems</td></tr>
<tr><td>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.</td><td>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.</td></tr>
<tr><td colspan="2">Learning aim C: Understand the principles of the provision of simple, single-phase electrical systems and domestic gas installations</td><td rowspan="2">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.</td></tr>
<tr><td>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.</td><td>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.</td></tr>
</table>

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 Principles
- Unit 2: Construction Design
- Unit 7: Graphical Detailing in Construction
- Unit 12: Low Temperature Hot Water Systems in Building Services.

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 15: 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 the BTEC Nationals in Construction programme, for example in surveying, electrical systems or structural analysis.

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 Higher National or 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	Recommended 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) $\sin ax$, $\cos ax$
- Derivatives of logarithmic functions, for example $\log_e ax$
- Derivatives of exponential functions, for example e^{ax}

- Product rule, e.g. $\frac{dy}{dx} = \frac{v du}{dx} + \frac{u dv}{dx}$
- Quotient rule, e.g. $\frac{dy}{dx} = \frac{\frac{v du}{dx} - \frac{u dv}{dx}}{v^2}$
- 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. $\int(x^2 - 3x + 4)dx$
  - 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. $\int(e^{3t})dt$
- 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.D1** Demonstrate, using complex algebraic and trigonometric techniques, the calculation for a given 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.	
Learning aim B: Examine how calculus can be used to solve a 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.
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.	
Learning aim C: Investigate the use of statistical methods to solve a construction problem		**C.D3** Demonstrate, using complex statistical analysis and assessment techniques, the outcome of a given 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.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 aim 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 aim 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 aim 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, i.e. 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 1: Construction Principles
- Unit 19: Quantity Surveying.

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: 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 limestone and not glass, or why they designed a flat roof and not an elaborated pitched roof with vaulted ceilings? 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, such as the Higher National in Construction, 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	Recommended 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.

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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.	

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Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 in the round 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 2: Construction Design
- Unit 4: Construction Technology.

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 18: Building Information Modelling

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners will develop knowledge and an awareness of the principles and use of building information modelling (BIM) technologies to streamline the design, construction and usage of building projects.

Unit introduction

Working in the construction industry, you will increasingly need to know about and use BIM. It aims to coordinate all aspects of a building project, from its design, construction and operation, to its repurposing and recycling at the end of its useful life.

This unit will introduce you to the Royal Institute of British Architects (RIBA) Digital Plan of Work (DPoW) and the Common Data Environment (CDE) in which it operates for a BIM-enabled design and construct project. It will cover the information management environment, Construction Operations Building information exchange (COBie) and BIM deployment strategies, and their contribution to improved communications between all parties, statutory control approval, sustainability and potential gains from modern methods of construction. The unit will investigate the effect of policies, standards and legislation in the BIM-enabled environment on a design and construct project.

You may further your knowledge and understanding of BIM by progressing to a construction industry-related degree, and then specialising in a BIM-specific role or using BIM in your chosen construction profession.

Learning aims

In this unit you will:

A Examine the application of the RIBA Digital Plan of Work in an information management environment

B Examine the construction information management environment

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

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

Summary of unit

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

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Content

Learning aim A: Examine the application of the RIBA Digital Plan of Work in an information management environment

A1 RIBA Digital Plan of Work

Learners will need an awareness of the stages of the RIBA Digital Plan of Work (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.

A2 BIM and its implementation in the RIBA DPoW

Learners will need an awareness of 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 lifecycle 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 RIBA DPoW

Learners will need an awareness of 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

Learners will need to be introduced to the concept of Construction Information Management.

B1 Construction Operations Building information exchange (COBie)

- The contribution of COBie to the ease of 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

Learners will need to have an awareness of 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

Learners will need to understand the importance of and requirements to protect data, intellectual properties, legal requirements, 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

Learners will need to have an awareness of the stages of information flow in a CDE including roles of the team at each point.

- 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 in a BIM-enabled design and construct project

C1 BIM and sustainability and statutory control approval

Learners will need an awareness of the contribution of BIM to sustainability and gaining statutory control approval before construction commencement.

- Sustainability requirements:
  - Building Research Establishment Environmental Assessment Method (BREEAM) assessment:
    - 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. building consent and planning permission for both retrofit projects for adaptation and new builds.

C2 BIM and modern methods of construction

Learners will need an understanding of 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.

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

Learners will need to show an awareness of the DPoW and BIM, their influence on new 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 due 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 Construction Design and Management (CDM) regulations and working practices

Learners will need to appreciate the ability of BIM to model designs and processes virtually and in advance of construction to enable the main parties in a design and construction project to:

- identify design issues
- consider best building methods and practices
- overcome construction planning clashes and logistical problems
- comply with Construction (Design and Management) Regulations 2015, or subsequent updates, to enable safe systems of work to be agreed on and put in place before construction commences.

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

Learners will need to know 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 commission (HSC)/executive(HSE) requirements
- building acts
- UK Construction Project Information Committee (CPIC)
- Construction Industry Council (CIC) BIM protocol, e.g. contracts for design and construct projects
- International Standards Organisation (ISO) and British Standard Institute (BSI) standards
- CIC

- Construction Leadership Council (CLC)
- Construction Product Regulations (CPR) and CE marking.

D4 Allocating roles and resources

Learners will understand the effect of the RIBA DPow and BIM on 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 the RIBA DPoW roles, 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:
  - The Construction Industry Council (CIC) BIM Protocol supplementary contract agreement for appointments by construction clients and their contractors key content:
    - BIM model production
    - delivery requirements
    - information requirements.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Examine the application of the RIBA Digital Plan of Work in an information management environment</td><td rowspan="2">A.D1 Evaluate the application of the RIBA DPoW and CDE in a BIM-enabled design and construct project.</td></tr>
<tr><td>A.P1 Describe the application of the RIBA 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 RIBA 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="3">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 in 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 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><td></td></tr>
<tr><td colspan="2">Learning aim D: Investigate the effect of policy, standards and legislation on the BIM-enabled environment</td><td rowspan="2">D.D3 Evaluate the effect of industry, professional and government policies, legislation and standards on construction activities, roles and resources for a given BIM-enabled design and construct project.</td></tr>
<tr><td>D.P7 Outline the effect of industry, professional and government policies, legislation and standards 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.</td><td>D.M4 Discuss the effect of industry, professional and government policies, legislation and standards on construction activities, roles and resources for a given BIM-enabled design and construct project.</td></tr>
</table>

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 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)

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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 RIBA 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 RIBA 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 RIBA 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 RIBA 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 RIBA 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 sometimes these may not 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 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 to support current sustainability standards, including the incorporation of modern construction methods and obtaining statutory control approval. Where they use graphical information, this 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 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, legislation and standards 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, legislation and standards 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, legislation and standards 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 2: Construction Design
- Unit 4: Construction Technology
- Unit 9: 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.

Tutors would benefit from accessing industry resource and expert training materials on BIM, for example those available through the websites of external experts, such as Offsite Ready, BIM Academy and MOBIE.

Unit 19: 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 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, such as the Higher National in Construction (with the quantity surveying pathway), 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 with a construction company.

Learning aims

In this unit you will:

A Understand the functions of a quantity surveyor

B Undertake the production of bills of quantities for a project

C Undertake the production of a final account for a project.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Understand the functions of a quantity surveyor	**A1** Professional quantity surveyor (PQS) functions **A2** Main contractor quantity surveyor functions **A3** Preparation of bills of quantities **A4** Financial management **A5** Contractual management	Learners will explain the differences between a professional quantity surveyor and a main contractor's quantity survey.
B Undertake the production of bills of quantities for a project	**B1** Taking off **B2** Abstraction and bill production	Using a set of given drawings, learners will produce bills of quantities 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.

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Content

Learning aim A: Understand the functions of a quantity surveyor

A1 Professional quantity surveyor (PQS) functions

The PQS acts mainly for a client in the preparation of the following in support of the feasibility of a proposal.

- The preparation of cost budgets:
  - providing guidance to the architect 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 Building Cost Information Service (BCIS) data:
    - types of available data from BCIS
    - 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:
    - taking off 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:
    - content and layout
    - preliminaries
    - preambles
    - measured work sections
    - PC and PS, including contingencies and dayworks
    - final summary
  - tender documentation:
    - covering letter
    - invitation to tender
    - form of tender and return envelope
    - bill of quantities 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
  - 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.

A2 Main contractor quantity surveyor functions

The functions of the main contractor's quantity surveyor and how these differ from the PQS 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.
- Agreeing subcontract accounts and authorising payments.
- Final account preparation:
  - providing information to the PQS to facilitate final account preparation
  - pricing dayworks
  - agreeing the final account with the PQS.
- 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 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, 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).
- Use of measurement and bills of quantity production software packages.
- Use of dimension paper, direct billing paper and cut and shuffle paper.
- Working up quantities and abstraction.
- Producing bill of quantities pages.
- Inclusion of PC and PS.
- 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:
  - changes to specifications to lower costs
  - monitoring monthly valuations
  - valuing variations
  - forecasting projected final account
  - life cycle analysis.
- Main contractor quantity surveyor:
  - 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).

Learning aim B: Undertake the production of bills of quantities 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).

- Site instructions, confirmation and issue of an AI.
- 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 and variations.
- Dayworks.
- Adjustments to PC and PS.
- 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		**A.D1** Evaluate the roles of quantity surveyors for a given project scenario.
A.P1 Explain the role of the professional quantity surveyor. **A.P2** Explain the role of the contractor's quantity surveyor.	**A.M1** Discuss the roles of quantity surveyors for a given project scenario.	
Learning aim B: Undertake the production of bills of quantities for a project		**B.D2** Produce bills of quantities 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 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* 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 for a given project scenario. Learners will consider how the roles of the professional quantity surveyor and the contractor's quantity surveyor 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.

For merit standard, learners must discuss the roles of quantity surveyors for a given project scenario. Learners will cover both professional and contractor's quantity surveyors and their roles in the given scenario. Learners will consider the objectives, key focus and content in their discussions, covering the quantity surveyor's work linked to the project scenario. This will include the work of the quantity surveyors during both the pre- and post-contract phases of construction projects. Learners will demonstrate a good understanding of the role of the quantity surveyor.

For pass standard, learners must explain the roles of the professional quantity surveyor and the contractor's quantity surveyor. Learners will consider, within their explanations, the key objectives and content of the quantity surveyor's work in generic terms but without focus on the project scenario. Learners will cover the work of the quantity surveyors during the pre- and post-contract phases of construction projects. Learners will demonstrate a generic understanding of the role of the quantity surveyor.

Learning aim B

For distinction standard, learners must produce bills of quantities 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.

For merit standard, learners must produce bills of quantities 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.

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 AI, dayworks, adjustment of prime cost (PC) and provisional sums (PS), 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 AI, dayworks, adjustment of PC and PS, 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 Principles
- Unit 2: Construction Design
- Unit 3: Tendering and Estimating
- Unit 4: Construction Technology
- Unit 7: Graphical Detailing in Construction
- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 14: Provision of Primary Services in 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.

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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	Recommended 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.

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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.	

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Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 9: Management of a Construction Project
- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 14: Provision of Primary Services in Buildings
- Unit 17: Projects in Construction.

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 27: 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 support you in progressing to a higher-level construction programme such as a Higher National in Construction and the Built Environment with Building Services Engineering pathway, or a general construction or building services degree. 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	Recommended 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	

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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.

Learning aim B: Apply the principles of building services control systems and the function and operational characteristics of control systems

The purpose of controls 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
  - check for conflicts and clashes between models, e.g. Autodesk Navisworks®, Autodesk® BIM 360™ Glue, Solibri Model Checker™
  - 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 (Autodesk Dynamo, Rhinoceros and Grasshopper).

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 their operational features, for a given scenario.
A.P1 Explain the selection of a building service control system, its components and some of their operational features, for a given scenario.	**A.M1** Assess the selection of a building services control system, its components and most of their 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 system 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* 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, 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 and explain 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 12: Low Temperature Hot Water Systems in Building Services
- Unit 28: Heating, Ventilation and Air Conditioning Design
- Unit 30: Plumbing Technology in Building Services Engineering
- Unit 31: Electrical Principles in Building Services Engineering
- Unit 32: Electrical Installation Standards, Components and Design.

