

Higher Nationals

Cloud Computing

Specification

For use with the Higher National Certificate and
Higher National Diploma in Cloud Computing

First Teaching from November 2020

First Certification from 2022



**Higher National
Certificate Lvl 4**

**Higher National
Diploma Lvl 5**



**Pearson
BTEC**

Edexcel, BTEC and LCCI qualifications

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Contents

1	Introduction	1
1.1	The Student Voice	1
1.2	Why choose Pearson BTEC Higher Nationals?	2
1.3	HN Global	2
1.4	Qualification titles	3
1.5	Qualification codes	3
1.6	Awarding institution	3
1.7	Key features	3
1.8	Collaborative development	4
1.9	Collaboration with AWS Educate	5
1.10	Support Package	6
2	Programme purpose and objectives	7
2.1	Purpose of the Pearson BTEC Higher Nationals in Cloud Computing	7
2.2	Objectives of the Pearson BTEC Higher Nationals in Cloud Computing	7
2.3	Aims of the Pearson BTEC Level 4 Higher National Certificate in Cloud Computing	8
2.4	Aims of the Pearson BTEC Level 5 Higher National Diploma in Cloud Computing	9
2.5	Use of mathematics and English in the curriculum	10
2.6	The Skills Framework for the Information Age	11
2.7	What could these qualifications lead to?	12
2.7.1	Progression to university	13
2.7.2	Employment	13
2.7.3	Occupational Maps and Apprenticeship Standards	14
2.8	How Pearson BTEC Higher Nationals in Cloud Computing provide both transferable employability skills and academic study skills	15
3	Planning your programme	17
3.1	Delivering the Pearson BTEC Higher Nationals in Cloud Computing	17
3.2	Entry requirements and admissions	17
3.2.1	English language requirements	18
3.2.2	Centre approval	18
3.2.3	Level of sector knowledge required	19

3.2.4	Resources required	19
3.2.5	HN Global support	19
3.2.6	Modes of delivery	19
3.2.7	Recommendations for employer engagement	19
3.2.8	Support from Pearson	19
3.2.9	Student employability	20
3.3	Access to study	20
3.4	Student registration and entry	20
3.5	Access to assessments	21
3.6	Administrative arrangements for internal assessment	21
3.6.1	Records	21
3.6.2	Reasonable adjustments to assessment	22
3.6.3	Special consideration	22
3.6.4	Appeals against assessment	22
3.7	Dealing with malpractice in assessment	23
3.7.1	Internally assessed units	23
3.7.2	Student malpractice	24
3.7.3	Tutor/centre malpractice	24
3.7.4	Sanctions and appeals	25
4	Programme structure	26
4.1	Units, credits and Total Qualification Time (TQT)	26
4.2	Programme structures	28
4.2.1	Pearson BTEC Level 4 Higher National Certificate in Cloud Computing	28
4.2.2	Pearson BTEC Level 5 Higher National Diploma in Cloud Computing	30
4.2.3	Units of combination	31
4.2.4	Meeting local needs (MLN)	38
4.2.5	Pearson BTEC Higher National Commissioned Development	39
4.3	Pearson-set assignments	40
4.4	The Unit Descriptor	41
4.5	Professional body recognition	44
4.6	Vendor accreditation	44
5	Teaching and learning	45
5.1	Delivering quality and depth	45
5.2	Engaging with employers	47
5.3	Engaging with students	47

5.4	Planning and structuring a programme	48
5.4.1	Sequencing units	49
5.4.2	Condensed, expanded or mixed delivery	49
5.4.3	Drawing on a wide range of delivery techniques	51
5.4.4	Assessment considerations	53
5.4.5	Formative assessment	54
5.4.6	Summative assessment	54
5.4.7	Assessment feedback	54
5.4.8	Designing valid and reliable assessments	55
6	Assessment	57
6.0.1	Example Assessment Briefs	58
6.1	Principles of internal assessment	58
6.1.1	Assessment through assignments	58
6.1.2	Assessment decisions through applying unit-based criteria	59
6.1.3	The assessment team	59
6.1.4	Effective organisation	60
6.1.5	Student preparation	60
6.2	Setting effective assessments	61
6.2.1	Setting the number and structure of assessments	61
6.2.2	Providing an assignment brief	62
6.2.3	Forms of evidence	62
6.3	Making valid assessment decisions	63
6.3.1	Authenticity of student work	63
6.3.2	Making assessment decisions using criteria	64
6.3.3	Dealing with late completion of assignments	64
6.3.4	Issuing assessment decisions and feedback	65
6.3.5	Resubmission opportunity	65
6.3.6	Repeat units	66
6.3.7	Assessment Boards	66
6.4	Planning and record keeping	66
6.5	Calculation of the final qualification grade	67
6.5.1	Conditions for the award	67
6.5.2	Compensation provisions	68
6.5.3	Calculation of the overall qualification grade	68
6.5.4	Modelled student outcomes	70

7	Quality assurance	71
7.1	The approval process	71
7.2	Monitoring of internal centre systems	72
7.3	Independent assessment review	72
7.4	Annual Programme Monitoring Report	72
7.5	Annual student survey	73
7.6	Centre and qualification approval	73
7.7	Continuing quality assurance and standards verification	73
8	Recognition of Prior Learning and attainment	75
9	Equality and diversity	76
10	Units	78
	Unit 1: Cloud Fundamentals	79
	Unit 2: Networking in the Cloud	87
	Unit 3: Security in the Cloud	94
	Unit 4: Programming	101
	Unit 5: Database Design and Development in the Cloud	106
	Unit 6: Deploying and Operating in the Cloud (Pearson Set)	115
	Unit 7: Website Design and Development in the Cloud	123
	Unit 8: Professional Practice	132
	Unit 9: Maths for Computing	140
	Unit 10: Computer Systems Architecture	146
	Unit 11: Strategic Information Systems	153
	Unit 12: Cloud Computing Research Project (Pearson Set)	159
	Unit 13: Cloud Architecture Design	167
	Unit 14: Operating Systems in the Cloud	174
	Unit 15: Cloud Systems Integration	182
	Unit 16: Information Security Management in the Cloud	190
	Unit 17: Applied Security in the Cloud	199
	Unit 18: Applied Cryptography in the Cloud	207
	Unit 19: Software Development Methodologies for the Cloud	218
	Unit 20: Application Development, Testing & Debugging	224
	Unit 21: Applied Programming and Design Principles	233
	Unit 22: Financing the Cloud	241

Unit 23: Forensics in the Cloud	249
Unit 24: Data Structures & Algorithms	258
Unit 25: Machine Learning	265
Unit 26: Artificial Intelligence	272
Unit 27: Internet of Things	281
Unit 28: Business Intelligence	289
Unit 29: E-Commerce & Strategy	297
Unit 30: Risk Analysis & Systems Testing	304
Unit 31: Critical Infrastructure Protection	311
Unit 32: Developing Individuals, Teams and Organisations	319
Unit 33: Understanding and Leading Change	327
Unit 34: Business Information Technology Systems	333
11 Appendices	341
Appendix 1: Skills Framework for the Information Age (SFIA)	342
SFIA LEVEL 3 SKILLS	342
SFIA LEVEL 4 SKILLS	359
Appendix 2: Glossary of terms used for internally assessed units	393
Appendix 3: Assessment Methods and Techniques for Pearson BTEC Higher Nationals	397
Appendix 4: Mapping of Pearson BTEC HND in Cloud Computing against FHEQ Level 5	401
Appendix 5: Pearson BTEC HNC/HND Cloud Computing Programme Outcomes for Students	406
Appendix 6: Transferable skills mapping	408
Level 5 Higher National Diploma in Cloud Computing: mapping of transferable employability and academic study skills	408

1 Introduction

BTEC is one of the world's most successful and best-loved applied learning brands, engaging students in practical, interpersonal and thinking skills for more than 30 years.

BTECs are work-related qualifications for students taking their first steps into employment, or for those already in employment and seeking career development opportunities. BTECs provide progression into the workplace either directly or via study at university and are also designed to meet employer's needs. Therefore, Pearson BTEC Higher National qualifications are widely recognised by industry and higher education as the principal vocational qualification at Levels 4 and 5.

When developing the Pearson BTEC Higher National qualifications in Cloud Computing, we collaborated with Amazon Web Services (AWS) as market leaders in the cloud space, alongside a range of employers, higher education providers, colleges, students, and subject experts, to ensure that the new qualifications meet their needs and expectations.

Research indicates that cloud computing has been ranked as a top skill requirement for the past several years and will continue to be in demand for the future as most companies move to a cloud-supported infrastructure. There is a shortage of skilled cloud professionals and this shortage is set to continue. The growth of opportunities in this field, along with a greater emphasis on employer engagement and work readiness, have necessitated the development of a qualification with pathways that offer a more specialist cloud focus. These pathways combine the best of academic rigour, technical expertise and hands-on experience.

The new Pearson BTEC Higher National qualifications in Cloud Computing are designed to reflect the increasing need for high quality professional and technical education pathways at Levels 4 and 5, giving students a clear line of sight to employment and progression to a degree at Level 6. In designing the qualifications, we worked closely with the relevant professional bodies to ensure alignment with recognised professional and occupational standards.

1.1 The Student Voice

Students are at the heart of what we do. That is why, from the outset, we consulted with students in the development of these qualifications. We involved them in writing groups, sought their feedback and added their voices and views to those of other stakeholders.

The result, we believe, are qualifications that will meet the needs and expectations of students worldwide.

1.2 Why choose Pearson BTEC Higher Nationals?

Pearson BTEC Higher Nationals are designed to help students secure the knowledge, skills and behaviours needed to succeed in the workplace. The qualifications represent the latest in professional standards and give students opportunities to develop behaviours for work, for example by undertaking a group project or responding to a client brief. To help students on their journey to professional competence, they may gain exemption from professional or vendor qualifications, and/or student membership of selected professional bodies.

At the same time, BTEC Higher Nationals are intended to keep doors open for future study should a student wish to progress further in their education after their Level 5 study. The qualifications do this by allowing space for the development of higher education study skills, such as the ability to research. Clear alignment of level of demand with the Framework for Higher Education Qualifications (FHEQ) qualification descriptors at Levels 4 and 5 means that students wishing to progress to Level 6 study should feel better prepared. The Pearson BTEC Higher Nationals address these various requirements by providing:

- a range of core, optional and specialist units, each with a clear purpose, so there is something to suit each student's choice of programme and future progression plans
- fully revised content that is closely aligned with the needs of employers, professional bodies, vendors and higher education for a skilled future workforce
- Learning Outcomes mapped against professional body standards and vendor accreditation requirements, where appropriate
- assessments and projects chosen to help students progress to the next stage (this means that some are set by the centre to meet local needs, while others are set by Pearson)
- an approach to demand at Levels 4 and 5 that is aligned with the FHEQ.

1.3 HN Global

Pearson BTEC Higher Nationals are supported by a specially designed range of digital resources, to ensure that tutors and students have the best possible experience during their course.

With HN Global (<http://hnglobal.highernationals.com/>), tutors can access programme specifications that contain useful information on programme planning and quality assurance processes. Tutors can also view schemes of work and example assessment briefs, helping them to create meaningful courses and assessments. HN Global allows tutors to create and annotate reading lists for their students and to keep up to date on the latest news on HN programmes.