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 28: 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 support you in progressing to a higher-level construction programme such as a Higher National in Construction and the Built Environment with Building Services Engineering pathway, or a general construction or building services degree. 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	Recommended 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	

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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.
- 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.
- 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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Understand the operational characteristics of ventilation and air-conditioning requirements for buildings</td><td rowspan="2">A.D1 Justify the ventilation and air-conditioning system, including all the component parts and their respective operational features.</td></tr>
<tr><td>A.P1 Explain the operational characteristics of the ventilation and air-conditioning system.</td><td>A.M1 Assess the elements of the ventilation and air-conditioning system.</td></tr>
<tr><td colspan="2">Learning aim B: Apply the principles of ventilation, warm-air heating and air-conditioning requirements for simple single-zone air-conditioning installations and buildings</td><td rowspan="4">B.D2 Produce a comprehensive design for a detailed ventilation and air-conditioning system that fully meets the requirements of the scenario.
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.</td></tr>
<tr><td>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.</td><td>B.M2 Produce a design for a detailed ventilation and air-conditioning system that mostly meets the requirements of the scenario.</td></tr>
<tr><td colspan="2">Learning aim C: Develop appropriate systems and specifications for ventilation and air-conditioning systems, ductwork, plant and equipment</td></tr>
<tr><td>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.</td><td>C.M3 Justify the selection of an appropriate ventilation and air-conditioning system that meets most of the needs of the given scenario.</td></tr>
</table>

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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

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 justified 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 12: Low Temperature Hot Water Systems in Building Services
- Unit 21: Building Services Science
- Unit 27: Building Services Control Systems
- Unit 29: Use of Static and Dynamic Fluids in Building Services Engineering
- Unit 30: Plumbing Technology in Building Services Engineering
- Unit 33: Quantity Surveying Measurement Techniques in Building Services Engineering
- Unit 34: Building Regulations and Control 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 29: Use of Static and Dynamic Fluids 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 pressurised systems used to produce steam for driving turbines. It is necessary to control the flow of fluids under various conditions to be able to put them to good use. 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. This begins with an understanding of the associated principles surrounding the behaviour of fluids and their physical properties. This is 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 as such this unit gives you a valuable insight into the types of systems available and how appropriate they are for use in a modern building. This unit will support you in progressing to a higher-level construction programme such as a Higher National in Construction and the Built Environment with Building Services Engineering pathway, or a general construction or building services degree.

Learning aims

In this unit you will:

A Understand the properties, behaviour, theory and applications of static fluid systems

B Apply the principles of dynamic fluid flow in pipes and ducts

C Develop appropriate fluid flow systems.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Understand the properties, behaviour, theory and applications of static fluid systems	**A1** Physical properties **A2** Behaviour of fluids **A3** Principles of pressure **A4** Pressure recording devices	Analyse a building services system in terms of the physical properties and behaviour of the fluids.
B Apply the principles of dynamic fluid flow in pipes and ducts	**B1** Dynamic fluid flow **B2** Pipes and ductwork	Evaluate a fluid flow system for a scenario. As part of the solution, produce a report that covers the selection of components, how fluids behave and the potential energy losses within the system.
C Develop appropriate fluid flow systems	**C1** Energy loss **C2** Losses in pipes and ductwork **C3** Pumps, fans and compressors	

Content

Learning aim A: Understand the properties, behaviour, theory and applications of static fluid systems

A1 Physical properties

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.

A2 Behaviour of fluids

The behaviour of fluids within building services systems.

- Static.
- Flowing.
- Fluid flow behaviour.
- Use of the Reynolds number to predict flow type.

A3 Principles of pressure

The need to consider the impact of pressure within fluid systems.

- Pressure at any point in a liquid is equal in all directions.
- Pressure at any two points at the same depth in a liquid is equal.
- Liquids 'find their own level'.
- Pascal's principle.
- Pressure is expressed as $P = \rho gh = wh$

A4 Pressure recording devices

Methods of measuring and recording pressure and their use within building services.

- Construction of pressure measuring devices.
- Operating principles and application of compound pressure gauges.
- Barometers.
- Simple piezometers.
- Manometers:
  - U-tube
  - differential pressure
  - inclined limb.
- Fluids in manometer.
- Calculation of pressures in manometers containing different fluids and combination of fluids.

Learning aim B: Apply the principles of dynamic fluid flow in pipes and ducts

The factors that need to be considered in the design of building services systems when fluids flow through pipes and ducts.

B1 Dynamic fluid flow

Consideration of the qualitative behaviour and fluid flow capacity within 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.

B2 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 in orifice plate and meter, and Venturi meters.

Learning aim C: Develop appropriate fluid flow systems

The need to consider energy losses in pipework and ducting as a result of flow patterns and fittings.

C1 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.

C2 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.
- Chezy 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.

C3 Pumps, fans and compressors

The selection of appropriate pumps, fans and compressors for differing situations and applications.

- Propeller.
- Centrifugal and axis fans.
- Liquid pumping devices.
- Reciprocating compression devices and rotary compression devices.
- Fan and pump performance curves.
- Simple fan and pump laws.
- Ways of changing performance.
- Matching pumps and fans to pipe and ductwork systems.
- Determining the duty point.
- Connecting in series and parallel.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the properties, behaviour, theory and applications of static fluid systems		**A.D1** Evaluate how the fluid properties and laws of fluid flow influence the design of a building services system.
A.P1 Explain the physical properties and behaviour of fluids. **A.P2** Explain the methods of measuring pressure in fluids.	**A.M1** Analyse the behaviour of fluids within a building services system.	
Learning aim B: Apply the principles of dynamic fluid flow in pipes and ducts		**B.D2** Produce a comprehensive system design that fully meets the requirements of the building services system for a given scenario. **C.D3** Demonstrate the selection of a pump, fan, compressor, 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 of the choices.
B.P3 Produce a building services systems diagram for a basic building services system. **B.P4** Assess the behaviour of fluids within the building services system.	**B.M2** Produce a pipe and duct system design that mostly meets the requirements of a given scenario.	
Learning aim C: Develop appropriate fluid flow systems		
C.P5 Select a pump, fan or compressor for use in the building. **C.P6** Select appropriate pipe and ducting for the building services system.	**C.M3** Demonstrate the selection of a pump, fan, compressor, pipes and ducting that meets most of the needs of a building services system for a given scenario, justifying most of the choices.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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

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 system and identify all the influences on fluid flow within the system. Learners' work will be accompanied by justified reasons that fully substantiate the evaluative comments relating to fluid behaviour. The evaluation should also justify why the various components were selected in relation to respective fluid laws. In evaluating the system, learners will draw on their experience and knowledge of the factors to consider 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 within the system. The analysis will be accompanied by reasons to support the findings relating to fluid behaviour. The analysis should also explain why the various components were selected in relation to the respective fluid laws. In analysing the system, learners will draw on their experience and knowledge of the factors to consider in the design of any building services system.

For pass standard, learners must consider a building services system and identify some of the components and explain some of their operational features. This explanation will be accompanied by reasons that support the findings. The explanation should also include information about the laws of fluids and how pressure is measured and recorded. In explaining the system, learners will demonstrate that they comprehend the factors that need to be considered in the design of any building services system.

Learning aims B and C

For distinction standard, learners will produce a comprehensive report, detailed in its compilation, containing full manufacturer details relating to all devices and components for a scenario. The selection of all pumps, fans, compressors, pipes and ducts needs to be justified. In justifying, learners will draw on their knowledge of building service systems in order to consider the flow rates and energy losses of the system for the given scenario.

For merit standard, learners, in meeting these criteria, will produce a design report that is detailed in its compilation, containing full manufacturer details of any fans, pumps or compressors and the pipes and ducting for the given scenario. Learners will draw on their knowledge of the design of building service systems to justify that key aspects of their designs are correct for the given scenario.

For pass standard, learners must produce a system for a given scenario. This should include information regarding any fluid flow systems, and pipe and duct sizes. Descriptions will be supported with diagrammatic illustrations of the system, including all key elements. Learners must assess the operational function of the system for the pipes and ducts used from the manufacturer's published information. The fans, pumps or compressors must be selected to meet the design requirements.

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Links to other units

This unit links to:

- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 27: Building Services Control Systems
- Unit 28: Heating, Ventilation and Air Conditioning Design
- Unit 30: Plumbing Technology in Building Services Engineering
- Unit 31: Electrical Principles 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 30: Plumbing Technology in Building Services Engineering

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners develop skills in the application and use of components and equipment when designing hot- and cold-water systems, above-ground drainage systems and gas installations.

Unit introduction

Plumbing systems are taken for granted; we give no thought to what happens when we turn on a tap and how that water has arrived in a potable condition. Increasingly, you will be working with modern technologies that include grey water recycling systems, or with clients who specify technology to promote convenience and efficiency, such as use of hands-free technology and consumer units that are integrated with smart systems with wireless control, or wider automation systems.

In this unit, you will learn about the sources, cleansing and distribution of cold water and the standards and legislation that need to be applied. You will develop skills, knowledge and understanding to enable you to design plumbing, above-ground drainage and gas installations for a domestic property, and in doing so you will develop a specification for material components and ancillary equipment to suit the needs of the system.

Plumbing installations are a critical feature of any building, and as such this unit gives you a valuable insight into the services requirements in relation to plumbing installations and site activities. This unit will support you in progressing to a higher-level construction programme such as the Higher National in Construction and the Built Environment with Building Services Engineering pathway, or a general construction or building services degree This unit will also help you to progress to employment as a site manager or quantity surveyor, both of whom need a generic understanding of these systems. It also supports progression to the workplace as a technician or direct entry to a plumbing or mechanical installations company.

Learning aims

In this unit you will:

A Understand how cold water is sourced, cleansed to the required standard and distributed to the consumer

B Undertake the design of plumbing, above-ground drainage and gas installations for a property

C Develop a specification for materials, components and ancillary equipment for a plumbing and gas installation.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Understand how cold water is sourced, cleansed to the required standard and distributed to the consumer	**A1** Sources of cold water **A2** Cleansing process **A3** Standards **A4** Distribution	Analyse a client brief in terms of all the current regulations and requirements.
B Undertake the design of plumbing, above-ground drainage and gas installations 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. As part of the solution, produce a specification for all the elements of the installation.
C Develop a specification for materials, components and ancillary equipment for a plumbing and gas installation	**C1** Gas supplies **C2** Gas installations **C3** Features and characteristics **C4** Regulations and standards	

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Content

Learning aim A: Understand how cold water is sourced, cleansed to the required standard and distributed to the consumer

A1 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.

A2 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.

A3 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, the Water Supply (Water Quality) Regulations 2010.
- Effects of contaminated water supplies on an area.

A4 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 authority 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, above-ground drainage and gas installations for a property

Consideration of the supply of hot and cold water, gas and associated drainage systems requirements to be safely met and provided within current regulations.

B1 Appliances and components

The selection of specification 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, 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.
- 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, e.g. Autodesk Navisworks®, Autodesk® BIM 360™ Glue, Solibri Model Checker™
  - 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 (Autodesk Dynamo, Rhinoceros and Grasshopper).

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.
- 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 for and procedures for testing of above-ground drainage to current regulations
- testing of trap and seal retention
- 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, e.g. Autodesk Navisworks, Autodesk BIM 360 Glue, Solibri Model Checker.
  - 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 (Autodesk Dynamo, Rhinoceros and Grasshopper).

Learning aim C: Develop a specification for materials, components and ancillary equipment for a plumbing and gas installation

C1 Gas supplies

The properties of gas supplied within the UK, including its distribution and transportation to the end user.

- Sources of natural gas and combustion.
- Extraction of natural gas supplies.
- Transportation systems.
- Liquid petroleum gas (LPG) supplies.
- Distribution systems.
- Materials used in the transportation of natural gas.
- Constituents of gas.
- Properties and combustion characteristics of natural and commercial LPG.
- Combustion process.
- Products of complete combustion.
- Causes, effects and prevention of incomplete combustion.

C2 Gas installations

The selection of components to meet requirements, including the assessment of output levels to meet design requirements and to fulfil legal parameters, to include:

- calculation of flow rates from heat inputs
- use of charts and tables to determine the size of gas pipe to comply with standards and legislation
- requirements for flues:
  - conventional flue
  - room-sealed flue arrangements
  - natural draught
  - fan-assisted flue
- flue routes and terminal requirements
- requirements for flues passing through buildings
- how information may be delivered by sensors, remote sources and digital devices to report and feed back information to a building to ensure natural resources are used as much as possible in heating and ventilation design
- ventilation requirements:
  - need for ventilation
  - permissible vents for gas-burning appliances
  - ventilation requirements for various appliances, flue arrangements and appliance locations
  - calculation of required ventilator size
  - location of ventilator
  - requirements for ventilator construction
  - requirements of current regulations and standards affecting the combustion of air and ventilation for gas-burning appliances.

C3 Features and characteristics

- Types of common gas appliances found in domestic properties:
  - cookers
  - space heaters
  - central-heating boilers
  - instantaneous hot-water heaters.
- Structure and layout of systems.
- Components and materials to be used:
  - pipework materials
  - jointing and assembly
  - types of valves
  - pressure control.

C4 Regulations and standards

- Requirements for current regulations and standards affecting the design, installation and use of gas installations.
- Procedures for testing and purging of domestic installations.
- Gas Safety (Installation and Use) Regulations 1998.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand how cold water is sourced, cleansed to the required standard and distributed to the consumer		**A.D1** Justify the current regulations and requirements that need to be considered 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 in 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 in the distribution of cold water and installation for a given scenario.	
Learning aim B: Undertake the design of plumbing, above-ground drainage and gas installations for a property		**B.D2** Produce a comprehensive design that fully meets regulations, standards and the needs of a given scenario.
B.P3 Produce a design layout for a property. **B.P4** Explain the design requirements for plumbing, above-ground drainage and gas installations for a given scenario. **B.P5** Explain the choice of a boiler 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 a plumbing and gas installation		**C.D3** Evaluate the selection of a boiler, materials, fittings and components that fully meet the needs of a given scenario.
C.P6 Select a boiler to meet the needs of a domestic property. **C.P7** Produce schedules of materials and equipment that meet some of the needs of a given scenario.	**C.M3** Justify the selection of a boiler, materials, components and fittings that meet most needs of a given scenario.	

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Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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, 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 cover the current regulations and standards when considering how cold water is sourced, cleaned and delivered to a given building. The factors will be supported and fully referenced by research. Learners' justifications should consider the requirements of all the stakeholders in the project linked to cold-water supply, design conditions and building restrictions. Learners will draw on their knowledge of the factors to consider their relevance or significance to the design of the installation for the given building.

For merit standard, learners must assess the current regulations and standards when considering how cold water is sourced, cleaned and delivered to a given building. This will include the requirements of the stakeholders, design conditions and building restrictions, and will consider the interrelationships between design needs and the requirements of the regulations.

For pass standard, learners must explain the factors relating to the current regulations and standards that will be considered when supplying clean cold water. This explanation will include the requirements of the stakeholders and design conditions, and will cover how water is distributed to the consumer. Learners will demonstrate that they comprehend the need to consider these factors during the design of 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 contains full manufacturer's details and drawings, produced to a professional design standard, for a given building. The selection of all equipment and materials, including a boiler, needs to be evaluated in meeting the requirements and current regulations and standards of the scenario for the given domestic property. In their evaluation, learners will draw on their knowledge of boilers and 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's details, including those of boilers, and drawings, produced to a good design standard, for a given building. The selection of a boiler and all other equipment needs to be justified in meeting the requirements, current regulations, standards and design needs of the scenario for the given domestic 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 include the boiler, its supply and flue details. Hot- and cold-water requirements should be linked to the stakeholders who will occupy the building in terms of their human interaction. Descriptions will be supported with diagrammatic illustrations of the pipe layout and equipment, and manufacturer's details, including all key elements. Learners must assess the amount of heat required within each space and select appropriate fittings accordingly, using the manufacturer's published information. The boiler must be selected to meet output and safety considerations in the building's design requirements. 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 12: Low Temperature Hot Water Systems in Building Services
- Unit 21: Building Services Science
- Unit 27: Building Services Control Systems
- Unit 29: Use of Static and Dynamic Fluids in Building Services Engineering
- Unit 33: Quantity Surveying Measurement Techniques in Building Services Engineering
- Unit 34: Building Regulations and Control 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 31: Electrical Principles in Building Services Engineering

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners develop knowledge and understanding of the principles of electricity, including the behaviour and interaction between electrical components when designing electrical systems.

Unit introduction

Electricity and electrical systems are taken for granted; we give no thought to what happens when we flick a light switch. An understanding of how electricity works is critical when it comes to designing, testing and commissioning electrical systems.

In this unit, you will develop an understanding of the electrical principles that underpin the design of electrical services and control systems. This will include the use of calculations to determine unit values associated with various circuits, and how components behave when used in different applications. This will enable you to select appropriate circuits and components for an electrical installation to suit the power and loading requirements.

This unit will support you in progressing to a higher-level construction programme such as Higher National in Construction and the Built Environment with Building Services Engineering pathway, or a general construction or building services degree. It will also provide you with an underpinning knowledge of electrical principles that will support you in other building services units. It also supports progression to the workplace as a technician, or direct entry to an electrical installations company.

Learning aims

In this unit you will:

A Understand and apply appropriate methods to determine quantities associated with electricity

B Apply the principles of electricity and the behaviour of simple electrical components for different applications

C Examine electrical circuits and components within an electrical system or installation.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Understand and apply appropriate methods to determine quantities associated with electricity	**A1** Units **A2** Calculations **A3** Instruments	Analyse a product to determine the quantities of electricity consumed. Include the use of supporting calculations.
B Apply the principles of electricity and the behaviour of simple electrical components for different applications	**B1** Terminology **B2** Principles and calculations **B3** Behaviour **B4** Components and applications	Develop a system for an industrial installation, from a set of criteria. As part of the solution, produce a specification for all the elements of the installation.
C Examine electrical circuits and components within an electrical system or installation	**C1** Circuits **C2** Transformers **C3** Rotating machines	

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Content

Learning aim A: Understand and apply appropriate methods to determine quantities associated with electricity

A1 Units

The standard units that are used in electrical systems and what they measure and their interrelationships.

- Basic electrical quantities:
  - charge
  - current
  - voltage
  - resistance
  - conductance
  - frequency
  - standard symbols and their abbreviations.

A2 Calculations

Calculations and their use within electrical circuits and installations.

- Calculation of electrical power.
- Electrical energy.
- Electrical charge.
- Quantity of energy:
  - Ohm's law
  - Kirchoff's law
  - series, parallel and combination circuits.
- Determination of values of:
  - resistance
  - voltage
  - current
  - power.
- Use of material resistivity to determine the resistance of materials.

A3 Instruments

Instruments used for checking, verifying and problem solving within electrical circuits and how and why they are used.

- Multimeter.
- Ammeter.
- Voltmeter.
- Ohmmeter.
- Wattmeter.
- Oscilloscope.

Learning aim B: Apply the principles of electricity and the behaviour of simple electrical components for different applications

Understanding and analysis of the behaviour of electrical components in different systems and applications.

B1 Terminology

The essential terms 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.

B2 Principles and calculations

The essential calculations that learners need to understand when working with simple electrical components.

- 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.

B3 Behaviour

The influence and impact of current flow within electrical circuits.

- Heating effects of current in thermostats and protective devices.
- Electric current:
  - conventional current flow
  - electron current flow
  - effects of magnetism in solenoids
  - electromagnet.

B4 Components and applications

The use and behaviour of components within electrical and electronic circuits, used within building services engineering.

- Electrical conductors.
- Electrical insulators.
- Cells.
- Generators.
- Resistors:
  - colour code.
- Capacitors and capacitance.
- Inductors and inductance.
- Diodes:
  - half-wave and full-wave rectification.
- Thyristors:
  - use of thyristors in power control circuits.
- Transistors and integrated circuits.
- Programmable integrated circuits (PICs).
- Photocell and photovoltaic devices.
- Thermistors:
  - electrical control circuits.
- Thermocouples.
- Use of AC and DC.

Learning aim C: Examine electrical circuits and components within an electrical system or installation

The selection of appropriate circuits, including the power and loading requirements, the use of rotating machines and the selection of appropriate transformers where necessary.

C1 Circuits

- Simple circuit design:
  - calculations to establish:
    - capacitive reactance
    - inductive reactance
    - impedance (including use of the impedance triangle in single-phase AC circuits)
    - true power
    - apparent power
    - power factor (including use of the power triangle in single and three-phase AC circuits)
    - three-phase delta circuits and star-connected systems
    - use of three-phase and delta- and star-connected systems.
- Single-phase circuits:
  - effects of pure resistance
  - pure capacitance
  - pure inductance in series and parallel circuits
  - current and voltage phasor relationship phasor diagrams
  - conditions for resonance
  - effects of frequency on reactance and impedance
  - effects of resonance
  - benefits of power correction.
- Three-phase circuits:
  - principles and application of star- and delta-connected systems, including phasor diagrams for balanced and unbalanced loads
  - advantages of load balancing
  - the relationship of three-phase supplies to single-phase supplies.

C2 Transformers

- Operating principles of single-phase transformer.
- Transformer construction.
- Transformer ratings.
- Circuit equivalent of a transformer.
- Transformer regulation, including:
  - iron losses, copper losses and eddy-current losses.
- Transformer efficiency.
- No-load and on-load phasor diagrams.
- Types of transformer:
  - small power
  - large power
  - auto
  - three-phase
  - current and voltage transformers.
- Transformer cooling methods.
- Calculations to apply transformer to specify transformers and determine efficiency.
- Practical applications of transformers:
  - step-up voltage and current
  - step-down voltage and current
  - to isolate
  - to measure voltage and current.

C3 Rotating machines

- Operating principles of AC inductance.
- Wound rotor.
- Synchronous motors.
- Operating principles of DC shunt-wound motor types.
- Armature reaction.
- Relationship between speed and torque.
- Energy conversion process.
- Construction of machines.
- Function of machines and generators.
- Action of commutator.
- Use of slip-rings and brushes.
- Control systems, including starter.
- Motor enclosures.
- Inverter control.
- Sizing and selection of motors.
- Selection of motors for specific applications.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand and apply appropriate methods to determine quantities associated with electricity		**A.D1** Justify a product in terms of the power consumption, including all relevant calculations and the use of appropriate instruments to measure the electrical quantities involved.
A.P1 Explain the amount of electrical energy a product consumes in relation to its output.	**A.M1** Assess the power consumption of a product and justify your conclusions with the relevant calculations.	
Learning aim B: Apply the principles of electricity and the behaviour of simple electrical components for different applications		**B.D2** Produce a comprehensive circuit diagram that fully meets the requirements of a domestic appliance.
B.P2 Produce a circuit diagram for a simple domestic appliance that includes the key components. **B.P3** Assess the current and power requirements for the product. **B.P4** Assess the behaviour of the components selected.	**B.M2** Produce a detailed circuit design that meets the requirements of a domestic appliance.	
Learning aim C: Examine electrical circuits and components within an electrical system or installation		**C.D3** Justify the selection of a circuit, transformer and rotating machines that fully meet the needs of the installation.
C.P5 Select a circuit for use in an industrial installation. **C.P6** Select appropriate transformers and rotating machines for use within the installation that meet some of the needs.	**C.M3** Justify the selection of an appropriate circuit and transformer and rotating machines that meet most of the needs of the installation.	