Through HN Global, access is provided to the Amazon Web Services (AWS) Educate platform, where the supporting vendor resources for these Cloud Computing qualifications will be made available. The resources are aligned to this specification by unit and by Learning Outcome.

Pearson will also provide additional vendor neutral resources, which will sit under the Cloud Computing subject pages on HN Global.

1.4 Qualification titles

Pearson BTEC Level 4 Higher National Certificate in Cloud Computing

Pearson BTEC Level 5 Higher National Diploma in Cloud Computing

Specialist pathways are given in brackets in the qualification title:

- Pearson BTEC Level 5 Higher National Diploma in Cloud Computing (Cloud Support)
- Pearson BTEC Level 5 Higher National Diploma in Cloud Computing (Cloud Cyber Security)
- Pearson BTEC Level 5 Higher National Diploma in Cloud Computing (Cloud Software Development).

1.5 Qualification codes

Ofqual Regulated Qualifications Framework (RQF) Qualification numbers:

Pearson BTEC Level 4 Higher National Certificate in Cloud Computing: **603/6674/6**

Pearson BTEC Level 5 Higher National Diploma in Cloud Computing: **603/6675/8**.

1.6 Awarding institution

Pearson Education Ltd.

1.7 Key features

Pearson BTEC Higher National qualifications in Cloud Computing offer the following:

- a stimulating and challenging programme of study that will be both engaging and memorable for students
- the essential subject knowledge that students need to progress to further study or the world of work
- a simplified structure – students undertake a substantial core of learning in the Pearson BTEC Higher National Certificate and can build on this in the Pearson BTEC Higher National Diploma, with specialist and optional units linked to their area of study

- three specialist pathways in the BTEC Level 5 Higher National Diploma, so there is something to suit each student's preference of study and progression plans
- refreshed content that is closely aligned with vendor, employer, professional body and higher education needs
- assessments that consider cognitive skills (what students know) along with affective and applied skills (how they behave and what they can do, respectively)
- unit-specific grading and Pearson-set assignments
- a varied approach to assessment that supports progression to Level 6 and which allows centres to offer assessment relevant to the local economy, thereby accommodating and enhancing different learning styles
- quality assurance measures – as outlined in *Sections 6 and 7* – to ensure that all stakeholders (for example professional bodies, vendors, universities, businesses, colleges, students) can feel confident in the integrity and value of the qualifications
- qualifications that are designed to meet the needs and expectations of students aspiring to work in an international business environment.

Qualification frameworks

Pearson BTEC Higher National qualifications are designated higher education qualifications in the UK. They are aligned to the Framework for Higher Education Qualifications (FHEQ) in England, Wales and Northern Ireland, and Quality Assurance Agency (QAA) Subject Benchmark Statements. These qualifications are part of the UK Regulated Qualifications Framework (RQF).

1.8 Collaborative development

Students completing their Pearson BTEC Higher Nationals in Cloud Computing may be aiming to go on to employment in the cloud computing field or to progress to a final year at university. Therefore, it was essential that we developed these qualifications in close collaboration with expert vendors such as AWS Educate, professional bodies, businesses and universities, and with the providers who will be delivering the qualifications.

We are grateful to the university and further education tutors, employers, vendors, professional body representatives and other individuals who have generously shared their time and expertise to help us develop these new qualifications.

- AWS Educate
- British Computing Society (BCS)
- KPMG
- Milton Keynes College (South Central IoT)
- Monzo Bank

- Morgan State University (USA)
- Newcastle University
- The Open University
- Ravensbourne University
- The University of Wolverhampton.

These qualifications have also been approved by the British Computing Society (BCS) as suitable qualifications for those students who want to gain membership. Further information is available in the Progression Hub on HN Global:
<https://hnglobal.highternationals.com/>

1.9 Collaboration with AWS Educate

AWS are leaders and innovators in developing the broadest and deepest, as well as one of the most mature, cloud platforms. They have one of the largest global communities of customers and partners, making them best placed to collaborate on the development of the Pearson BTEC Higher Nationals in Cloud Computing.

AWS Educate is Amazon's global initiative to accelerate cloud learning and to prepare students for cloud-enabled jobs. We worked closely with AWS Educate to ensure that the qualifications offer students progression to entry-level jobs in the sector after completing Levels 4 and 5.

The HNC Level 4 qualification has been aligned with the Cloud Practitioner Certification from AWS and the Cloud Support Associate job role. On completion of the Level 4 Higher National Certificate (HNC), students will be suitably prepared to attempt the AWS Certified Cloud Practitioner examination, although it is recommended that students have six months of fundamental AWS Cloud and industry knowledge before taking it.

The HND Level 5 pathways are aligned broadly to job roles as follows:

- HND Cloud Support – Cloud Support Engineer
- HND Cloud Cyber Security – Cyber Security Specialist
- HND Cloud Software Development – Software Development Engineer.

All three of the Level 5 Higher National Diploma (HND) pathways include foundational content, which can help students to partially prepare for both the AWS Certified Solutions Architect and the AWS Certified Developer exams at Associate Level, with the Software Development pathway offering the most coverage in content in preparation for the latter. See *Section 4.6* for further information.

1.10 Support Package

This specification has been developed in such a way that it will allow students to gain underpinning generic cloud computing knowledge, complemented by a support package of vendor content. The package contains a wide range of resources for students to learn about cloud computing and for teachers to deliver the units through the vendor's lens.

AWS is the first vendor that Pearson has collaborated with in building a support package specifically for the Higher Nationals in Cloud Computing.

Examples of the AWS materials and benefits include:

- alignment to AWS Educate Pathways
- digital badges
- use of virtual classrooms
- access to console and sandbox environments for lab activities
- access to all AWS Educate learning and teaching content
- access to the AWS Educate job board
- facilitator guides
- AWS cloud credits to put towards accessing the additional paid tools and services to build applications.

Centres are encouraged to sign up to the vendor support package, which is signposted on HN Global. Please visit: <https://hnglobal.highternationals.com/>.

2 Programme purpose and objectives

2.1 Purpose of the Pearson BTEC Higher Nationals in Cloud Computing

The purpose of the Pearson BTEC Higher Nationals in Cloud Computing is to develop students as professional, self-reflecting individuals able to meet the demands of employers in the cloud computing sector and to adapt to a constantly changing world. The qualifications aim to widen access to higher education and enhance the career prospects of those who undertake them.

2.2 Objectives of the Pearson BTEC Higher Nationals in Cloud Computing

The objectives of the Pearson BTEC Higher Nationals in Cloud Computing are as follows:

- to equip students with cloud computing skills, knowledge and the understanding necessary to be job ready in the cloud computing field
- to provide education and training for a range of careers in cloud computing, with specific emphasis on roles in cloud support, cyber security and software development
- to provide opportunities for students to enter or progress in employment in cloud computing roles or to progress to higher education qualifications such as an Honours degree in cloud computing or a related area
- to provide insight and understanding into international cloud computing operations and the opportunities and challenges presented by a globalised marketplace
- to equip students with knowledge and understanding of culturally diverse organisations, cross-cultural issues, diversity and values
- to provide opportunities for students to develop the skills, techniques and personal attributes essential for successful working lives
- to provide opportunities for those students with a global outlook to aspire to international career pathways
- to provide opportunities for students to achieve a nationally recognised professional qualification
- to provide opportunities for students to achieve vendor accredited certifications
- to offer students the chance of career progression in their chosen field
- to allow flexibility of study and to meet local or specialist needs

- to offer a balance between employability skills and the knowledge essential for students with entrepreneurial, employment or academic aspirations.

We meet these objectives by:

- providing a thorough grounding in cloud computing principles at Level 4 that leads the student to a range of specialist progression pathways at Level 5 that relate to individual professions in the cloud computing sector
- enabling progression to a university degree by supporting the development of appropriate academic study skills
- enabling progression to further professional qualifications in specific cloud-based computing areas by mapping to units in vendor accredited certificates
- support for students and tutors through a specialised package of resources, development tools and credits towards certification, provided by AWS Educate. The package content has been aligned with the units and Learning Outcomes of the core and specialist units. Schemes of Work and Example Assessment Briefs are also provided.

Who are these qualifications for?

The Pearson BTEC Higher National qualifications in Cloud Computing are aimed at students who want to continue their education through applied learning. Pearson BTEC Higher Nationals provide an intensive study of the cloud computing sector and are designed for students who wish to pursue a career in the field, either as a general cloud practitioner or in a specialism such as cyber security or software development. In addition to the knowledge, understanding and skills that underpin the study of cloud-based learning, Pearson BTEC Higher Nationals in Cloud Computing give students experience of the breadth and depth of the sector that will prepare them for further study or training.

2.3 Aims of the Pearson BTEC Level 4 Higher National Certificate in Cloud Computing

The Pearson BTEC Level 4 Higher National Certificate in Cloud Computing offers students a broad introduction to the subject area via a mandatory core of learning, while allowing for the acquisition of skills and experience through the selection of optional units across a range of occupational sectors at Level 4. This builds underpinning core skills while preparing students for subject specialisation at Level 5. Students will gain a wide range of sector knowledge tied to practical skills gained in research, self-study, directed study and workplace scenarios.

At Level 4, students develop a broad knowledge and awareness of key aspects of the cloud sector through six core units, including a unit assessed through a Pearson-set assignment. The six core units are:

- Unit 1: Cloud Fundamentals
- Unit 2: Networking in the Cloud
- Unit 3: Security in the Cloud
- Unit 4: Programming
- Unit 5: Database Design and Development in the Cloud
- Unit 6: Deploying and Operating in the Cloud (Pearson Set).

The centre can also choose two further optional units at Level 4 from the following five units:

- Unit 7: Website Design and Development in the Cloud
- Unit 8: Professional Practice
- Unit 9: Maths for Computing
- Unit 10: Computer Systems Architecture
- Unit 11: Strategic Information Systems.

Graduates successfully completing the Pearson BTEC Higher National Certificate in Cloud Computing will be able to demonstrate a sound knowledge of the foundational concepts of cloud computing, including hands-on practical experience. They will be able to communicate accurately and appropriately and will have the qualities needed for employment that requires some degree of personal responsibility. Students will have developed a range of transferable skills to ensure effective team working, to take independent initiative, organisational competence and problem-solving strategies. They will be adaptable and flexible in their approach to computing, show resilience under pressure, and meet challenging targets within a given resource.

2.4 Aims of the Pearson BTEC Level 5 Higher National Diploma in Cloud Computing

The Pearson BTEC Level 5 Higher National Diploma in Cloud Computing offers students three specialist pathways designed to support progression into relevant occupational areas or on to degree-level study. These pathways are aligned to job roles in the cloud computing field, as defined by the AWS Educate Cloud Competency Framework, and to professional standards and vendor accredited certification (where appropriate), the pathways can also provide professional status and progression to direct employment.

The Pearson BTEC Higher National Diploma offers the following specialist pathways for students who wish to concentrate on a particular aspect of cloud computing:

- Cloud Support
- Cyber Security
- Cloud Software Development.

Holders of the Pearson BTEC Higher National Diploma will have developed a sound understanding of the principles in their field of study and will have learned to apply the principles more widely. They will have learned to evaluate the appropriateness of different approaches to solving problems. They will be able to perform effectively in their chosen field and will have the qualities needed for employment in situations that require the exercise of personal responsibility and decision making.