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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

There are no specific additional requirements for this unit.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners must consider an electrical product or appliance to establish the power consumption and the cost of running the product or appliance. Learners' written work will be accompanied by calculations that fully substantiate their findings, and a comprehensive circuit diagram that fully meets all the requirements of the product or appliance. In their justification, learners should justify the selection of the test equipment and instruments used to take appropriate readings and measurements. They will draw on their knowledge of the factors to consider in the design of any electrical product or appliance.

For merit standard, learners must consider an electrical product or appliance to establish the power consumption of the product or appliance. Learners' work will be accompanied by calculations and a circuit diagram that mostly supports the findings. In analysing the product, learners should consider the test equipment and instruments used to take appropriate readings and measurements. Learners will draw on their knowledge of the factors to consider in the design of any electrical product or appliance.

For pass standard, learners must consider the amount of energy an electrical product or appliance consumes, including a circuit diagram that shows some of the features of the product or appliance. In their explanations, learners will include information about the equipment used to take any necessary measurements. Learners will demonstrate that they comprehend the factors that need to be considered when designing electrical products and appliances.

Learning aims B and C

For distinction standard, learners will produce a comprehensive report that gives full manufacturer's details and includes drawings, produced to a professional standard, for a given scenario. The selection of all equipment and materials, including a circuit, transformers and rotating machines, needs to be justified in meeting the power requirements and the design needs of the scenario. In their evaluation, learners will draw on their knowledge of circuits, transformers and rotating machines 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 scenario.

For merit standard, learners will produce a design and a report that is detailed in its compilation and includes full manufacturer's details, and an appropriate circuit, transformers and rotating machines for the given scenario. The selection needs to be justified. Learners will draw on their knowledge of the design of circuits, transformers and rotating machines to prove that key aspects of their designs are correct for the scenario.

For pass standard, learners must produce a circuit diagram for an industrial installation, and it must include transformers or rotating machines. Descriptions will be supported with diagrammatic illustrations of the circuit diagram and equipment and manufacturer's details, including all key elements. Learners must assess the amount of power consumed using manufacturer-published information. The transformer or rotating machine must be selected with the output and safety considerations to meet the design requirements.

Links to other units

This unit links to:

- Unit 27: Building Services Control Systems
- Unit 32: Electrical Installation Standards, Components and Design.

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 32: Electrical Installation Standards, Components and Design

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 in the UK, 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. This begins with an understanding of the regulations and legislation applicable to any electrical installation. This is followed with an 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 finally the commissioning and certification of the installation.

Electrical installations are a critical feature of any building. This unit gives you a valuable insight into the legal requirements and legislation in relation to both installations and site activities. This unit will support you in progressing to a higher-level construction programme such as the Higher National in Construction and the Built Environment with Building Services Engineering pathway, or a general construction or building services degree. This unit will also help you to progress to employment supporting a site manager or quantity surveyor. It also supports progression to the workplace as a technician, or direct entry into an electrical installations company.

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	Recommended assessment approach
A Understand the regulations and legislation applicable to electrical installations	**A1** Regulations and legislation **A2** Earthing and bonding **A3** Final circuits and circuit protection	Analyse a client brief in terms of all of the 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	

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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.

- British Standards BS 7671 Requirements for Electrical Installations.
  IET Wiring Regulations:
  - Part P
  - Local Authority Building Control (LABC)
  - Competent Person
  - Electrical Installation Condition Report (EICR)
  - permit to work.
- Special locations:
  - bathroom zones 0, 1 and 2
  - swimming pools
  - outdoor power and lights.
- Site safety:
  - Electricity at Work Regulations 1989
  - 110 V 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 etc. Act 1974:
  - 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.
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995.
- Workplace (Health, Safety and Welfare) Regulations 1992.
- Construction (Design and Management) Regulations 2015:
  - inspection, testing and commissioning, to include initial verification, compliance with regulations, meeting design specifications, testing instruments.
- Test methods and requirements, including their purpose:
  - sequence of tests
  - precautions to be taken
  - continuity
  - insulation resistance
  - polarity
  - earth fault loop impedance
  - earth
  - residual current device (RCD)
  - functional testing
  - test values
  - results and actions to be taken.

- Certification:
  - electrical installation certificate
  - schedule of inspection
  - schedule of test results
  - periodic inspection report
  - report forms
  - operation and maintenance manual and schedule.

A2 Earthing and bonding

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.
- Bonding requirements and methods:
  - main
  - supplementary bonding
  - equipotential bonding.

A3 Final circuits and circuit protection

The safety devices that must be incorporated within the consumer unit in the design of electrical installations, and the benefits that they provide.

- 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).

Learning aim B: Undertake the design of an electrical installation for a property

Consideration of the demand and power requirements to be safely met and provided.

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.
- Current carrying capacity.
- Number and location of socket outlets and other power loads.
- Cable routing.

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)
  - spur
  - floor area limits for each circuit
  - 12 V down lights
  - transformers
  - smoke and fire alarms
  - intruder
  - data and communications
  - bathroom extraction isolation
  - central heating systems, to include boiler control panels, thermostats, underfloor heating.
- Cable protection:
  - PVC and sheathed
  - trunking metal and plastic.
- Voltage drop.
- Cable capacity.
- Current capacity and cable sizing:
  - 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, e.g. Autodesk Navisworks, Autodesk BIM 360 Glue, Solibri Model Checker
  - 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 etc. to automatically generate optimised solutions
  - Software packages, e.g. Autodesk Dynamo, Rhinoceros and Grasshopper.

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 the 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 (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 that provides adequate zoning and protection, including non-combustible enclosure.

- Location of unit.
- Types of circuit.
- Types of unit:
  - 16/13/1/6-way high integrity dual RCD units
  - 4-way RCD shower units
  - 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 that 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; the production of as-built drawings.

- Layout.
- Schematic.
- Graphical symbols.
- Distribution board.
- Schedules.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Understand the regulations and legislation applicable to electrical installations</td><td rowspan="2">A.D1 Justify the regulations and legal requirements that need to be considered when designing an electrical installation for a given scenario.</td></tr>
<tr><td>A.P1 Explain the regulations and legal factors that need to be considered in relation to electrical installations.</td><td>A.M1 Assess the regulations and legal factors that need to be considered in relation to electrical installations for a given scenario.</td></tr>
<tr><td colspan="2">Learning aim B: Undertake the design of an electrical installation for a property</td><td rowspan="4">B.D2 Produce a comprehensive electrical system design that fully meets legislative requirements and the needs of a given scenario.
C.D3 Evaluate the selection of a consumer unit, materials and fittings that fully meet the needs of a given scenario.</td></tr>
<tr><td>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.</td><td>B.M2 Produce a detailed design that meets the needs of a given scenario.</td></tr>
<tr><td colspan="2">Learning aim C: Develop a specification for materials, components and ancillary equipment for an electrical installation</td></tr>
<tr><td>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.</td><td>C.M3 Justify the selection of a consumer unit, materials and fittings that meet most of the needs of a given scenario.</td></tr>
</table>

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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 when designing an electrical installation for a given building. The factors will be supported and fully referenced by research. Learners must consider the requirements of all the stakeholders in 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 and 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 when designing an electrical installation for a given building. Their analysis will include the requirements of the stakeholders, design conditions and building restrictions. In assessing these factors, learners will consider their conflicting interrelationships and present the outcome of their detailed and methodical examination.

For pass standard, learners must explain the factors relating to the relevant regulations and legal factors for the design of an electrical installation. This explanation will include the requirements of the stakeholders, design conditions and building restrictions. Learners will demonstrate that they comprehend the need to consider these factors during the design of 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 contains full manufacturer's 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 meeting 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 design and report that is detailed in its compilation and contains full manufacturer's details, including those 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 meeting 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 situation.

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For pass standard, learners must produce a wiring diagram for a domestic installation. This should include the consumer unit, its fuses and protective devices. Electrical requirements should be linked to the stakeholders who will occupy the building in terms of their human interaction. Descriptions will be supported with diagrammatic illustrations of the wiring layout, and equipment and manufacturer's details, including all key elements. Learners must assess the amount of power and light required within each space and select appropriate fittings accordingly, using the manufacturer's 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, manufacturer references and total quantities.

Links to other units

This unit links to:

- Unit 27: Building Services Control Systems
- Unit 31: Electrical Principles in Building Services Engineering.

Employer involvement

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

- office visits to electrical installation designers
- talks by visiting electrical engineers.

Unit 33: Quantity Surveying Measurement Techniques in Building Services Engineering

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners undertake the quantity surveying techniques used to apply measurement rules in the production of a bill of quantities.

Unit introduction

Quantity surveyors are specialists who measure the costs of building services in order to produce bills of quantities. This is the first part of the process and facilitates the pricing of work, enabling tenders to be submitted and assisting with the quantification of the physical resources required for the completion of a project. The measurement, known as a 'take-off', is produced in accordance with the Standard Method of Measurement (SMM). The take-off is then converted into bills of quantities that are used to price and tender for a project.

In this unit, you will examine the process of taking off quantities and the production of bills of quantities, with a focus on building services. You will learn how employers and client organisations use agreed methods of measurement for building services work. These standard methods set out clearly the rules for measuring quantities from drawings and schedules produced by the design team, including building services engineers. You will use these methods and rules to produce quantities for building services and associated elements, followed by the production of relevant sections of the bills of quantities.

This unit gives you the opportunity to progress to construction sector roles, including estimator, bid writer, buyer, quantity surveyor 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 services

B Undertake the production of quantities for building services work

C Undertake the production of bills of quantities for building services work.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Examine the measurement rules for building services	**A1** Introduction to quantity take-offs **A2** Standard methods of measurement	A guidance document for new learners to comprehend the use of quantities in building services and the use of the Standard Method of Measurement.
B Undertake the production of quantities for building services work	**B1** Processes in the production of quantities **B2** Production of mechanical services quantities for a building **B3** Production of electrical services quantities for a building **B4** Builder's work in connection with mechanical and electrical services installations	A take-off of quantities from teacher-provided drawings for building services works and associated builder's work in connection with services installations. Bills of quantities from teacher-provided drawings for building services works and associated builder's work in connection with services installations.
C Undertake the production of bills of quantities for building services work	**C1** Composition of bills of quantities **C2** Abstraction of quantities for building services **C3** The production of bills of quantities for building services	

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Content

Learning aim A: Examine the measurement rules for building services

A1 Introduction to quantity take-offs

Reasons for producing both approximate and accurate quantities and their use within building services for:

- the production of bills of quantities for building services elements
- tendering and estimating
- preparation of tender documents for nominated subcontracts
- budgets for feasibility studies during design stages, including justification of included provisional and prime cost sums
- cost comparison of different designs
- preparation of estimates
- interim valuations
- pricing variations
- production of a final account
- ordering materials.

A2 Standard methods of measurement

The use of the Standard Method of Measurement (SMM) rules in the production of quantities for building services.

- Measurement rules:
  - the need for rules
  - origins of measurement rules
  - measurement initiative steering group
  - status of the Royal Institution of Chartered Surveyors (RICS) New Rules of Measurement (NRM)
  - typical considerations:
    - drawings that must accompany building services measurement sections
    - minimum information to be provided on drawings
    - 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
    - non-measurable works.
- The New Rules of Measurement (NRM):
  - NRM1 – order of cost estimating and cost planning for capital building works:
    - application to budgeting for projects
    - uses of NRM1
  - NRM2 – detailed measurement for building works
    - application of this to taking off quantities for projects
    - uses of NRM2
  - NRM3 – order of cost estimating and cost planning for building maintenance works
    - application of this to maintaining projects
    - uses of NRM3.

Learning aim B: Undertake the production of quantities for building services work

B1 Processes in the production of quantities

The use of dimension paper or direct billing paper and the techniques used to take off quantities for building services works.

- Preparation and planning, to include the compilation of a take-off list.
- Interpretation of building services drawings, schematic diagrams and schedules:
  - mechanical
  - electrical.
- Non-measurable works.
- The vocationally correct format and layout of quantities and calculations on dimension paper and direct billing paper:
  - 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 quantity surveyors' abbreviations
  - marking the extent of a calculation
  - waste calculations, to include centre lines.