2.5 Use of mathematics and English in the curriculum

Those working in the wider computing sector cannot rely on just their technical skills so to increase their employment opportunities, they must ensure that **all** their skills are relevant. They will be required to communicate appropriately with stakeholders throughout their career and the ability to use maths and English in a professional context is an essential employability skill that must be developed at all levels of study.

Development of essential maths and English skills are embedded throughout these qualifications in accordance with industry requirements. Examples of how these skills are developed in the Pearson BTEC Higher Nationals Curriculum:

- written reports
- formal presentations
- informal conversations
- use of professional, sector-specific language
- using digital data
- understanding algorithms
- calculating costs.

Some aspects of cloud computing study require maths skills and throughout your studies you will be using some level of maths. It is vital that students taking a BTEC Higher National in Cloud Computing are aware that these skills will be required throughout their studies and that they are part of their learning activities and assessments in order to ensure that their skills are in line with current industry standards.

2.6 The Skills Framework for the Information Age

The Skills Framework for the Information Age (SFIA) is the global skills and competency framework that describes IT roles and the skills needed for them. It is supported by companies, government and academic institutions worldwide. SFIA describes standard levels of responsibility and accountability used in the framework and they are divided according to generic levels of responsibility and skills.

The SFIA Level 3 responsibilities correlate with those expected from an employer of an HNC graduate.

SFIA levels of responsibility: Level 3

- Autonomy
 - Works under general direction. Uses discretion in identifying and responding to complex issues and assignments. Usually receives specific instructions and has work reviewed at frequent milestones. Determines when issues should be escalated to a higher level.
- Influence
 - Interacts with and influences colleagues. Has working level contact with customers, suppliers and partners. May supervise others or make decisions which impact the work assigned to individuals or phases of projects.
- Complexity
 - Performs a range of work, sometimes complex and non-routine, in a variety of environments.
- Business skills
 - Demonstrates an analytical and systematic approach to issue resolution. Takes the initiative in identifying and negotiating appropriate personal development opportunities. Demonstrates effective communication skills. Contributes fully to the work of teams. Plans, schedules and monitors own work (and that of others where applicable) competently within limited deadlines and according to relevant legislation, standards and procedures. Appreciates the wider business context, and how own role relates to other roles and to the business of the employer or client.

The SFIA Level 4 responsibilities correlate with those expected from an employer of a HND graduate.

SFIA levels of responsibility: Level 4

- Autonomy
 - Works under general direction within a clear framework of accountability. Exercises substantial personal responsibility and autonomy. Plans own work to meet given objectives and processes.
- Influence
 - Influences customers, suppliers and partners at account level. May have some responsibility for the work of others and for the allocation of resources. Participates in external activities related to own specialism. Makes decisions which influence the success of projects and team objectives.
- Complexity
 - Work includes a broad range of complex technical or professional activities, in a variety of contexts. Investigates, defines and resolves complex issues.
- Business skills
 - Selects appropriately from applicable standards, methods, tools and applications. Communicates fluently, orally and in writing, and can present complex information to both technical and non-technical audiences. Facilitates collaboration between stakeholders who share common objectives. Plans, schedules and monitors work to meet time and quality targets. Rapidly absorbs new information and applies it effectively. Maintains an awareness of developing technologies and their application and takes some responsibility for driving own development.

For full details of the skills covered in each category for SFIA Levels 3 and 4, see *Appendix 1*.

The SFIA framework was used throughout the design and content creation of the Pearson BTEC Higher Nationals in Cloud Computing.

The British Computing Society (BCS) have mapped their membership schemes to the SFIA framework.

2.7 What could these qualifications lead to?

The Pearson BTEC Higher National Certificate provides a solid grounding in cloud related computing at Level 4, vendor-accredited certification and professional body membership. Students can build on these should they decide to continue their studies beyond the Certificate stage. The Pearson BTEC Higher National Diploma allows students to specialise by committing to specific career paths and progression routes to degree-level study.

On successful completion of the Pearson BTEC Higher National Diploma at Level 5, students can develop their careers in the cloud computing sector through:

- entering employment
- continuing existing employment
- linking with the appropriate vendor accredited certificates
- committing to Continuing Professional Development (CPD)
- progressing to university.

The Level 5 Higher National Diploma is recognised by higher education providers as meeting admission requirements to many relevant cloud-computing-related courses.

The skills offered as part of the Pearson BTEC Higher National Diploma can give graduates the opportunity to work in many different areas of the cloud computing sector.

2.7.1 Progression to university

We work with a range of higher education institutions around the world that recognise and accept Pearson BTEC Higher Nationals as qualifications for entry to an undergraduate degree. Many universities allow advanced entry to the second or third year of a degree, and agreements can include credit transfer, articulation and case-by-case admission.

Students should be aware that university admission criteria are always subject to change and remain at the discretion of the institution. Students should take time to understand the course entry requirements for subject, year and grade before applying. For more information on entry requirements, including 2+1 articulations, please visit: <https://www.highternationals.com/degree-finder>.

2.7.2 Employment

The skills that are offered as part of the Pearson BTEC Higher National Diploma can give graduates the opportunity to work in many different areas of the cloud computing sector.

AWS Educate Map

Below are some examples of job roles that each qualification could eventually lead to, according to the designations on AWS Educate Cloud Competency Framework.

Please note that the Cloud Computing qualification will prepare students for entry-level Cloud Support Associate roles, for example cloud helpdesk, where they will need to gain necessary experience and time in console to build their skills, and continue their path towards higher cloud certifications and more skilled cloud-related roles.

Pathway	Job roles
Cloud Support	Cloud Support Associate, including: Network Technician Computer Specialist Computer Analyst Systems Analyst Technical Support Associate Technical Sales Executive
Cloud Cyber Security	Cyber Security Specialist, including: Data Security Administrator Network Security Analyst Systems Analyst Information Security Analyst Computer Security Specialist IT Risk Specialist
Cloud Software Development	Application Developer, including: Software Developer Computer Applications Engineer Systems Software Developer Computer Systems Engineer Mobile Applications Developer

2.7.3 Occupational Maps and Apprenticeship Standards

The Occupational Standards are industry standards for skills, developed in collaboration with employers, professional bodies and others, which make it easier for employers to describe job roles, externally and internally. All Apprenticeships and T Levels are based on occupations recognised by employers. The Occupational Maps bring these together to show where technical education can lead.

The Pearson BTEC Higher Nationals in Cloud Computing can also lead to job roles as identified in the Occupational Map for Digital route as follows.

Pathway	Job roles
Cloud Support	Network Technician Systems Engineer Network Administrator Web Developer Network Engineer
Cloud Cyber Security	Cyber Security Technologist Cyber Intrusion Analyst Network Intrusion Analyst Incident Response Centre Analyst Network Operations Centre Security Analyst
Cloud Software Development	Software Developer Mobile App Developer Application Developer Software Tester Software Test Analyst

Full details of how the Pearson BTEC Higher Nationals in Cloud Computing align to specific Occupational Standards is available on HN Global at <https://hnglobal.highternationals.com>.

2.8 How Pearson BTEC Higher Nationals in Cloud Computing provide both transferable employability skills and academic study skills

Students need relevant qualifications and employability skills to enhance their career prospects and to contribute to their personal development. Pearson BTEC Higher National Cloud Computing qualifications embed the development of key skills throughout the programme – attributes and strengths required by 21st-century employers.

Where employability skills are referred to in this specification, they generally refer to skills in three main categories:

- **cognitive and problem-solving skills** – critical thinking, approaching non-routine problems by applying expert and creative solutions, use of systems and digital technology, generating and communicating ideas creatively
- **intra-personal skills** – self-management, adaptability and resilience, self-monitoring and self-development, self-analysis and reflection, planning and prioritising
- **interpersonal skills** – effective communication and articulation of information, working collaboratively, negotiating and influencing, self-presentation.

Pearson Example Assessment Briefs make recommendations for a range of real or simulated assessment activities, for example group work where appropriate, to encourage development of collaborative and interpersonal skills or a solution-focused case study to provide the opportunity to develop cognitive skills. There are specific requirements for the assessment of these skills, as relevant, given in the assessment grids for each unit. Example Assessment Briefs are for guidance and support only and must be customised and amended according to localised needs and requirements. All assignments must still be verified as per the internal verification process.

Students can also benefit from opportunities for deeper learning, where they are able to make connections between units and select areas of interest for detailed study. In this way, Pearson BTEC Higher Nationals provide a vocational context in which students can develop the knowledge and academic study skills required for progression to university degree courses, including:

- active research skills
- effective writing skills
- analytical skills
- critical thinking
- creative problem-solving
- decision making
- team building
- exam preparation skills
- digital literacy
- competence in assessment methods used in higher education.

To support tutors in developing these skills in their students, we have developed a map of higher education relevant transferable and academic study skills, shown in a number of the appendices.

3 Planning your programme

3.1 Delivering the Pearson BTEC Higher Nationals in Cloud Computing

You play a central role in helping your students to choose the right Pearson BTEC Higher National qualification.

You should assess your students very carefully to ensure that they take the right qualification and the right pathways or optional units, to allow them to progress to the next stage. You should check the qualification structures and unit combinations carefully when advising students.

You will need to ensure that your students have access to a full range of information, advice and guidance in order to support them in making the necessary qualification and unit choices. When students are recruited, you need to give them accurate information on the title and focus of the qualification for which they are studying.

3.2 Entry requirements and admissions

Although Pearson do not specify formal entry requirements, as a centre it is your responsibility to ensure that the students you recruit have a reasonable expectation of success on the programme. The Cloud Computing qualification is a specialist area of study within a wider computing context and as such requires students to be reasonably confident and competent in understanding and applying prior knowledge and IT skills.

For students who have recently been in education, the entry profile is likely to include one of the following.

- A BTEC Level 3 qualification in Computing or strongly related discipline.
- A GCE Advanced Level profile that demonstrates strong performance in a relevant subject or adequate performance in more than one GCE subject. This profile is likely to be supported by GCSE grades at A* to C (or equivalent) and/or 9 to 4 (or equivalent).
- Other related Level 3 qualifications.
- An Access to Higher Education Diploma, awarded by an approved further education institution.
- Related work experience.
- An international equivalent of the above.

Centres may wish to consider applicants' prior learning when considering their acceptance to Pearson BTEC Higher Nationals, through Recognition of Prior Learning. (For further information please refer to *Section 8*.)

3.2.1 English language requirements

Pearson's mission is to help people make more of their lives through learning. For students to be successful on Pearson BTEC Higher National qualifications, which are taught and assessed in English, it is critical that they have an appropriate level of English language skills.

The following information clarifies the requirements for all centres when recruiting applicants to new Pearson BTEC Higher National qualifications.

All centres delivering the new Pearson BTEC Higher National qualifications must ensure that all students who are non-native English speakers and who have not undertaken their final two years of schooling in English, can demonstrate capability in English at a standard equivalent to the levels identified below, before being recruited to the programme **where the programme is both taught and assessed in English:**

- Common European Framework of Reference (CEFR) level B2
- PTE 51
- IELTS 5.5; Reading and Writing must be at 5.5
- or equivalent.

It is up to the centre to decide what proof will be necessary to evidence individual student proficiency.

The following information clarifies the requirements for all centres when recruiting applicants to new Pearson BTEC Higher National qualifications that are taught in a language other than English but which are assessed in English.

All centres delivering the new Pearson BTEC Higher National qualifications **wholly or partially** in a language other than English, but who are assessed in English, must ensure that all students can demonstrate capability in English at a standard equivalent to the levels identified below, on completion of the programme:

- Common European Framework of Reference (CEFR) level B2
- PTE 51
- IELTS 5.5; Reading and Writing must be at 5.5
- or equivalent.

It is up to the centre to decide what proof will be necessary to evidence individual student proficiency.

3.2.2 Centre approval

To ensure that centres are ready to assess students and so that we can provide the support that is needed, all centres must be approved before they can offer these qualifications. For more information about becoming a centre and seeking approval to run our qualifications please visit the support section on our website (<https://qualifications.pearson.com/>).

3.2.3 Level of sector knowledge required

We do not set any requirements for tutors, but we strongly recommend that centres assess the overall skills and knowledge of the teaching team, which should be relevant, up to date and at the appropriate level.

3.2.4 Resources required

As part of your centre approval, you will need to show that the necessary material resources and workspaces are available to deliver Pearson BTEC Higher Nationals. For some units, specific resources are required, this is clearly indicated in the unit descriptors.

3.2.5 HN Global support

HN Global is an online resource that supports centre planning and delivery of Pearson BTEC Higher Nationals by providing appropriate teaching and learning resources. For further information see *Sections 5 and 6*.

3.2.6 Modes of delivery

Subject to approval by Pearson, centres are free to deliver Pearson BTEC Higher Nationals using modes of delivery that meet the needs of their students. We recommend making use of a wide variety of modes, including:

- full-time
- part-time
- online/virtual
- blended learning.

3.2.7 Recommendations for employer engagement

Pearson BTEC Higher Nationals are vocational qualifications and, as an approved centre, you are encouraged to work with employers on the design, delivery and assessment of the course. This will ensure that students enjoy a programme of study that is engaging and relevant, and which equips them for progression. In *Section 5.2*, there are suggestions as to how employers could become involved in delivery and/or assessment, but these are not intended to be exhaustive and there will be other possibilities at a local level.

3.2.8 Support from Pearson

We provide a range of support materials, including Schemes of Work and suggested assignments, with supporting templates. You will be allocated an External Examiner early in the planning stage to support you with planning your assessments, and there will be training events and support from our Subject Leads.

3.2.9 Student employability

All Pearson BTEC Higher Nationals have been designed and developed with consideration of National Occupational Standards, where relevant, and have been mapped to relevant professional body standards and vendor accreditation requirements (see *HN Global for full alignment and membership descriptions*).

Employability skills, such as team working and project management, as well as practical hands-on skills have been built into the design of the learning aims and content. This gives you the opportunity to use relevant contexts, scenarios and materials to enable students to develop a portfolio of evidence demonstrating the breadth of their skills and knowledge in a way that equips them for employment.

3.3 Access to study

This section focuses on the administrative requirements for delivering a Pearson BTEC Higher National qualification. It will be of value to Quality Nominees, Programme Leaders and Examinations Officers.

Our policy regarding access to our qualifications is that:

- they should be available to everyone who is capable of reaching the required standards
- they should be free from any barriers that restrict access and progression.

There should be equal opportunities for all those wishing to access the qualifications. We refer centres to the *Pearson Equality, Inclusion and Diversity Policy*, which can be found in the support section of our website (<https://qualifications.pearson.com/>).

Centres are required to recruit students to Pearson BTEC Higher National programmes with integrity. They will need to make sure that applicants have relevant information and advice about the qualification, to make sure it meets their needs. Centres should review the applicant's prior qualifications and/or experience to consider whether this profile shows that they have the potential to achieve the qualification. For students with disabilities and specific needs, this review will need to take account of the support available to the student during the teaching and assessment of the qualification. For further guidance and advice please refer to *Section 9* on reasonable adjustments.

3.4 Student registration and entry

Within 30 days (home students) and 60 days (international students) of enrolment, all students should be registered for the qualification, and appropriate arrangements made for internal and external verification. For information on making registrations for the qualification, you will need to refer to the information manual available in the support section of our website (<https://qualifications.pearson.com/>).

Students can be formally assessed only for a qualification on which they are registered. If students' intended qualifications change (for example if a student decides to choose a different specialist pathway), then the centre must transfer the student to the chosen pathway appropriately. Please note that student work cannot be sampled if the student is not registered or is registered on an incorrect pathway.

3.5 Access to assessments

Assessments need to be administered carefully, to ensure that all students are treated fairly and that results and certification are issued on time, allowing students to move on to chosen progression opportunities.

Our equality policy requires that all students should have equal opportunity to access our qualifications and assessments, and that our qualifications are awarded in a way that is fair to every student. We are committed to making sure that:

- students with a protected characteristic (as defined in legislation) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students 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 on the Joint Council for Qualifications website (<http://www.jcq.org.uk/>).

3.6 Administrative arrangements for internal assessment

3.6.1 Records

You are required to retain records of assessment for each student. Records should include assessments taken, decisions reached and any adjustments or appeals.

Further information on quality and assessment can be found in our UK and international guides available in the support section on our website (<https://qualifications.pearson.com/>). We may ask to audit your records, so they must be retained as specified. All student work must be retained for **a minimum of 12 weeks** after certification has taken place.

3.6.2 Reasonable adjustments to assessment

A reasonable adjustment is one that is made before a student 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 students. 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 students with protected characteristics are available on the support section of our website (<https://qualifications.pearson.com/>).

3.6.3 Special consideration

Special consideration is given after an assessment has taken place for students who have been affected by adverse circumstances, such as illness, and require an adjustment of grade to reflect normal level of attainment. You must operate special consideration in line with Pearson policy (see *section 3.5*). 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, which can be found on the support section of the Pearson website (<https://qualifications.pearson.com/>).

Please note that your centre must have a policy for dealing with mitigating circumstances if students are affected by adverse circumstances, such as illness, which result in non-submission or late submission of assessment.

3.6.4 Appeals against assessment

Your centre must have a policy for dealing with appeals from students. 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 Programme Leader or other member of the programme team. The assessment plan should allow time for potential appeals after assessment decisions have been given to students. If there is an appeal by a student, you must document the appeal and its resolution. Students have a final right of appeal to Pearson, but only if the procedures that you have put in place have been followed. Further details of our policy on enquiries and appeals is available on the support section of our website (<https://qualifications.pearson.com/>).

If your centre is located in England or Wales and the student is still dissatisfied with the final outcome of their appeal they can make a further appeal to the Office of the Independent Adjudicator (OIA) by emailing: enquiries@oiahe.org.uk. In Northern Ireland, a further appeal may be lodged with the Northern Ireland Public Service Ombudsman (NIPSO) by emailing: nipso@nipso.org.uk.

3.7 Dealing with malpractice in assessment

'Malpractice' means acts that undermine the integrity and validity of assessment, the certification of qualifications and/or may damage the authority of those responsible for delivering the assessment and certification.

Pearson does not tolerate actual 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 malpractice or attempted malpractice has been proven.

Malpractice may occur or be suspected in relation to any unit or type of assessment within a qualification. For further details on malpractice and advice on preventing malpractice by learners, please see *Pearson's Centre Guidance: Dealing with Malpractice*, available on our website.

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

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 a centre is failing to conduct internal assessment according to our policies. The above document gives further information and examples, and details the penalties and sanctions that may be imposed.

In the interests of learners and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice.

3.7.1 Internally assessed units

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Students must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the centre. Full information on dealing with malpractice and plagiarism is available on the support section of our website (<https://qualifications.pearson.com/>). It provides full information on the actions we expect you to take.

Pearson may conduct investigations if it is believed that a centre is failing to conduct internal assessment according to Pearson policies. The *Centre Guidance: Dealing with Malpractice* document gives further information, provides examples and details the penalties and sanctions that may be imposed.

3.7.2 Student malpractice

The head of centre is required to report incidents of suspected learner malpractice that occur during Pearson qualifications. We ask centres to complete *JCQ Form M1* (www.jcq.org.uk/malpractice) and email it with any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc) to the Investigations Processing 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.

Failure to report malpractice constitutes staff or centre malpractice.

3.7.3 Tutor/centre malpractice

The head of centre is required to inform Pearson's Investigations team of any incident of suspected malpractice (which includes maladministration) by centre staff, before any investigation is undertaken. The head of centre is requested to inform the Investigations team by submitting a *JCQ M2 Form* (downloadable from www.jcq.org.uk/malpractice) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example Pearson staff, anonymous informants), the Investigations team will conduct the investigation directly or may ask the head of centre to assist.

Pearson reserves the right in cases of suspected malpractice to withhold the issuing of results/certificates while an investigation is in progress. Depending on the outcome of the investigation, results and/or certificates may not be released or they may be withheld.

We reserve the right to withhold certification when undertaking investigations, audits and quality assurance processes. You will be notified within a reasonable period of time if this occurs.

3.7.4 Sanctions and appeals

Where malpractice is proven, we may impose sanctions or penalties, such as:

- mark reduction for affected external assessments
- disqualification from the qualification
- debarment 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 centres to create an improvement action plan
- requiring staff members to receive further training
- placing temporary suspensions on certification of students
- placing temporary suspensions on registration of students
- 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 the head of centre (on behalf of learners and/or members or staff) and from individual members (in respect of a decision taken against them personally). Further information on appeals can be found in the *JCQ Appeals booklet* (<https://www.jcq.org.uk/exams-office/appeals>).

4 Programme structure

4.1 Units, credits and Total Qualification Time (TQT)

The Pearson BTEC Higher National Certificate (HNC) is a Level 4 qualification made up of 120 credits. It is usually studied full time over one year, or part time over two years.

The Pearson BTEC Higher National Diploma (HND) is a Level 4 and Level 5 qualification made up of 240 credits. It is usually studied full time over two years, or part time over four years.

Pearson would expect that a BTEC Higher National Diploma student would have achieved at least 90 credits at Level 4 before progressing to Level 5 units. This allows for students to submit the remaining 30 credits at Level 4 while undertaking their Level 5 study.

Students undertaking a Pearson BTEC Higher National Diploma who fail to successfully complete the full qualification may be awarded an HNC, if their credit achievement permits.

Pearson BTEC Higher Nationals consist of core units, specialist units and optional units:

- core are mandatory
- specialist units are designed to provide a specific occupational focus to the qualification and are aligned to vendor accredited certification
- required combinations of optional units are clearly set out in the tables below.

All units are usually 15 credits in value, or a multiple thereof. These units have been designed from a learning time perspective and are expressed in terms of **Unit Learning Hours (ULH)**.

- **Unit Learning Hours (ULH)** represent the total hours that a student needs to achieve the required learning outcomes, for a given *unit*.
- **Total Qualification Time (TQT)** is an estimate of the total amount of time that could reasonably be expected to be required for a student to achieve and demonstrate the achievement of the level of attainment necessary for the award of a *qualification*.

ULH contribute to the overall TQT. TQT includes undertaking each of the activities of Guided Learning, Directed Learning and Invigilated Assessment. Each 15-credit unit approximates to 150 Unit Learning Hours (ULH); including 60 hours of Guided Learning.

Total Qualification Time (TQT) Higher National Certificate (HNC) = 1,200 hours

Total Qualification Time (TQT) Higher National Diploma (HND) = 2,400 hours

Examples of activities that can contribute to TQT include:

- guided Learning
- independent and unsupervised research/learning
- unsupervised compilation of a portfolio of work experience
- unsupervised e-learning
- unsupervised e-assessment
- unsupervised coursework
- watching a pre-recorded podcast or webinar
- unsupervised work-based learning.