B2 Production of mechanical services quantities for a building

Taking off quantities for mechanical services elements, including the use of NRM hierarchical descriptors.

- Drawings that must accompany this section of measurement.
- Minimum information to be shown on drawings.
- Primary equipment.
- Terminal equipment and fittings.
- Pipework.
- Pipe fittings.
- Pipe ancillaries.
- Ventilation ducts.
- Duct fittings.
- Duct ancillaries.
- Insulation and fire protection, to include pipework, ducts, fittings and ancillaries.
- Fire stopping.
- Identification.
- Testing.
- Commissioning.
- System validation.
- Operation and maintenance manuals.
- Drawing preparation.
- Training.
- Loose ancillaries.
- Post-completion services.

B3 Production of electrical services quantities for a building

Taking off quantities for electrical services elements, including the use of NRM hierarchical descriptors.

- Drawings that must accompany this section of measurement.
- Minimum information to be shown on drawings.
- Primary equipment.
- Terminal equipment and fittings.
- Cable containment.
- Cable containment fittings.
- Cables.
- Cable termination and joints.
- Final circuits.
- Modular wiring systems.
- Busbar.
- Busbar fittings.
- Tapes.
- Electrodes, earth rods, air terminations, termination bars.
- Fire stopping and other associated fire protection work.
- Identification.
- Testing.
- Commissioning.
- System validation.
- Operation and maintenance manuals.
- Drawing preparation.
- Training.
- Loose ancillaries.
- Post-practical completion services.

B4 Builder's work in connection with mechanical and electrical services installations

Taking off quantities for builder's work in connection with mechanical and electrical services elements, including the use of NRM hierarchical descriptors.

- General builder's work.
- Marking the position of holes, mortices and chases in the structure.
- Pipe and duct sleeves.
- Bases, plinths (and similar).
- Duct covers and frames.
- Supports for services not provided by the services contractor.
- Catenary cables.
- Cutting holes through existing structures.
- Cutting mortices and sinkings in existing structure.
- Cutting chases through existing structures.
- Lifting and replacing floorboards.
- Lifting and replacing duct covers or chequer plates.
- Underground service runs.
- Extra service overruns.
- Pipe and duct fittings.
- Accessories.
- Manholes, access chambers, valve chambers, inspection chambers, surface boxes and stopcock pits.
- Marker posts and marker plates.
- Connections.
- Testing and commissioning.

Learning aim C: Undertake the production of bills of quantities for building services work

C1 Composition of bills of quantities

The section layout and use of bills of quantities in both trade and elemental format.

- Preliminaries.
- Preambles.
- Measured work.
- Risks.
- Provisional sums.
- Credits.
- Dayworks.
- Summary.
- Director's adjustment.
- Form of tender.
- Annexes.

C2 Abstraction of quantities for building services

How quantities with common descriptors are amalgamated.

- 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.
- Preparation for transfer to billing paper:
  - codification and ordering of item descriptions
  - writing up item descriptions
  - final checks and quality procedures.

C3 The production of bills of quantities for building services

How the quantities and descriptions are summarised in a bill of quantities, to include:

- preparation of bills of quantities for building services:
  - assembly of quantities taken from relevant method of abstraction
  - writing out full item descriptors
  - item codification and correct ordering and layout
  - collections and summaries
  - final summary.

Assessment criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">Learning aim A: Examine the measurement rules for building services</td><td rowspan="2">A.D1 Justify the use of a recognised standard method of measurement to ensure consistency when tendering and estimating for building services projects.</td></tr>
<tr><td>A.P1 Explain how approximate and accurate quantities are used for different applications within building services by quantity surveyors.
A.P2 Explain the reasons for the use of a recognised standard method of measurement within building services.</td><td>A.M1 Assess the benefits of using a recognised standard method of measurement for building services projects.</td></tr>
<tr><td colspan="2">Learning aim B: Undertake the production of quantities for building services work</td><td rowspan="4">B.D2 Perform an accurate and comprehensive take-off of quantities for a building services project using the Standard Method of Measurement and a vocationally correct layout of dimensions and methodology.
C.D3 Produce comprehensive bills of quantities for a building services project.</td></tr>
<tr><td>B.P3 Perform a take-off of quantities for a mechanical services section of a project using the Standard Method of Measurement and an appropriate layout of dimensions.
B.P4 Perform a take-off of quantities for an electrical services section of a project using the Standard Method of Measurement and an appropriate layout of dimensions.</td><td>B.M2 Perform an accurate take-off of quantities for a building services project using the Standard Method of Measurement and a vocationally correct layout of dimensions.</td></tr>
<tr><td colspan="2">Learning aim C: Undertake the production of bills of quantities for building services work</td></tr>
<tr><td>C.P5 Produce bills of quantities for a building services project.</td><td>C.M3 Produce accurate bills of quantities for a building services project.</td></tr>
</table>

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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, 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 building services drawings and specifications.

Essential information for assessment decisions

Learning aim A

For distinction standard, learners will justify the use of a standard method of measurement to ensure consistency when tendering and estimating for mechanical and electrical services projects. They will consider how quantities are used for building services projects during the various stages of a project and consider the benefits and drawbacks of the use of a recognised standard method of measurement. In their justification, 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 assess the benefits of using recognised standard methods of measurement for mechanical and electrical services projects. They will consider how quantities are used for mechanical and electrical services projects during the various stages of the project and consider the relevant use of a standard method of measurement. In their assessment, learners will consider the different aspects of the Standard Method 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 within building services. Additionally, learners will explain the reasons for the use of a recognised standard method of measurement for building services projects. 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 take-off of quantities for a building services 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 take-off will include both electrical and mechanical services and the associated builder's work in connection with these services. They will produce comprehensive bills of quantities from their take-off with clarity of language and layout, vocationally correct layout, bill format, units of measurement, codification of items, ordering of sizes and use of headings.

For merit standard, learners will perform an accurate take-off of quantities for a building services project using a recognised standard method of measurement and using vocationally correct layout of dimensions. Their take-off will include both electrical and mechanical services and some elements of builder's work in connection with these services. They will produce accurate bills of quantities from their take-off with appropriate use of language and layout, vocationally correct layout, bill format, units of measurement, ordering of sizes and use of headings.

For pass standard, learners will perform a take-off of quantities for a building services project using a recognised standard method of measurement and using an appropriate layout of dimensions, allowing for some computational inaccuracy. Their take-off will include both electrical and mechanical services. They will produce bills of quantities from their take-off with appropriate use of language and layout, vocationally appropriate layout, units of measurement and use of headings.

Links to other units

This unit links to:

- Unit 1: Construction Principles
- Unit 4: Construction Technology
- Unit 7: Graphical Detailing in Construction
- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 14: Provision of Primary Services in Construction
- Unit 27: Building Services Control Systems
- Unit 28: Heating, Ventilation and Air Conditioning Design
- Unit 30: Plumbing Technology in Building Services Engineering
- Unit 31: Electrical Principles in Building Services Engineering
- Unit 32: Electrical Installation Standards, Components and Design
- Unit 34: Building Regulations and Control 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 34: Building Regulations and Control in Building Services Engineering

Level: **3**

Unit type: **Internal**

Guided learning hours: **60**

Unit in brief

Learners interpret and apply the requirements of the building regulations to building services in construction projects, including the application process and different methods of inspection and control.

Unit introduction

The building regulations are steeped in history, with many crediting their birth at the Great Fire of London in 1666, when the city was rebuilt with a view to fire prevention. However, building codes have been around even longer than this. Over the years, there have been many versions and variations of building regulations as they have grown and evolved, leading to the documents we now use. Today's construction professionals need a wide and far-reaching knowledge to achieve compliance.

In this unit, you will learn how to apply for building regulations approval, which you will be able to use in professional practice in your future career. You will specifically focus on the requirements of the Approved Documents for building regulations that relate to building services installations. To enable you to do this, you will learn about the different options available, the documents required and the process of making an application. This unit is designed to be hands-on and practical and, on successful completion, you will have a good knowledge and understanding of the process.

The content of this unit will broaden your knowledge of one of the key legislative requirements in construction, with a specific focus on building services. It will prepare you for a range of roles in industry, ranging from the practical and production roles through to the professional and planning roles, such as building surveyors, architects, site supervisors, building inspectors and clerk of works. This unit will also prepare you for entry to higher-level courses in architecture, building construction and building services engineering.

Learning aims

In this unit you will:

A Understand the requirements of building regulations

B Examine the requirements of the building regulations within building services applications

C Undertake a building regulations application.

Summary of unit

Learning aim	Key content areas	Recommended assessment approach
A Understand the requirements of building regulations	**A1** The building regulations **A2** Control and implementation of Building Regulations 2010	A written report and presentation to discuss the requirements of Building Regulations 2010 and the different methods of control and of demonstrating compliance with it for building services works.
B Examine the requirements of the building regulations within building services applications	**B1** Approved documents with impact on building services design and installations **B2** Alternative methods of achieving compliance	
C Undertake a building regulations application	**C1** Types of application **C2** Preparing a building notice application **C3** Preparing a full plans application	Portfolio of evidence showing the preparation for a full plans building regulations application for a new-build domestic scheme.

Content

Learning aim A: Understand the requirements of building regulations

The specifics of the Building Act 1984 and the Building Regulations 2010, and how to find and use the relevant information.

A1 The building regulations

- Application of the Building Act 1984.
- The requirements of the Building Act 1984:
  - definition of building work and the extent of the building regulations application
  - material alterations
  - exemptions to the regulations
  - dispensation or relaxation of the regulations.

A2 Control and implementation of Building Regulations 2010

- Application procedure and the correct use of each method:
  - full plans
  - building notice.
- Notification of commencement and certain stages of the works.
- Supervision of works and the powers of inspectors:
  - local authority
  - private inspectors
  - National House Building Council (NHBC).
- Testing and commissioning.
- Certification of the works.
- Self-certification schemes.
- Non-compliance and the consequences.

Learning aim B: Examine the requirements of the building regulations within building services applications

Interpretation, design, application and compliance with the requirements of the Building Regulations 2010 in respect of building services installations.

B1 Approved documents with impact on building services design and installations

- Ventilation (Approved Document F):
  - the requirements
  - general guidance
  - types of ventilation
  - control of ventilation
  - performance of ventilation
  - ventilation systems for new dwellings
  - ventilation systems for new buildings other than dwellings
  - work on existing buildings.
- Sanitation, hot water safety and water efficiency (Approved Document G):
  - cold water supply
  - water efficiency
  - hot water supply and systems
  - sanitary conveniences and washing facilities
  - bathrooms
  - food preparation areas
  - water efficiency calculations
  - wholesome water.

- Drainage and waste disposal (Approved Document H):
  - sanitary pipework (above ground only)
  - rainwater drainage (above ground only).
- Combustion appliances and fuel storage systems (Approved Document J):
  - air supply
  - discharge of products of combustion
  - warning of release of carbon monoxide
  - protection of building
  - provision of information
  - protection of liquid fuel storage systems
  - protection against pollution.
- Conservation of fuel and power (Approved Documents L1A, L1B, L2A, L2B):
  - design standards
    - target emission rates
    - fuel factors
  - heat losses and gains from circulation pipes
  - commissioning of heating and hot water systems
  - air leakage testing of ductwork
  - provision of information
    - operation manuals
    - building logbook.
- Electrical safety – Dwellings (Approved Document P):
  - design and installation
    - BS7671, IET Wiring Regulations
    - provision of information
    - electrical installation certificates
    - permanent labels
  - notifiable work
  - inspection and testing.
- Physical infrastructure for high-speed electronic communications networks (Approved Document R):
  - in-building physical infrastructure
    - ductwork for copper and fibre optic cables
    - satellite and wireless communications
    - network termination points.

B2 Alternative methods of achieving compliance

Methods of demonstrating compliance with Building Regulations 2010 for a variety of different project types, to include:

- British Standards
- European Standards
- NHBC Standards
- competent person/self-certification schemes.