Guided Learning Hours (GLH) are defined as the time when a tutor is present to give specific guidance towards the learning aim being studied on a programme. This definition includes lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. Guided Learning includes any supervised assessment activity, including invigilated examination and observed assessment, and observed work-based practice.

Total Guided Learning (GL) Higher National Certificate (HNC) = 480 hours

Total Guided Learning (GL) Higher National Diploma (HND) = 960 hours

Some examples of activities that can contribute to Guided Learning include:

- classroom-based learning supervised by a tutor
- work-based learning supervised by a tutor
- live webinar or telephone tutorial with a tutor in real time
- e-learning supervised by a tutor in real time
- all forms of assessment that take place under the immediate guidance or supervision of a tutor or other appropriate provider of education or training, including where the assessment is competency based and may be turned into a learning opportunity.

4.2 Programme structures

The programme structures specify the:

- total credit value of the qualification
- minimum credit to be achieved at the level of the qualification
- core units
- specialist units
- optional units
- maximum credit value in units that can be centre commissioned.

When combining units for a Pearson BTEC Higher National qualification, it is the centre's responsibility to make sure that the correct unit combinations are followed.

4.2.1 Pearson BTEC Level 4 Higher National Certificate in Cloud Computing

- Qualification credit value: a minimum of 120 credits. This is made up of eight units, each with a value of 15 credits.
- **Total Qualification Time (TQT)** Higher National Certificate (HNC) = 1,200 hours
- **Total Guided Learning Hours (GLH)** Higher National Certificate (HNC) = 480 hours
- There is a required mix of core, specialist and optional units totalling 120 credits. All units are at Level 4.
- In some cases, a maximum of 30 credits can be imported from another RQF Pearson BTEC Higher National qualification and/or from units designed by the centre and approved by Pearson. Core units may **not** be substituted and are **mandatory**. For more information please refer to Higher National Commissioned Qualifications on the Pearson website.
- Please note that some specialist units are available as optional units.

Pearson BTEC Level 4 Higher National Certificate in Cloud Computing		Unit credit	Level
Core unit Mandatory	1: Cloud Fundamentals	15	4
Core unit Mandatory	2: Networking in the Cloud	15	4
Core unit Mandatory	3: Security in the Cloud	15	4
Core unit Mandatory	4: Programming	15	4
Core unit Mandatory	5: Database Design and Development in the Cloud	15	4
Core unit Mandatory	6: Deploying and Operating in the Cloud (Pearson Set)	15	4
Plus, TWO optional units, which can be selected from the optional units given below.			
Optional unit	7: Website Design & Development in the Cloud	15	4
Optional unit	8: Professional Practice	15	4
Optional unit	9: Maths for Computing	15	4
Optional unit	10: Computer Systems Architecture	15	4
Optional unit	11: Strategic Information Systems	15	4

4.2.2 Pearson BTEC Level 5 Higher National Diploma in Cloud Computing

- Qualification credit value: a minimum of 240 credits of which 120 credits are at Level 5, and 120 credits are at Level 4, and usually attained via the HNC
- **Total Qualification Time (TQT)** Higher National Diploma (HND) = 2,400 hours.
- **Total Guided Learning Hours (GLH)** Higher National Diploma (HND) = 960 hours.
- There is a required mix of core, specialist and optional units for each pathway.
- The core units required for each Level 5 pathway (in addition to the specialist units) are *Unit 12: Cloud Computing Research Project (Pearson Set)*, which is weighted at 30 credits, and *Unit 13: Cloud Architecture Design*, weighted at 15 credits.
- The requirements of the Higher National Certificate (or equivalent) have to be met. In some cases, a maximum of 60 credits can be imported from another RQF Pearson BTEC Higher National qualification and/or from units designed by the centre and approved by Pearson. Core units and specialist units may **not** be substituted.
- Please note that *some* specialist units are available as optional units.

The Level 5 Higher National Diploma consists of the Level 4 Higher National Certificate (above) plus an additional 120 credits at Level 5 delivered via one of the following three specialist pathways:

- Cloud Support
- Cloud Cyber Security
- Cloud Software Development.

The pathways and unit combinations are as follows; for the list of optional units for all pathways at Level 5, please see the following pages.

4.2.3 Units of combination

In order to ensure that BTEC HND students have the skills required to achieve on specialist pathways, we strongly advise that students intending to study the BTEC Higher National Diploma: Cloud Software Development pathway, select optional units which will allow them to practice their application and/or software development and project management skills.

Students across all pathways are advised to broaden their study by selecting units that allow them to develop wider skills and knowledge, for example *Unit 22: Financing the Cloud, Unit 32: Developing Individuals, Teams and Organisations*.

The Cloud Support Pathway and the Cloud Cyber Security Pathway both share 'Unit 16: Information Security Management in the Cloud' as a specialist unit. Students on either of these two pathways must not select the **same two** specialist units of the other pathway as their two optional unit choices.

For example, students on the Cloud Support Pathway may select only **one** of the following two units as their optional unit of study:

- Unit 17: Applied Security in the Cloud
- Unit 18: Applied Cryptography in the Cloud.

Students on the Cloud Cyber Security Pathway may select only **one** of the following two units as their optional unit of study:

- Unit 14: Operating Systems in the Cloud
- Unit 15: Cloud Systems Integration.

See additional comments in the tables below on unit selection.

Pearson BTEC Level 5 Higher National Diploma in Cloud Computing (Cloud Support Pathway)			Unit credit	Level
Level 4 units:				
Core unit Mandatory	1: Cloud Fundamentals	15	4	
Core unit Mandatory	2: Networking in the Cloud	15	4	
Core unit Mandatory	3: Security in the Cloud	15	4	
Core unit Mandatory	4: Programming	15	4	
Core unit Mandatory	5: Database Design and Development in the Cloud	15	4	
Core unit Mandatory	6: Deploying and Operating in the Cloud (Pearson Set)	15	4	
Plus, TWO optional units, which can be selected from the Level 4 optional units given below.				
Optional unit	7: Website Design & Development in the Cloud	15	4	
Optional unit	8: Professional Practice	15	4	
Optional unit	9: Maths for Computing	15	4	
Optional unit	10: Computer Systems Architecture	15	4	
Optional unit	11: Strategic Information Systems	15	4	
Level 5 units:				
Core unit Mandatory	12: Cloud Computing Research Project (Pearson Set)	30	5	
Core unit Mandatory	13: Cloud Architecture Design	15	5	
Specialist unit Mandatory	14: Operating Systems in the Cloud	15	5	
Specialist unit Mandatory	15: Cloud Systems Integration	15	5	

Specialist unit Mandatory	16: Information Security Management in the Cloud	15	5
Plus, an additional TWO units, which can be selected from the specialist and optional units given below. *Please note that only one specialist unit can be selected from each of the Specialist Groups B and C			
Specialist Group B: Cyber Security			
Specialist unit	17: Applied Security in the Cloud	15	5
Specialist unit	18: Applied Cryptography in the Cloud	15	5
Specialist Group C: Software Development			
Specialist unit	19: Software Development Methodologies for the Cloud	15	5
Specialist unit	20: Application Development, Testing & Debugging	15	5
Specialist unit	21: Applied Programming and Design Principles	15	5
Level 5 Optional units			
Optional unit	22: Financing the Cloud	15	5
Optional unit	23: Forensics in the Cloud	15	5
Optional unit	24: Data Structures & Algorithms	15	5
Optional unit	25: Machine Learning	15	5
Optional unit	26: Artificial Intelligence	15	5
Optional unit	27: Internet of Things	15	5
Optional unit	28: Business Intelligence	15	5
Optional unit	29: E-commerce and Strategy	15	5
Optional unit	30: Risk Analysis & Systems Testing	15	5
Optional unit	31: Critical Infrastructure Protection	15	5
Optional unit	32: Developing Individuals, Teams and Organisations	15	5
Optional unit	33: Understanding and Leading Change	15	5
Optional unit	34: Business Information Technology Systems	15	5

Pearson BTEC Level 5 Higher National Diploma in Cloud Computing (Cloud Cyber Security Pathway)			Unit credit	Level
Level 4 units:				
Core unit Mandatory	1: Cloud Fundamentals	15	4	
Core unit Mandatory	2: Networking in the Cloud	15	4	
Core unit Mandatory	3: Security in the Cloud	15	4	
Core unit Mandatory	4: Programming	15	4	
Core unit Mandatory	5: Database Design and Development in the Cloud	15	4	
Core unit Mandatory	6: Deploying and Operating in the Cloud (Pearson Set)	15	4	
Plus, TWO optional units, which can be selected from the Level 4 optional unit bank given below.				
Optional unit	7: Website Design and Development in the Cloud	15	4	
Optional unit	8: Professional Practice	15	4	
Optional unit	9: Maths for Computing	15	4	
Optional unit	10: Computer Systems Architecture	15	4	
Optional unit	11: Strategic Information Systems	15	4	
Level 5 units:				
Core unit Mandatory	12: Cloud Computing Research Project (Pearson Set)	30	5	
Core unit Mandatory	13: Cloud Architecture Design	15	5	
Specialist unit Mandatory	16: Information Security Management in the Cloud	15	5	
Specialist unit Mandatory	17: Applied Security in the Cloud	15	5	

Specialist unit Mandatory	18: Applied Cryptography in the Cloud	15	5
Plus, an additional TWO units, which can be selected from the specialist and optional units given below. * Please note that only one specialist unit can be selected from each of the Specialist Groups A and C			
Specialist Group A: Cloud Support			
Specialist unit	14: Operating Systems in the Cloud	15	5
Specialist unit	15: Cloud Systems Integration	15	5
Specialist Group C: Software Development			
Specialist unit	19: Software Development Methodologies for the Cloud	15	5
Specialist unit	20: Application Development, Testing & Debugging	15	5
Specialist unit	21: Applied Programming and Design Principles	15	5
Level 5 Optional Units			
Optional unit	22: Financing the Cloud	15	5
Optional unit	23: Forensics in the Cloud	15	5
Optional unit	24: Data Structures & Algorithms	15	5
Optional unit	25: Machine Learning	15	5
Optional unit	26: Artificial Intelligence	15	5
Optional unit	27: Internet of Things	15	5
Optional unit	28: Business Intelligence	15	5
Optional unit	29: E-commerce and Strategy	15	5
Optional unit	30: Risk Analysis & Systems Testing	15	5
Optional unit	31: Critical Infrastructure Protection	15	5
Optional unit	32: Developing Individuals, Teams and Organisations	15	5
Optional unit	33: Understanding and Leading Change	15	5
Optional unit	34: Business Information Technology Systems	15	5

Pearson BTEC Level 5 Higher National Diploma in Cloud Computing (Cloud Software Development Pathway)			Unit credit	Level
Level 4 units				
Core unit Mandatory	1: Cloud Fundamentals		15	4
Core unit Mandatory	2: Networking in the Cloud		15	4
Core unit Mandatory	3: Security in the Cloud		15	4
Core unit Mandatory	4: Programming		15	4
Core unit Mandatory	5: Database Design and Development in the Cloud		15	4
Core unit Mandatory	6: Deploying and Operating in the Cloud (Pearson Set)		15	4
Plus, TWO optional units, which can be selected from the Level 4 optional unit bank given below.				
Optional unit	7: Website Design and Development in the Cloud		15	4
Optional unit	8: Professional Practice		15	4
Optional unit	9: Maths for Computing		15	4
Optional unit	10: Computer Systems Architecture		15	4
Optional unit	11: Strategic Information Systems		15	4
Level 5 units				
Core unit Mandatory	12: Cloud Computing Research Project (Pearson Set)		30	5
Core unit Mandatory	13: Cloud Architecture Design		15	5
Specialist unit Mandatory	19: Software Development Methodologies for the Cloud		15	5
Specialist unit Mandatory	20: Application Development, Testing & Debugging		15	5

Specialist unit Mandatory	21: Applied Programming and Design Principles	15	5
Plus, an additional TWO units, which can be selected from the specialist and optional units given below. * Please note that only one specialist unit can be selected from each of the Specialist Groups A, B or the Shared Group			
Specialist Group A: Cloud Support			
Specialist unit	14: Operating Systems in the Cloud	15	5
Specialist unit	15: Cloud Systems Integration	15	5
Specialist Group B: Cyber Security			
Specialist unit	17: Applied Security in the Cloud	15	5
Specialist unit	18: Applied Cryptography in the Cloud	15	5
Specialist Group: Shared Unit			
Specialist unit	16: Information Security Management in the Cloud	15	5
Level 5 optional units			
Optional unit	22: Financing the Cloud	15	5
Optional unit	23: Forensics in the Cloud	15	5
Optional unit	24: Data Structures & Algorithms	15	5
Optional unit	25: Machine Learning	15	5
Optional unit	26: Artificial Intelligence	15	5
Optional unit	27: Internet of Things	15	5
Optional unit	28: Business Intelligence	15	5
Optional unit	29: E-commerce and Strategy	15	5
Optional unit	30: Risk Analysis & Systems Testing	15	5
Optional unit	31: Critical Infrastructure Protection	15	5
Optional Unit	32: Developing Individuals, Teams and Organisations	15	5
Optional unit	33: Understanding and Leading Change	15	5
Optional unit	34: Business Information Technology Systems	15	5

4.2.4 Meeting local needs (MLN)

Centres should note that Pearson BTEC Higher National qualifications have been developed in consultation with centres, employers and relevant professional organisations. The units were designed to meet the skill needs of the sector and thereby allow coverage of the full range of employment within the sector. Centres should make maximum use of the choices available to them in the specialist pathways to meet the needs of their students, as well as the local skills and training needs.

Where centres identify a specific need that cannot be addressed using the units in this specification, they can seek approval to use units from other RQF Pearson BTEC Higher National qualifications, through the MLN process (refer to *Commissioned qualification design and validation service*) given on our website <https://qualifications.pearson.com>, or you can get in touch with your Pearson regional contact for application details. Centres will need to justify the rationale for importing units from other RQF Pearson BTEC Higher National specifications. **Meeting local need applications must be made in advance of delivery and before 31 January in the year of student registration.**

The flexibility to import standard units from other RQF Pearson BTEC Higher National specifications is **limited to a maximum of 30 credits in a BTEC HNC qualification and a maximum of 60 credits in a BTEC HND qualification (30 credits at Level 4 and 30 credits at Level 5)**. This is an overall maximum of units that can be imported. MLN units cannot be used at the expense of the mandatory units in any qualification nor can the qualification's rules of combination, as detailed in the specification, be compromised. It is the responsibility of the centre requesting the MLN to ensure that approved units are used only in eligible combinations.

For the **Pearson BTEC Level 4 Higher National Certificate in Cloud Computing** and **Pearson BTEC Level 5 Higher National Diploma in Cloud Computing**, the maximum number of credits that can be imported by pathway are as follows:

Qualification	Pathway	Import at Level 4	Import at Level 5
Pearson BTEC Level 4 Higher National Certificate in Cloud Computing	General	30	-
Pearson BTEC Level 5 Higher National Diploma in Cloud Computing	Cloud Support	30	30
	Cloud Cyber Security	30	30
	Cloud Software Development	30	30

4.2.5 Pearson BTEC Higher National Commissioned Development

Where MLN does not provide enough flexibility in terms of qualification structure, centres can request design and development of units by Pearson to meet their specific needs. This is offered by the following types of developments: full commission, partial commission.

We would be pleased to discuss your ideas for a Pearson BTEC Higher National Commissioned Development. For more information, please refer to the *Commissioned qualification design and validation service* on our website:

<https://qualifications.pearson.com>

Once the centre is ready to proceed with a commissioned development, an application must be made, providing a clear rationale for the development request. Pearson will review the application and may confirm or deny the request. The commissioned unit(s) will be authored by Pearson, in full consultation within the commissioning centre. Applications must be made one year in advance of the first year of commissioned unit(s) delivery.

4.3 Pearson-set assignments

There are Pearson-set assignments, as part of the core units. Each year, Pearson will issue a *Theme* and (for Level 4) a set of related *Topics*. Centres will develop an assignment, to be internally assessed, to engage students in work related to the Pearson-set Theme.

At Level 4, students will select a Topic to further define their approach to the Theme and assignment. At Level 5, it is expected that students will define their own Topic, in negotiation with tutors, based on the Pearson-set Theme.

For example, from the Higher Nationals in Computing:

- Are technology companies responsible for protecting the health, safety and wellbeing of users of their products and services?
- Do digital technologies improve life or distract from it? The efficacy of products and features specifically designed to improve health and wellbeing.
- Making digital technologies accessible: how can digital products and features ensure a great end-user experience for all?
- Digital detox: tools and strategies to manage the impact of the increasing reliance on digital technologies in the modern world.

Centres can find relevant support in the Pearson-set Assignment Guidance for the units, and the Theme and Topic release documentation, which will be provided for each level.

The aim of the Pearson-set assignments is to provide a common framework for centres to develop work that will allow cross-sector benchmarking, through the standardisation of student work, and identification and sharing of ‘best practice’ in higher education teaching and learning. Pearson will share the ‘best practice’ results with all centres. For further information about Pearson-set assignments and assessment, see *Section 6*.

4.4 The Unit Descriptor

The Unit Descriptor is how we define the individual units of study that make up a Higher National qualification. Students will study and complete the units included in the programme offered at your centre.

We have described each part of the unit, as below. You may refer to any of the Unit Descriptors given in *Section 10*.

Unit Title	A broad statement of what the unit will cover.
Unit Code	The Ofqual unit designation
Unit Type	There are three unit types: core (mandatory to all pathways); specialist (mandatory to specific pathways); and optional (available to most pathways)
Unit level	All Higher National Certificate units are at Level 4 and all Higher National Diploma are at Level 5
Credit value	The credit value is related to Total Qualification Time (TQT) and Unit Learning Hours (ULH), and is easy to calculate. 1 credit is equal to 10 ULH, so 15 credits are equal to 150 ULH. To complete a Higher National Certificate or Diploma, students are expected to achieve the appropriate number of credits
Introduction	Some general notes on the unit, setting the scene, stating the purpose, outlining the topics and skills gained on completion of the unit
Learning Outcomes	The Learning Outcomes are explicit statements that clearly express what students will be able to do after the completion of the unit. There are, typically, four Learning Outcomes for each unit.
Essential Content	This section covers the content that students can expect to study as they work towards achieving their Learning Outcomes.

Learning Outcomes and Assessment Criteria

Each unit sets out the ‘Pass’, ‘Merit’ and ‘Distinction’ criteria for that unit. When assignments are graded, a tutor will refer to this table, which connects the unit’s Learning Outcomes with the student’s work. This assignment may be graded at ‘Pass’, ‘Merit’ or ‘Distinction’ level, depending on the quality of the student’s work.

Recommended Resources

Lists the resources appropriate to support the study of this unit. This includes books, journals and online material to support learning. The programme tutor may suggest alternatives and additions, usually with a local application or relevance.

Web resources

Some units have web resources as part of their recommended resources lists. Hyperlinking to these resources directly can be problematic as locations and addresses of resources can change over time. To combat this, we have referenced web resources as follows.

- [1] A link to the main page of the website
- [2] The title of the site
- [3] The name of the section or element of the website where the resource can be found
- [4] The type of resource it is, which may be one of the following:
 - o research
 - o general reference
 - o tutorials
 - o training
 - o e-books
 - o report
 - o wiki
 - o article
 - o datasets
 - o development tool
 - o discussion forum.

Web (Example)

- | | |
|--|-------------------------------|
| [1] www.lynda.com | [2] Lynda.com |
| | [3] Database Training |
| | [4] (Tutorials) |
| [1] mva.microsoft.com | [2] Microsoft Virtual Academy |
| | [3] Database Development |
| | [4] (Training) |

4.5 Professional body recognition

In developing the Pearson BTEC Higher National qualifications in Cloud Computing, we have worked closely with the British Computing Society (BCS). With their agreement, we have secured exemptions from certain membership types for students achieving Pearson BTEC Higher Nationals in Cloud Computing as follows:

- Student Member whilst studying
- Associate Member on graduation
- Exemption from 2 years IT related work experience towards becoming a Professional Member on graduation (3 years work experience as opposed to the normal 5 years).

All member grades will allow access to the Specialist Groups.

By aligning to professional body competency standards, the content and assessment supports student development as professional practitioners for the future. This adds value for students by offering them access to continuing professional development.

In some circumstances, professional bodies will enable students to gain certification of a professional qualification on completion of their Higher National in Cloud Computing.

For additional professional body recognition and membership details for this qualification, please see our Progression Hub on HN Global where the most up to date information can be found: <https://hnglobal.highernationals.com/>.

4.6 Vendor accreditation

In developing the BTEC Higher National qualifications in Cloud Computing, we have worked closely with vendors to offer students the skills required to gain accredited certifications.

As part of our collaboration with AWS, we have specifically aligned the qualification to certifications available from AWS. See *Section 1.9*.

Students will not automatically gain any vendor-accredited certificates as a result of studying a BTEC HNC and/or a BTEC HND. Instead, the skills required to achieve a vendor-accredited certificate have been included in specific units. Once these units have been completed, a student can then put themselves forward for vendor accreditation via the vendor-specific route.

Full details of how Cloud Computing aligns to the different vendor certificates and how to claim them is available on HN Global. Please visit <https://hnglobal.highernationals.com/>.

5 Teaching and learning

The aim of this section is to provide guidance to centres so that they can engage students in a dynamic, interactive and reflective learning experience. This experience should prepare students to successfully engage in the assessments, which will measure depth, as well as breadth, of knowledge. Teaching should stimulate academic engagement, develop challenging yet constructive discourse and encourage students to reflect on their own performance in preparation for a professional career. Additionally, centres are encouraged to expose students to autonomous and independent learning, which will facilitate the development of their academic skills, experiences and techniques required as they progress from one level of study to the next.

Centres are encouraged to develop programmes that have a distinctive focus on entry into work, delivering a curriculum that embeds employability, has a strong commitment to ethics and diversity, and introduces students to contemporary, as well as seminal, research. All teaching and learning should reflect the expectations of employers and society and should be informed and guided by external benchmarks such as professional and statutory bodies. In so doing, students completing a Pearson BTEC Higher National qualification in Cloud Computing will have the attributes, skills, principles and behaviours that will enable them to make a valuable contribution to local, national and international commerce.

The contributions that students make to their own experiences, alongside the experience of their peers, is invaluable. Student engagement and the student voice should form a significant aspect of a student's life. Centres are encouraged to gather student opinions on a range of teaching and learning matters, which will be used to inform and enhance future practice within a programme of study and in a centre.