Learning aim C: Undertake a building regulations application

C1 Types of application

The type of work for which each application is used and the conditions of application and expiration.

- Full plans.
- Building notice.

C2 Preparing a building notice application

Learners need to be able to make a building notice application for a given scenario, including all the relevant documentation as stipulated in the Building Regulations 2010.

- Statement of application.
- Description of the proposed works.
- Location of the building.
- Current and intended use of the building.
- For schemes with an extension or addition to the building:
  - details to show the size of the extension and the relationship to the adjoining boundaries
  - the boundaries of the existing curtilage, and the position and size of other buildings within the curtilage
  - location of the property in relation to the surrounding streets
  - a statement specifying the number of storeys
  - provisions made for drainage.
- Use of fee schedules to determine the correct fee for the application.

C3 Preparing a full plans application

Learners need to be able to make a full plans application for a given scenario, including all the relevant documentation as stipulated in the Building Regulations 2010.

- Statement of application.
- Copies of the plans (multiple copies as specified by the regulating authority).
- Description of the proposed works.
- All other associated plans required to show compliance with Building Regulations 2010 (which will include):
  - details to show the size of the building/extension and the relationship to the adjoining boundaries
  - the boundaries of the existing curtilage, and the position and size of other buildings within the curtilage
  - location of the property in relation to the surrounding streets
  - a statement specifying the number of storeys
  - provisions made for drainage
  - details of the works and materials
  - copies of relevant calculations and relevant supporting documentation.
- Statement in relation to Regulatory Reform (Fire Safety) Order 2005.
- Request for completion certificate.
- Determination of the appropriate fee.

Assessment criteria

Pass	Merit	Distinction
Learning aim A: Understand the requirements of building regulations		
A.P1 Describe the requirements of the building regulations. **A.P2** Explain the different methods of control and implementation for building regulations applications.	**A.M1** Discuss the different methods of application and control for a building regulations application.	**A.D1** Evaluate the different methods of control for a building regulations application on a variety of project types. **B.D2** Evaluate the different methods of demonstrating compliance with Building Regulations 2010 for building services works.
Learning aim B: Examine the requirements of the building regulations within building services applications		
B.P3 Describe the different methods of achieving compliance with Building Regulations 2010 for building services works. **B.P4** Describe requirements of the Approved Documents for building services works.	**B.M2** Analyse the different methods of demonstrating compliance with Building Regulations 2010 for building services works.	
Learning aim C: Undertake a building regulations application		
C.P5 Describe the method and process for a building notice application from application to completion. **C.P6** Describe the method and process for a full plans application from application to completion. **C.P7** Complete the application forms and produce outline plans for a building notice and a full plans application for a new-build residential project.	**C.M3** Produce a detailed full plans building regulations application for a new-build residential project.	**C.D3** Analyse the documentation produced for a full plans application in relation to the requirements of the building regulations.

Essential information for assignments

The recommended structure of assessment is shown in the unit summary along with suitable forms of evidence. *Section 6* 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.D3)

Further information for teachers and assessors

Resource requirements

For this unit, learners must have access to:

- a range of documents relating to Building Regulations 2010 (online access optional)
- completed building regulations applications, drawings, forms and any other relevant supporting documentation.

Essential information for assessment decisions

Learning aims A and B

For distinction standard, learners will evaluate a number of different types of building services project (provided by the teacher) that use different methods of application and control, assessing the options for each scheme in terms of meeting the requirements of the Approved Documents and coming to a conclusion about which they believe to be the most appropriate. Learners will validate their discussion and justify why they believe the chosen methods to be the most appropriate. If they can do so, they will demonstrate higher-level thinking, which is essential at distinction level and is more important than aligning with any preconceived thoughts held by the teacher.

For merit standard, learners will discuss in detail the different methods of application and control, considering when each method of application would be used, and when and why an applicant may choose to use an alternative method of control to that of the traditional local authority route. Their discussion will be considered and will describe the options available, without necessarily being evaluative of each one individually. In their analysis, learners will focus on the application of the Approved Documents relating to building services.

For pass standard, learners will describe the basic requirements of the Building Regulations 2010 and the different methods of control and implementation. They will also describe the range of methods available to demonstrate compliance and expand this specifically to take into account the Approved Documents, with a specific focus on building services. Learners should make reference to the Building Act 1984 and to how the Building Regulations 2010 relate to this. They should discuss who is responsible for the implementation and regulation, and the different ways in which the applicant can demonstrate compliance. Learners will demonstrate an understanding of the requirements of the Approved Documents covered in the unit content. Learners will select one as an example and describe in greater detail how the contents of the document will ensure compliance is achieved, for example using pertinent and succinct extracts from Building Regulations 2010, alongside the relevant part of an Approved Document, to demonstrate a sound understanding.

Learning aim C

For distinction standard, learners will produce an analytical statement to support their application, choosing the form they feel to be most appropriate, for example a letter to the client explaining what all the various documents are, why they have produced them, and how they demonstrate compliance with the requirements of the regulations. Learners should be analytical and consider other options, and conclude why the methods selected were deemed the most appropriate.

For merit standard, learners will develop the form and produce the supporting documentation for a full plans application for a residential project, which should be modest in scope. Learners will produce the documents specific to the scheme, for example a new stand-alone development, or a reasonable-sized extension (at least an addition of 40 per cent to the existing property and containing at least two storeys). Each option will present its own unique set of challenges and one is not considered easier than the other. Learners' work may tie in and support work in other modules, or be bespoke for this unit. It is acceptable to provide learners with blank plans and elevations so that they may annotate the drawings and produce the supplementary documents.

Learners will provide sufficient information to be able to submit the application to the relevant body. They should clarify in the submission any assumptions made with regard to issues such as connection to the mains services.

For pass standard, learners will describe the process of making an application for both a building notice and full plans using a simple narrative or a flow chart. They will then complete an application form for a new-build residential scheme. Learners should be encouraged to obtain their own forms from the local authority in their area (typically available on the local authority website). It is expected that they include details of all the relevant supporting documents and a schedule of the key dates/stages for on-site inspection from the application stage through to final sign-off.

Links to other units

This unit links to:

- Unit 4: Construction Technology
- Unit 5: Health and Safety in Construction
- Unit 7: Graphical Detailing in Construction
- Unit 18: Building Information Modelling
- Unit 27: Building Services Control Systems
- Unit 28: Heating, Ventilation and Air Conditioning Design
- Unit 30: Plumbing Technology in Building Services Engineering
- Unit 31: Electrical Principles in Building Services Engineering
- Unit 32: Electrical Installation Standards, Components and Design.

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 National qualification for my learners?

BTEC Nationals come in a range of sizes, each with a specific purpose. You will need to assess learners very carefully to ensure that they start on the right size of qualification to fit into their 16–19 study programme, and that they take the right pathways or optional units that allow them to progress to the next stage.

If a learner is clear that they want to progress to the workplace they should be directed towards an occupationally-specific qualification, such as a BTEC National Diploma, from the outset.

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 National Certificate or Extended Certificate. Learners who then decide to continue with a fuller vocational programme can transfer to a BTEC National Diploma or Extended Diploma, for example for their second year.

Some learners are sure of the sector they want to work in and are aiming for progression into that sector via higher education. These learners should be directed to the two-year BTEC National Extended Diploma as the most suitable qualification.

As a centre, you may want to teach learners who are taking different qualifications together. You may also wish to transfer learners between programmes to meet changes in their progression needs. You should check the qualification structures and unit combinations carefully as there is no exact match among the different sizes. You may find that learners need to complete more than the minimum number of units when transferring.

When learners are recruited, you need to give them accurate information on the title and focus of the qualification for which they are studying.

Is there a learner entry requirement?

As a centre it is your responsibility to ensure that learners who are recruited 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 GCSEs at good grades and/or
- BTEC qualification(s) at Level 2
- achievement in English and mathematics through GCSE or Functional Skills.

Learners may demonstrate ability to succeed in various ways. For example, learners may have relevant work experience or specific aptitude shown through diagnostic tests or non-educational experience.

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*.

What level of sector knowledge is needed to teach these qualifications?

We do not set any requirements for teachers but expect that centres will 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. As part of the requirements of the programme are to involve employers in delivery this should support centres in ensuring that they are following up to date practices when delivering the programme.

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 Nationals. For some units, specific resources are required. This is indicated in the units.

Which modes of delivery can be used for these qualifications?

You are free to deliver BTEC Nationals 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 requirements for meaningful employer involvement?

Requirements

This BTEC National Diploma in Building Services Engineering has been designed as a Tech Level qualification. As an approved centre you are required to ensure that during their study, every learner has access to meaningful activity involving employers. Involvement should be with employers from the construction and the built environment sector and should form a significant part of the delivery or assessment of the qualification. Each centre's approach to employer involvement will be monitored in two ways. It will be monitored at centre level in the first term each year as part of the annual quality management review process that addresses centre strategy for delivery, assessment and quality assurance, when we will ask you to show evidence of how employer involvement is provided for all learners. You will need to show evidence in order to gain reporting clearance for certification. It will be monitored also at programme level as part of the standards verification process to confirm that plans for employer involvement meet the requirements of the specification. These approaches are designed to ensure additional activities can be scheduled where necessary so learners are not disadvantaged (see *Section 8: Quality assurance*).

We know that the vast majority of programmes already have established links with employers. In order to give you maximum flexibility in creating and strengthening employer involvement, we have not specified a particular level of input from employers. However, meaningful employer involvement, as defined below, should contribute significantly to at least **two** units, of which one must be a mandatory unit.

These are the mandatory units that specify where delivery and/or assessment will be linked to employers:

- Unit 4: Construction Technology
- Unit 9: Management of a Construction Project.

There are suggestions in many of the units about how employers could become involved in delivery and/or assessment. These suggestions are not exhaustive and there will be other possibilities at local level.

Employer involvement in these units is subject to verification as part of the standards verification process (see *Section 8*).

Definition

Activities that are eligible to be counted as meaningful engagement are:

- structured work experience or work placements that develop skills and knowledge relevant to the qualification
- projects or assessments set with input from industry practitioners
- master classes or guest lectures from industry practitioners
- 'expert witness' reports from practitioners that contribute to the assessment of a learner's work.

There may be other ways in which learners can benefit from contact with employers or prepare for employment, such as listening to careers talks or working in simulated environments. While they provide benefits to learners they do not count as meaningful engagement.

Support

It is important that you give learners opportunities that are high quality and directly relevant to their study. We will support you in this through guidance materials and by giving you examples of best practice.

What support is available?

We provide a wealth of support materials, including curriculum plans, delivery guides, authorised assignment briefs, additional papers for external assessments 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*.

How will my learners become more employable through these qualifications?

All BTEC Nationals are mapped to relevant occupational standards (see *Appendix 1*).

In the mandatory content and the selected optional units that focus on technical preparation learners will be acquiring the key knowledge and skills that employers need. Also, employability skills, such as teamwork and entrepreneurialism, and completing realistic tasks 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.

For careers that focus on building regulations and measurement in building services, we recommend learners take the following optional units:

- Unit 9: Management of a Construction Project
- Unit 19: Quantity Surveying
- Unit 33: Quantity Surveying Measurement Techniques in Building Services Engineering
- Unit 34: Building Regulations and Control in Building Services Engineering.

For careers that focus on electrical engineering in building services, we recommend learners take the following optional units:

- Unit 15: Further Mathematics for Construction
- Unit 27: Building Services Control Systems
- Unit 31: Electrical Principles in Building Services Engineering
- Unit 32: Electrical Installation Standards, Components and Design.

For careers that focus on plumbing and heating in building services, we recommend learners take the following optional units:

- Unit 12: Low Temperature Hot Water Systems in Building Services
- Unit 28: Heating, Ventilation and Air Conditioning Design
- Unit 29: Use of Static and Dynamic Fluids in Building Services Engineering
- Unit 30: Plumbing Technology in Building Services Engineering.