5.1 Delivering quality and depth

A high-quality teaching and learning experience should include qualified and experienced tutors, an interactive and engaging curriculum, motivated and inspired students, and a support system that caters for the pastoral, as well as academic, interests of students.

In addition to delivering a quality learning experience, centres must encourage students to have a deeper understanding of the subject, where they are able to go beyond the fundamentals of explaining and describing. Students are expected to show that they can analyse data and information, make sense of it and then reach evaluative judgements. At the higher levels of study, there is an expectation that students will be able to apply a degree of criticality to their synthesis of knowledge. This criticality would come from exposure to appropriate and relevant theories, concepts and models.

One of the reasons for delivering a quality learning experience, which has depth as well as breadth, is the benchmarking of the qualification to the Framework for Higher Education Qualifications (FHEQ). The qualification also meets requirements set by the Regulated Qualifications Framework (RQF). The first stage of a Pearson BTEC Higher National in Cloud Computing is the BTEC Higher National Certificate (HNC), which is aligned with Level 4 of both frameworks; with the BTEC Higher National Diploma (HND) aligned with Level 5. This means that the HNC has the same level of demand and expectations as the first year of a degree programme, with the HND having the same level of demand and expectations as the second year of a degree programme.

Centres are expected to provide a broadly similar experience for students to that which they would have if they attended a similar programme at a university. This could mean:

- providing access to library facilities which have, as a minimum, available copies (physically and/or electronically) of all required reading material
- access to research papers and journals
- utilising a Virtual Learning Environment (VLE) to support teaching and learning
- working with local employers (see *section 5.2* below) to present real-life case studies
- creating schemes of work that embrace a range of teaching and learning techniques
- listening to the student voice.

Irrespective of the type of programme on which a student is enrolled, it is highly advisable that students are inducted on to their BTEC Higher National programme. Induction should include an introduction to the course programme and the academic study skills that will be essential in supporting their research and studies, and, therefore, enhance the learning experience.

An induction programme should consist of the following:

- course programme overview
- preparing for lessons
- effective engagement in lectures and seminars
- making the most of their tutor
- assignment requirements
- referencing and plagiarism
- centre policies
- academic study skills.

Pearson offers Higher National Global Study Skills to all students – an online toolkit that supports the delivery, assessment and quality assurance of BTECs in centres. This is available on the HN Global website: www.highternationals.com. HN Global provides a wealth of support to ensure that tutors and students have the best possible experience during their course. With HN Global, students can converse with other students from around the world, find useful training on how to prepare for their studies and get access to comprehensive online career services.

5.2 Engaging with employers

Just as the student voice is important, so too is the employer's. Employers play a significant role in the design and development of all regulated qualifications, including Pearson BTEC Higher Nationals in Cloud Computing. This input should extend to the learning experience, where engagement with employers will add value to students, particularly in transferring theory into practice.

Centres should consider a range of employer engagement activities. These could include:

- field trips to local businesses
- inviting members of the local computing community to present guest lectures
- using employers to judge the quality of assessed presentations and/or products
- coding challenges set by a local employer.

While detailed guidance on assessment is given in *Section 6*, it is worth considering the involvement of employers when determining assessment strategies and the use of different assessment vehicles. This enables centres to design assessments that are more closely related to what students would be doing in the workplace. Employers are able to comment on relevance and content, as well as the challenge presented by an assessment. Notwithstanding, ultimately it is the centre's responsibility to judge the extent to which any employer contributes to teaching and learning.

5.3 Engaging with students

Students are integral to teaching and learning. As such, it is important that they are involved as much as possible with most aspects of the programme on which they are enrolled. This input could include taking into account their views on how teaching and learning will take place, their role in helping to design a curriculum, or on the assessment strategy that will test their knowledge and understanding.

There are many ways in which to capture the student voice and student feedback, both formal and informal. Formal mechanisms include the nomination of student representatives to act as the collective student voice for each student cohort, student representation at course team meetings, and an elected higher education representative as part of the student union. Student forums should also take place periodically throughout the year, with minutes and action plans updated and informing the overall annual course-monitoring process. Unit-specific feedback can also be collated by students using unit-feedback forms, end-of-year course evaluations and scheduled performance review meetings with their tutor.

However, this should not be the only time when feedback from students is sought. Discourse with students should be constant, whereby teachers adopt a ‘reflection on action’ approach to adjust teaching, so that students are presented with an environment that is most supportive of their learning needs. Just as employers could have an input into assessment design, so too could students. This will support the development of assignments that are exciting and dynamic, and will fully engage students in meaningful and informative assessment.

The biggest advantage of consulting students on their teaching, learning and assessment is securing their engagement in their own learning. Students are likely to feel empowered and develop a sense of ownership of all matters related to teaching, learning and assessment, not just their own experiences. Students could also view themselves as more accountable to their tutors, ideally seeing themselves as partners in their own learning and not just part of a process.

5.4 Planning and structuring a programme

Learning should be challenging, yet exciting; teaching should be motivating and inspirational. Consequently, both teaching and learning should form part of a programme structure that is active, flexible and progressive, and which has an industry focus wherever possible.

It is important for a programme structure to be effectively planned, taking into account the nature of the student cohort, the primary mode of delivery (face-to-face or distance learning) and the level of study. It is also advisable to consider the student voice (whether that voice is heard through end of programme feedback, or through ongoing dialogue) when planning how and when students will be exposed to a particular subject. One other vital source of information that centres would do well to embrace is feedback from tutors who have been and/or will be delivering learning.

It is recommended that centres establish a programme planning forum where various stakeholders are represented. This forum could consider different perspectives of teaching and learning, and how they are planned into an effective programme structure. Consideration could be given to, for example, the holistic and consistent use of Virtual Learning Environments (VLEs), a programme of field trips, a strategy for engaging with employers, how and when to assess learning.

Consideration should be given to a number of factors when planning a programme structure. These include:

- the sequencing of units
- whether to have condensed or expanded delivery
- teaching and learning techniques.

5.4.1 Sequencing units

The level of demand embedded in a unit is benchmarked to recognised standards. This applies to all units in a level of study and means that all Level 4 units have similar demands, as do all Level 5 units. However, this does not mean that units can, or should, be delivered in any order. For example, in the Pearson BTEC Higher National Diploma in Cloud Computing Level 4 units are delivered, and achieved, by students before progression to Level 5. However, students are able to progress to Level 5 with a minimum of 90 credits at Level 4.

In each level it is advisable to sequence units so that those providing fundamental knowledge and understanding are scheduled early in the programme. It may also be advisable to schedule the assessment of units that require the practice and application of more advanced skills later in the programme.

5.4.2 Condensed, expanded or mixed delivery

The next consideration is whether to deliver a unit in a condensed format alongside other units, to deliver units over an extended period or to deliver using a combination of these. The following tables provide examples of this, based on four units being delivered in one teaching block.

Condensed version:

Weeks 1 to 6	Week 7	Weeks 8 to 13	Week 14
Unit 1	Assessment	Unit 3	Assessment
Unit 2		Unit 4	

Expanded version:

Weeks 1 to 12				Weeks 13 and 14	
Unit 1				Assessment	
Unit 2					
Unit 3					
Unit 4					

Mixed version:

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Unit 1													
Unit 2					Assessment	Unit 3					Assessment		
Unit 4													

The decision to deliver a condensed, expanded or mixed programme would depend on a number of factors, including availability of resources, the subjects to be taught and the requirements of students. Each version has advantages: the condensed version would provide an opportunity for students to gain early success and achievement. This will enhance their self-efficacy, the sense of one's belief in one's ability to succeed, and self-confidence, with tutors being able to identify and respond to less-able students early in the teaching and learning cycle.

The advantages of the expanded version include providing a longer timescale for students to absorb new knowledge and therefore, potentially, improve success, and giving tutors an opportunity to coach and support less-able students over a longer period of time. The mixed version, with some units spanning over the entire period and others lasting for shorter periods, provides opportunities for learning in some units to support development in others. This format may be particularly suited to a combination of practical and theoretical units. In all cases, the choice of which type of unit sequence must consider student opportunities as well as staff and physical resources of the centre.

As there are pros and cons to each approach, the use of a planning forum would help to ensure the most appropriate approach is taken. For example, centres could choose to deliver the first teaching block using the expanded version, with the subsequent teaching block being delivered through a condensed approach.

It should be noted that the above consideration would apply equally to programmes that are being delivered face-to-face or through distance learning.

5.4.3 Drawing on a wide range of delivery techniques

As part of planning the range of techniques that will be used to deliver the syllabus, centres should also consider an appropriate combination of techniques for the subject.

The table below lists some of the techniques that centres could introduce to a planned programme structure.

Technique	Face-to-face	Distance learning
Lectures and seminars	These are the most common techniques used by tutors. They offer an opportunity to engage with a large number of students, where the focus is on sharing knowledge through the use of presentations.	Delivery would be through video conferencing and/or pre-recorded audio, and/or visual material, available through an online platform. Synchronous discussion forums could also be used.
Workshops	These are used to build on knowledge shared via tutors and seminars. Teaching can be more in depth where knowledge is applied, for example to case studies or real-life examples. Workshops could be student led, where students present, for example, findings from independent study.	While more challenging to organise than for face-to-face delivery, workshops should not be dismissed. Smaller groups of three or four students could access a forum simultaneously and engage in the same type of activity as for face-to-face.

Technique	Face-to-face	Distance learning
Tutorials	<p>These present an opportunity for focused one-to-one support, where teaching is led by an individual student's requirements. These can be most effective in the run up to assessment, where tutors can provide more focused direction, perhaps based on a formative assessment.</p>	<p>Other than not necessarily being in the same room as a student, tutors could still provide effective tutorials. Video-conferencing tools provide the means to see a student, which makes any conversation more personal.</p>
Virtual Learning Environments (VLEs)	<p>These are invaluable to students studying on a face-to-face programme. Used effectively, VLEs not only provide a repository for taught material such as presentation slides or handouts but could be used to set formative tasks such as quizzes. Further reading could also be located on a VLE, along with a copy of the programme documents, such as the handbook and assessment timetable.</p>	<p>Where students are engaged with online delivery through distance or blended learning, a VLE is a must, as this would be the primary or the key source of learning. Where distance learning is primarily delivered through hard copies of workbooks, etc., the same principle would apply as for face-to-face learning.</p>
Blended learning	<p>The combination of traditional face-to-face learning and online learning. This can enable students to gain personalised support, instruction and guidance, while completing assigned activities and tasks remotely.</p>	<p>Offline learning enables students to develop autonomy and self-discipline by completing set activities and tasks with limited direction and traditional classroom-based constraints.</p>
Work-based learning	<p>Any opportunity to integrate work-based learning into a curriculum should be taken. This adds realism and provides students with an opportunity to link theory to practice in a way in which case studies do not. Many full-time students are involved in some form of employment, either paid or voluntary, which could be used, where appropriate, as part of their learning, for example when assignments require students to contextualise a response to a real organisation.</p>	<p>It is likely that the majority of distance learning students would be employed and possibly classed as mature students. Bringing theory to life through a curriculum, which requires work-based application of knowledge, would make learning for these students more relevant and meaningful. Perhaps, more importantly, assessment should be grounded in a student's place of work, wherever possible.</p>

Technique	Face-to-face	Distance learning
Guest speakers	These could be experts from industry or visiting academics in the subject area that is being studied. They could be used to present a lecture/seminar, a workshop or to contribute to assessment. The objective is to make the most effective use of an expert's knowledge and skill by adding value to the teaching and learning experience.	As long as the expert has access to the same platform as the students, then the value-added contribution would still be very high. Consideration would need to be given to timings and logistics, but with some innovative management this technique would still have a place in distance learning programmes.
Field trips	Effectively planned field trips, which have a direct relevance to the syllabus, will add value to the learning experience. Through these trips, students can relate theory to practice, have an opportunity to experience organisations in action, and potentially open their minds to career routes.	The use of field trips can be included as part of a distance learning programme. They will add the same value and require the same planning. One additional benefit of field trips for distance learning is that they provide an opportunity for all students in a cohort to meet, which is a rare occurrence for distance learning students.