5 Assessment structure and external assessment

Introduction

BTEC Nationals are assessed using a combination of *internal assessments*, which are set and marked by teachers, and *external assessments* which are set and marked by Pearson:

- mandatory units have a combination of internal and external assessments
- all optional units are internally assessed.

We have taken great care to ensure that the assessment method chosen is appropriate to the content of the unit and in line with requirements from employers and higher education.

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. Some units are defined as synoptic units (see *Section 2*). Normally, a synoptic assessment is one that a learner would take later in a programme and in which they will be expected to apply learning from a range of units. Synoptic units may be internally or externally assessed. Where a unit is externally assessed you should refer to the sample assessment materials (SAMs) to identify where there is an expectation that learners draw on their wider learning. For internally-assessed units, you must plan the assignments so that learners can demonstrate learning from across their programme. A unit may be synoptic in one qualification and not another because of the relationship it has to the rest of the qualification.

We have addressed the need to ensure that the time allocated to final assessment of internal and external units is reasonable so that there is sufficient time for teaching and learning, formative assessment and development of transferable skills.

In administering internal and external assessment, 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*.

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*, and the requirements for delivering assessment given in *Section 6*.

External assessment

A summary of the external assessment for this qualification is given in *Section 2*. You should check this information carefully, together with the unit specification and the sample assessment materials, so that you can timetable learning and assessment periods appropriately.

Learners must be prepared for external assessment by the time they undertake it. In preparing learners for assessment, you will want to take account of required learning time, the relationship with other external assessments and opportunities for retaking. You should ensure that learners are not entered for unreasonable amounts of external assessment in one session. Learners may resit an external assessment to obtain a higher grade of near pass or above. If a learner has more than one attempt, then the best result will be used for qualification grading, up to the permitted maximum. It is unlikely that learners will need to or benefit from taking all assessments twice so you are advised to plan appropriately. Some assessments are synoptic and learners are likely to perform best if these assessments are taken towards the end of the programme.

Key features of external assessment in construction and the built environment

In construction and the built environment, after consultation with stakeholders, we have developed the following.

- Unit 1: Construction Principles – learners complete a written examination, demonstrating the skills needed to solve a variety of practical construction problems by applying science knowledge and carrying out mathematical and statistical techniques. Learners 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.
- Unit 2: Construction Design – learners will complete an externally-marked task, demonstrating their understanding of the principles and practice involved in the design and construction of low- and medium-rise buildings and structures, showing an understanding of how design is influenced by client requirements and external constraints.

Units

The externally-assessed units have a specific format which we explain in *Section 3*. The content of the units will be sampled across external assessments over time through appropriate papers and tasks. The ways in which learners are assessed are shown through the assessment outcomes and grading descriptors. External assessments are marked and awarded using the grade descriptors. The grades available are Distinction (D), Merit (M), Pass (P) and Near Pass (N). The Near Pass (N) grade gives learners credit below a Pass, where they have demonstrated evidence of positive performance which is worth more than an unclassified result but not yet at the Pass standard.

Sample assessment materials

Each externally-assessed unit has a set of sample assessment materials (SAMs) that accompanies this specification. The SAMs are there to give you an example of what the external assessment will look like in terms of the feel and level of demand of the assessment. In the case of units containing synoptic assessment, the SAMs will also show where learners are expected to select and apply from across the programme.

The SAMs show the range of possible question types that may appear in the actual assessments and give you a good indication of how the assessments will be structured. While SAMs can be used for practice with learners, as with any assessment the content covered and specific details of the questions asked will change in each assessment.

A copy of each of these assessments can be downloaded from our website. An additional sample of each of the Pearson-set units will be available before the first sitting of the assessment to allow your learners further opportunities for practice.

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 *Pearson Quality Assurance Handbook*. All members of the assessment team need to refer to this document.

For BTEC Nationals 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 national standards.

Principles of internal assessment

Assessment through assignments

For internally-assessed 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, and formative assessment by, 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.

Assessment decisions through applying unit-based criteria

Assessment decisions for BTEC Nationals 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 among the criteria so that assessors can apply all the criteria to the learner's evidence at the same time. In *Appendix 2* 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 simply 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 national framework.

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. Full information is given in the *Pearson Quality Assurance Handbook*.

- The Lead Internal Verifier (the Lead IV) has overall responsibility for the programme, its assessment and internal verification to meet our requirements, record keeping and liaison with the Standards Verifier. The Lead IV registers with Pearson annually. The Lead IV acts as an assessor, supports the rest of the assessment team, makes sure that they have the information they need about our assessment requirements and organises training, making use of our guidance and support materials.
- Internal Verifiers (IVs) oversee all assessment activity 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 to national standards. Before taking 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 in line with national standards. We support you through, for example, providing training materials and sample documentation.

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.

Setting effective assignments

Setting the number and structure of assignments

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 some units we provide authorised assignment briefs, for all the units we give you suggestions on how to create suitable assignments. You can find these materials along with this specification 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 tasks.
- 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

BTEC Nationals 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 provide learners with the opportunity to apply a range of employability or transferable skills. Centres may choose to use different suitable forms for evidence to those proposed. Overall, learners should be assessed using varied forms of evidence.

Full definitions of types of assessment are given in *Appendix 2*. 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.

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:

- 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*.

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 2*
- examples of assessed work provided by Pearson
- your Lead IV and assessment team's collective experience, supported by the standardisation materials we provide.

Pass and Merit criteria relate to individual learning aims. The Distinction criteria as a whole relate to outstanding performance 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.

Dealing with late completion of assignments

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 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.

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.

Resubmission of improved evidence

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 remains valid.

Once an assessment decision has been given to the learner, the resubmission opportunity must have a deadline within 15 working days 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.

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 only be achieved at a pass.

The Lead Internal Verifier must only authorise a retake of an assignment in exceptional circumstances where they believe it is necessary, appropriate and fair to do so. For further information on offering a retake opportunity, you should refer to the *BTEC Centre Guide to Assessment*. We provide information on writing assignments for retakes on our website (www.btec.co.uk/keydocuments).

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 also work closely with us so that we can quality assure that national standards are being satisfied. This process gives stakeholders confidence in the assessment approach.

The Lead IV must have an assessment plan, produced as a spreadsheet. When producing a plan, the assessment team may wish 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 external assessments and when quality assurance will take place
- the completion dates for different assignments
- who is acting as IV for each assignment and the date by which the assignment needs to be verified
- setting an approach to sampling assessor decisions though internal verification that covers all assignments, assessors and a range of learners
- 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:

- verification of assignment briefs
- learner authentication declarations
- assessor decisions on assignments, with feedback given to learners
- verification of assessment decisions.

Examples of records and further information are given in the *Pearson Quality Assurance Handbook.*

7 Administrative arrangements

Introduction

This section focuses on the administrative requirements for delivering a BTEC qualification. It will be of 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 and external assessment. You need to refer to the *Information Manual* for information on making registrations for the qualification and entries for external assessments.

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

Both internal and external 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 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 Joint Council for Qualifications (JCQ) document *Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational Qualifications*.

Administrative arrangements for internal 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 *Information Manual.* We may ask to audit your records so they must be retained as specified.

Reasonable adjustments to assessment

A reasonable adjustment is one that is made before a learner takes an assessment to ensure that they have fair access to demonstrate the requirements of the assessments. 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 adjustment and special consideration in vocational internally-assessed units*.

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 previous paragraph). You can provide 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 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*.

Administrative arrangements for external assessment

Entries and resits

For information on the timing of assessment and entries, please refer to the annual examinations timetable on our website.

Access arrangements requests

Access arrangements are agreed with Pearson before an assessment. They allow students with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

Access arrangements should always be processed at the time of registration. Learners will then know what type of arrangements are available in place for them.

Granting reasonable adjustments

For external assessment, a reasonable adjustment is one that we agree to make for an individual learner. A reasonable adjustment is defined for the individual learner and informed by the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, to include:

- the needs of the learner with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the learner with the disability and other learners.

Adjustment may be judged unreasonable and not approved if it involves unreasonable costs, timeframes or affects the integrity of the assessment.

Special consideration requests

Special consideration is an adjustment made to a student's mark or grade after an external assessment to reflect temporary injury, illness or other indisposition at the time of the assessment. An adjustment is made only if the impact on the learner is such that it is reasonably likely to have had a material effect on that learner being able to demonstrate attainment in the assessment.

Centres are required to notify us promptly of any learners who they believe have been adversely affected and request that we give special consideration. Further information can be found in the special requirements section on our website.

Conducting external assessments

Centres must make arrangements for the secure delivery of external assessments. External assessments for BTEC qualifications include examinations, set tasks and performance.

Each external assessment has a defined degree of control under which it must take place. Some external assessments may have more than one part and each part may have a different degree of control. We define degrees of control as follows.

High control

This is the completion of assessment in formal invigilated examination conditions.

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 task.

Low control

These are activities completed without direct supervision. They may include research, preparation of materials and practice. The materials produced by learners under low control will not be directly assessed.

Further information on responsibilities for conducting external assessment is given in the document *Instructions for Conducting External Assessments*, available on our website.

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 in vocational qualifications*, available on our website.

The procedures we ask you to adopt vary between units that are internally-assessed and those that are externally assessed.

Internally-assessed units

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* document gives full 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, 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.

Externally-assessed units

External assessment means all aspects of units that are designated as external in this specification, including preparation for tasks and performance. For these assessments, centres must follow the JCQ procedures set out in the latest version of *JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures* (www.jcq.org.uk).

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

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

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

Teacher/centre malpractice

Heads of Centres are required to inform Pearson's Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. Heads of centres are requested to inform the Investigations Team by submitting a *JCQ Form M2(a)* (available at www.jcq.org.uk/exams-office/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff or anonymous informants), the Investigations Team will conduct the investigation directly or may ask the head of centre to assist.

Incidents of maladministration (accidental errors in the delivery of Pearson qualifications that may affect the assessment of learners) should also be reported to the Investigations Team using the same method.

Heads of Centres/Principals/Chief Executive Officers or their nominees are required to inform learners and centre staff suspected of malpractice of their responsibilities and rights; see Section 6.15 of the *JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures* document.

Pearson reserves the right in cases of suspected malpractice to withhold the issuing of results and/or certificates while an investigation is in progress. Depending on the outcome of the investigation results and/or certificates may be released or withheld.

You should be aware that Pearson may need to suspend certification when undertaking investigations, audits and quality assurances processes. You will be notified within a reasonable period of time if this occurs.

Sanctions and appeals

Where malpractice is proven we may impose sanctions or penalties.

Where learner malpractice is evidenced, penalties may be imposed such as:

- mark reduction for external assessments
- 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 *Enquiries and appeals about Pearson vocational qualifications and end point assessment 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, even if final results for external assessments have not been issued, then the centre can claim certification for the learner, provided that quality assurance has been successfully completed. For the relevant procedures please refer to our *Information Manual*. You can use the information provided on qualification grading to check overall qualification grades.

Results issue

After the external assessment session, learner results will be issued to centres. The result will be in the form of a grade. You should be prepared to discuss performance with learners, making use of the information we provide and post-results services.

Post-assessment services

Once results for external assessments are issued, you may find that the learner has failed to achieve the qualification or to attain an anticipated grade. It is possible to transfer or reopen registration in some circumstances. The *Information Manual* gives further information.

Changes to qualification requests

Where a learner who has taken a qualification wants to resit an externally-assessed 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. For a learner receiving their results in August, you should decline the grade by the end of September if the learner intends to resit an external assessment.

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 this documentation. These documents are reviewed annually and are reissued if updates are required.

- *Pearson 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, entering for external assessments and claiming certificates.
- *Lead Examiners' Reports*: these are produced after each series for each external assessment and give feedback on the overall performance of learners in response to tasks or questions set.
- *Instructions for the Conduct of External Assessments (ICEA)*: this explains our requirements for the effective administration of external assessments, such as invigilation and submission of materials.
- *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 legislation.
- Centres should refer to the teacher guidance section in individual units to check for any specific resources required.

Continuing quality assurance and standards verification

On an annual basis, we produce the *Pearson Quality Assurance Handbook.* It contains detailed guidance on the quality processes required to underpin planning for delivery including appropriate employer involvement, and for robust assessment and internal verification.

The key principles of quality assurance are that:

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

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

The methods we use to do this for BTEC 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
- undertaking an overarching review and assessment of a centre's strategy for ensuring sufficient and appropriate engagement with employers at the beginning of delivery of any BTEC programme(s)
- undertaking a review of the employer involvement planned at programme level to ensure its appropriateness at a time when additional activities can be scheduled where necessary
- 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, for example making sure that synoptic units are placed appropriately in the order of delivery of the programme.

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.

The awarding and certification of these qualifications will comply with regulatory requirements.

Eligibility for an award

In order to be awarded a qualification, a learner must complete all units, achieve a Near Pass (N) or above in all external units and a pass or above in all mandatory units unless otherwise specified. Refer to the structure in *Section 2*.

To achieve any qualification grade, learners must:

- complete and **have an outcome** (D, M, P, N or U) for all units within a valid combination
- achieve the **required units at pass or above** shown in *Section 2*, and for the Diploma achieve a minimum of 600 GLH and Extended Diploma achieve a minimum 900 GLH at Pass or above (or N or above in external units)
- 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 (N or 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.

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.

In the event that 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 Nationals are Level 3 qualifications and are awarded at the grade ranges shown in the table below.

Qualification	Available grade range
Certificate, Extended Certificate, Foundation Diploma	P to D*
Diploma	PP to D*D*
Extended Diploma	PPP to D*D*D*

The *Calculation of qualification grade* table, shown further on in this section, shows the minimum thresholds for calculating these grades. The table will be kept under review over the lifetime of the qualification. The most up to date table will be issued on our website.

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

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 internal units

The table below shows the number of **points** available for internal units. For each internal unit, points are allocated depending on the grade awarded.

	Unit size	
	60 GLH	**90 GLH**
U	0	0
Pass	6	9
Merit	10	15
Distinction	16	24

Points available for external units

Raw marks from the external units will be awarded **points** based on performance in the assessment. The table below shows the **minimum number of points** available for each grade in the external units.

	Unit size	
	90 GLH	**120 GLH**
U	0	0
Near Pass	6	8
Pass	9	12
Merit	15	20
Distinction	24	32

Pearson will automatically calculate the points for each external unit once the external assessment has been marked and grade boundaries have been set. For more details about how we set grade boundaries in the external assessment please go to our website.

Claiming the qualification grade

Subject to eligibility, Pearson will automatically calculate the qualification grade for your learners when the internal 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 for the cohort.

Calculation of qualification grade

Applicable for registration from 1 September 2017.

Extended Certificate		Foundation Diploma		Diploma		Extended Diploma	
360 GLH		540 GLH		720 GLH		1080 GLH	
Grade	**Points threshold**	**Grade**	**Points threshold**	**Grade**	**Points threshold**	**Grade**	**Points threshold**
U	0	U	0	U	0	U	0
Pass	36	P	54	PP	72	PPP	108
				MP	88	MPP	124
						MMP	140
Merit	52	M	78	MM	104	MMM	156
				DM	124	DMM	176
						DDM	196
Distinction	74	D	108	DD	144	DDD	216
				D*D	162	D*DD	234
						D*D*D	252
Distinction*	90	D*	138	D*D*	180	D*D*D*	270

The table is subject to review over the lifetime of the qualification. The most up-to-date version will be issued on our website.

Examples of grade calculations based on table applicable to registrations from September 2017

Example 1: Achievement of a Diploma with a PP grade

	GLH	Type (Int/Ext)	Grade	Unit points
Unit 1	120	Ext	Pass	12
Unit 2	120	Ext	Pass	12
Unit 4	60	Int	Pass	6
Unit 5	60	Int	Pass	6
Unit 7	60	Int	Pass	6
Unit 12	60	Int	Distinction	16
Unit 14	60	Int	Pass	6
Unit 21	60	Int	Merit	10
Unit 27	60	Int	U	0
Unit 28	60	Int	Distinction	16
Totals	**720**		**PP**	**90**

The learner has achieved N or higher in Units 1 and 2, and P or higher in Unit 4.

The learner has sufficient points for a PP grade.

Example 2: Achievement of a Diploma with a DD grade

	GLH	Type (Int/Ext)	Grade	Unit points
Unit 1	120	Ext	Near Pass	8
Unit 2	120	Ext	Distinction	32
Unit 4	60	Int	Merit	10
Unit 5	60	Int	Distinction	16
Unit 7	60	Int	Distinction	16
Unit 12	60	Int	Merit	10
Unit 14	60	Int	Merit	10
Unit 21	60	Int	Distinction	16
Unit 27	60	Int	Merit	10
Unit 28	60	Int	Distinction	16
Totals	**720**		**DD**	**144**

The learner has sufficient points for a DD grade.

Example 3: An Unclassified result for a Diploma

	GLH	Type (Int/Ext)	Grade	Unit points
Unit 1	120	Ext	Merit	20
Unit 2	120	Ext	U	0
Unit 4	60	Int	U	0
Unit 5	60	Int	Pass	6
Unit 7	60	Int	Distinction	16
Unit 12	60	Int	Merit	10
Unit 14	60	Int	Pass	6
Unit 21	60	Int	Merit	10
Unit 27	60	Int	Pass	6
Unit 28	60	Int	Pass	6
Totals	**720**		**U**	**80**

The learner has a U in Units 2 and 4.

The learner has sufficient points for a PP grade but has not met the minimum requirement for a Near Pass or higher in Units 1 and 2, and Pass or higher in Unit 4.

10 Resources and support

Our aim is to give you a wealth of resources and support to enable you to deliver BTEC National qualifications with confidence. On our website you will find a list of resources to support teaching and learning, and professional development.

Support for setting up your course and preparing to teach

Specification

This **specification** (for teaching from September 2017) includes details on the administration of qualifications and information on all the units for the qualification.

Delivery Guide

This free guide gives 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. It explains the key features of BTEC Nationals (for example employer involvement and employability skills). It also covers guidance on assessment (internal and external) and quality assurance. The guide tells you where you can find further support and gives detailed unit-by-unit delivery guidance. It includes teaching tips and ideas, assessment preparation and suggestions for further resources.

Schemes of work

Free sample schemes of work are provided for each mandatory unit. These are available in Word™ format for ease of customisation.

Curriculum models

These show how the BTECs in the suite fit into a 16–19 study programme, depending on their size and purpose. The models also show where other parts of the programme, such as work experience, maths and English, tutorial time and wider study, fit alongside the programme.

Study skills activities

A range of case studies and activities is provided; they are designed to help learners develop the study skills they need to successfully complete their BTEC course. The case studies and activities are provided in Word™ format for easy customisation.

Support for teaching and learning

Pearson Learning Services provides a range of engaging resources to support BTEC Nationals, including:

- textbooks in e-book and print formats
- revision guides and revision workbooks in e-book and print formats
- teaching and assessment packs, including e-learning materials via the Active Learn Digital Service.

Teaching and learning resources are also available from a number of other publishers. Details of Pearson's own resources and of all endorsed resources can be found on our website.

Support for assessment

Sample assessment materials for externally-assessed units

Sample assessments are available for the Pearson-set units. One copy of each of these assessments can be downloaded from the website/available in print. For each suite an additional sample for one of the Pearson-set units is also available, allowing your learners further opportunities for practice.

Further sample assessments will be made available through our website on an ongoing basis.

Sample assessment materials for internally-assessed units

We do not prescribe the assessments for the internally-assessed units. Rather, we allow you to set your own, according to your learners' preferences and to link with your local employment profile.

We do provide a service in the form of Authorised Assignment Briefs, which are approved by Pearson Standards Verifiers. They are available via our website.

Sample marked learner work

To support you in understanding the expectation of the standard at each grade, examples of marked learner work at PM/MD grades are linked to the Authorised Assignment Briefs.

Training and support from Pearson

People to talk to

There are many people who are available to support you and provide advice and guidance on delivery of your BTEC Nationals. These include:

- Subject Advisors – available for all sectors. They understand all Pearson qualifications in their sector and so 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
- Curriculum Development Managers (CDMs) – they are regionally based and have a full overview of the BTEC qualifications and of the support and resources that Pearson provides. CDMs 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 National 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 Nationals. They include an overview of the qualifications' structures, planning and preparation for internal and external 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 Nationals have been developed in consultation with industry and appropriate sector bodies to ensure that the qualification content and approach to assessment aligns 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.

In the construction and the built environment sector, the following approach has been used.

The mandatory content has been mapped to NOS to reflect the essential skills and knowledge needed for entry to employment.

Appendix 2 Glossary of terms used for internally-assessed units

This is a summary of the key terms used to define the requirements in the units.

Term	Definition
Analyse	Learners present the outcome of methodical and detailed examination, either: • breaking down a theme, topic or situation in order to interpret and study the interrelationships between the parts and/or • of information or data to interpret and study key trends and interrelationships. Analysis can be through performance, practice, written or, less commonly, verbal presentation.
Assess	Learners present a careful consideration of varied factors or events that apply to a specific situation or, to identify those which are the most important or relevant and arrive at a conclusion.
Carry out	Learners demonstrate skills through practical activities, in line with certain requirements. Learners do this in order to complete an identified activity or to demonstrate personal achievement for an audience.
Compare	Learners identify the main factors relating to two or more items/situations or aspects of a subject that is extended to explain the similarities, differences, advantages and disadvantages. This is used to show depth of knowledge through selection and isolation of characteristics.
Demonstrate	Learners' work, performance or practice evidences the ability to carry out and apply knowledge, understanding and/or skills in a practical situation.
Develop	Learners acquire and apply skills and understanding through practical activities that involve the use of concepts, processes or techniques to expand or progress something.
Discuss	Learners consider different aspects of: • a theme or topic; • how they interrelate; and • the extent to which they are important. A conclusion is not required.

Term	Definition
Evaluate	Learners' work draws on varied information, themes or concepts to consider aspects such as: • strengths or weaknesses • advantages or disadvantages • alternative actions • relevance or significance. Learners' inquiries should lead to a supported judgement showing relationship to its context. This will often be in a conclusion. Evidence of explanations could be through visual explanations with annotations, as well as written work, presentation, performance or practice.
Examine	Learners select and apply knowledge to less familiar contexts.
Explain	Learners' work shows clear detail and gives reasons and/or evidence to support an opinion, view or argument. It could show how conclusions are drawn (arrived at). Learners to show that they comprehend the origins, functions and objectives of a subject, and its suitability for purpose.
Explore	Learners apply their skills and/or knowledge in contexts involving practical research or investigation.
Investigate	Learners' application of knowledge is based on personal research and development.
Justify	Learners give reasons or evidence to: • support an opinion • prove something right or reasonable.
Perform	Learners demonstrate a range of skills required to complete a given activity.
Review	Learners make a formal assessment of work produced. The assessment allows learners to appraise existing information or prior events, and reconsider information with the intention of making changes, if necessary.
Understand	Learners demonstrate knowledge related to defined situations.
Undertake	Learners demonstrate skills through practical activities, often referring to given processes or techniques.

This is a key summary of the types of evidence used for BTEC Nationals.

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.
Practical task (artefact/outcome)	Learners carry out a defined or self-defined task to produce an outcome.
Presentation	To show presentation skills, including communication. To direct to a given audience and goal. To extract and summarise information.
Written task/report	Individual completion of a task in a work-related format, e.g. a report, marketing communication, set of instructions.

Pearson BTEC Level 3 Nationals in Building Services Engineering

Extended Certificate in Construction and the Built Environment

Foundation Diploma in Construction and the Built Environment

Diploma in Construction and the Built Environment

Extended Diploma in Construction and the Built Environment

Diploma in Building Services Engineering

Extended Diploma in Building Services Engineering

Diploma in Civil Engineering

Extended Diploma in Civil Engineering

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