5.4.4 Assessment considerations

Centres should design assessment for learning. This is where an assessment strategy requires students to engage with a variety of assessment tools that are accessible, appropriately challenging, and which support the development of student self-efficacy and self-confidence. To ensure that assignments are valid and reliable, centres must implement robust quality assurance measures and monitor the effectiveness of their implementation (see *Section 6*). This includes ensuring that all students engage in assessment positively and honestly.

Assessment also provides a learning opportunity for all stakeholders of the assessment to have access to feedback that is both individual to each student and holistic to the cohort. Feedback to students should be supportive and constructive. Student self-efficacy (and therefore self-confidence) can be significantly enhanced where feedback not only focuses on areas for improvement but also recognises a student's strengths. At the cohort level, similar trends could be identified that inform future approaches to assessments and teaching. Assessment is an integral part of the overall learning process and assessment strategy must be developed to support effective, reflective, thinking computing practitioners for the future. Assessment can be either formative, summative or both.

5.4.5 Formative assessment

Formative assessment is primarily developmental in nature and designed to give feedback to students on their performance and progress. Assessment designed formatively should develop and consolidate knowledge, understanding, skills and competencies. It is a key part of the learning process and can enhance learning and contribute to raising standards.

Through formative assessment, tutors can identify students' differing learning needs early on in the programme and so make timely corrective interventions. Tutors can also reflect on the results of formative assessment to measure how effective the planned teaching and learning is at delivering the syllabus. Each student should receive one set of written formative feedback, otherwise some students may feel that others are being given more than their share of verbal feedback.

5.4.6 Summative assessment

Summative assessment is where students are provided with the assignment grades contributing towards the overall unit grade. For summative assessment to be effective it should also give students additional formative feedback to support ongoing development and improvement in subsequent assignments.

5.4.7 Assessment feedback

Effective assessment feedback is part of continuous guided learning which promotes learning and enables improvement. It also allows students to reflect on their performance and helps them understand how to make effective use of feedback. Constructive and useful feedback should enable students to understand the strengths and limitations of their performance, providing positive comments where possible, as well as explicit comments on how improvements can be made. Feedback should reflect the Learning Outcomes and Assessment Criteria to also help students understand how they inform the process of judging the overall grade.

The timing of the provision of feedback and of the returned assessed work also contributes to making feedback effective. Specific turnaround time for feedback should be agreed and communicated with both tutors and students. Timing should allow students the opportunity to reflect on the feedback and consider how to make use of it in forthcoming assessments, taking into account the tutor's workload and ability to provide effective feedback.

5.4.8 Designing valid and reliable assessments

To help ensure that valid and reliable assignments are designed and that they are consistent across all units, centres could consider a number of actions.

Use of language

The first aspect of an assignment that a centre could focus on is ensuring that language makes tasks/questions more accessible to students.

Due consideration must be given to the command verbs (i.e. the verbs used in unit assessment criteria) when considering the Learning Outcomes of a unit. Assignments must use appropriate command verbs that equate to the demand of the Learning Outcome. If the outcome requires 'analysis' then 'evaluative' requirements within the assignment must not be set when testing that outcome. This would be viewed as over-assessing. Similarly, it is possible to under-assess where analytical demands are tested using, for example explanatory command verbs.

The following can be used as a guide to support assignment design.

- Ensure there is a holistic understanding (by tutors and students) and use of command verbs.
- Set assignment briefs that use a single command verb, focusing on the highest level of demand expected for the Learning Outcome(s) that is (are) being tested.
- Assignments should be supported by additional guidance that helps students to interpret the demand of the assessment criteria.
- Time-constrained assessments should utilise the full range of command verbs (or acceptable equivalents) appropriate to the academic level. Modes of time-constrained assessments include in-class tests and exams that could be both open- or closed-book. Centres should pay close consideration to ensuring that tests and exams are not replicated over the course of the year.

Consistency

This relates to the consistency of presentation and structure, the consistent use of appropriate assessment language, and the consistent application of grading criteria. Where assignments are consistent, reliability is enhanced. Where validity is present in assignments this will result in assignments that are fit for purpose and provide a fair and equitable opportunity for all students to engage with the assignment requirements.

Employing a range of assessment tools

Just as variation in teaching methods used is important to the planning of a programme structure, so too is the use of a range of assessment tools appropriate to the unit and its content. Centres should consider taking a holistic view of assessment, ensuring a balanced assessment approach with consideration given to the subject being tested and what is in the best interests of students. As mentioned above, consultation with employers could add a sense of realism to an assessment strategy. (A comprehensive list of assessment tools is provided in *Section 6.2 Setting effective assessments.*)

No matter what tool is used, assignments should have a sector focus (whether this is in a workplace context or through a case study) and be explicitly clear in its instructions. In the absence of a case study, a scenario should be used to provide some context. Finally, students should be clear on the purpose of the assignment and which elements of the unit it is targeting.

6 Assessment

BTEC Higher Nationals in Cloud Computing are assessed using a combination of internally assessed **centre-devised internal assignments** (which are set and marked by centres) and internally assessed **Pearson-set assignments** (which are set by Pearson and marked by centres). Pearson-set assignments are mandatory and target particular industry-specific skills. The number and value of these units are dependent on qualification size.

For the HNC, one Core, 15-credit unit at Level 4 will be assessed by a mandatory Pearson-set assignment, targeted at particular skills.

For the HND, two Core units: one Core, 15-credit unit at Level 4 and one Core, 30-credit unit at Level 5, will be assessed by a mandatory Pearson-set assignment, targeted at particular skills.

All other units in both qualifications are assessed by centre-devised internal assignments.

The purpose and rationale of having Pearson-set units on Higher Nationals is as follows.

- **Standardisation of student work** – assessing the quality of student work, that it is meeting the level and the requirements of the unit across all centres, that grade decisions and assessor feedback are justified, and that internal verification and moderation processes are picking up any discrepancies and issues.
- **Sharing of good practice** – we will share good practice in relation to themes such as innovative approaches to delivery, the use of digital literacy, enhancement of student employability skills and employer engagement. **These themes will align to those for QAA Higher Education Reviews.**

An appointed External Examiner (EE) for the centre will ask to sample the Pearson-set assignment briefs in advance of the external examination visit. Although this is not a mandatory requirement for centres, we strongly advise that centres seek guidance and support from their EE on the Pearson-set assignments. The EE may also include the Pearson-set units in their sample of student work during their centre visit.

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 professional bodies, 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 will take place over short or long periods of time and when assessment can take place.

6.0.1 Example Assessment Briefs

Core and some specialist units have supporting Example Assessment Briefs (EABs) that are available to download from the course materials section on our website (<https://qualifications.pearson.com>). EABs are there to give you an example of what the assessment will look like in terms of the feel and level of demand of the assessment.

The EABs, with the exception of the mandatory Pearson-set unit, provide tutors with suggested types of assignment and structure that can be adopted and, if so, **must** be adapted accordingly.

6.1 Principles of 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 available in the support section of our website (<https://qualifications.pearson.com/>). All of the assessment team will need to refer to this document.

For Pearson BTEC Higher Nationals it is important that you can meet the expectations of stakeholders and the needs of students by providing a programme that is practical and applied. Centres can tailor programmes to meet local needs and should use links with local employers and the wider computing sector.

When internal assessment is operated effectively it is challenging, engaging, practical and up to date. It must also be fair to all students and meet national standards.

6.1.1 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 fully delivered. An assignment may take a variety of forms, including practical and written types. An assignment is a distinct activity completed independently by students (either alone or in a team). An assignment is separate from teaching, practice, exploration and other activities that students complete with direction from and, formative assessment by, tutors.

An assignment is issued to students as an **assignment brief** with a handout date, a completion date and clear requirements for the evidence that students are expected to provide. There may be specific observed practical components during the assignment period. Assignments can be divided into separate parts and may require several forms of evidence. A valid assignment will enable a clear and formal assessment outcome based on the assessment criteria.

6.1.2 Assessment decisions through applying unit-based criteria

Assessment decisions for Pearson BTEC Higher Nationals are based on the specific criteria given in each unit and set at each grade level. The criteria for each unit have been defined according to a framework, to ensure that standards are consistent in the qualification and across the suite as a whole. 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 the qualifications.

The assessment criteria for a unit are hierarchical and holistic. For example, if an M criterion requires the student to show ‘analysis’ and the related P criterion requires the student to ‘explain’, then to satisfy the M criterion a student 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 student’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 student 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 student is judged to have met all the criteria. Therefore:

- **to achieve a Pass**, a student must have satisfied all the Pass criteria for the Learning Outcomes, showing coverage of the unit content and therefore attainment at Level 4 or 5 of the national framework
- **to achieve a Merit**, a student must have satisfied all the Merit criteria (and therefore the Pass criteria) through high performance in each Learning Outcome
- **to achieve a Distinction**, a student must have satisfied all the Distinction criteria (and therefore the Pass and Merit criteria), these define outstanding performance across the unit as a whole.

The award of a Pass is a defined level of performance and cannot be given solely on the basis of a student completing assignments. Students who do not satisfy the Pass criteria should be reported as Unclassified.

6.1.3 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, and these roles are listed below. Full information is given in the Pearson Quality Assurance Handbook available in the support section of our website (<https://qualifications.pearson.com/>).

- **The Programme Leader** has overall responsibility for the programme, its assessment and internal verification to meet our requirements, record keeping and liaison with the EE. The Programme Leader registers annually with Pearson and acts as an assessor, supports the rest of the assessment team, makes sure 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 Programme Leader. They check that assignments and assessment decisions are valid and that they meet our requirements. IVs will be standardised by working with the Programme Leader. Normally, IVs are also assessors, but they do not verify their own assessments.
- **Assessors** set or use assignments to assess students to national standards. Before taking any assessment decisions, assessors participate in standardisation activities led by the Programme Leader. They work with the Programme Leader and IVs to ensure that the assessment is planned and carried out in line with our requirements.
- Your **EE** will sample student work across assessors. Your EE will also want to see evidence of informal verification of assignments and assess decisions.

6.1.4 Effective organisation

Internal assessment needs to be well organised so that student progress can be tracked and so that we can monitor that assessment is being carried out in line with national standards. We support you in this through, for example, providing training materials and sample documentation. Our online HN Global service can also help support you in planning and record keeping.

It is particularly important that you manage the overall assignment programme and deadlines to make sure that all your students are able to complete assignments on time.

6.1.5 Student preparation

To ensure that you provide effective assessment for your students, 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 students are motivated to work consistently and independently to achieve the requirements of the qualifications. They 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 your students a guide that explains how:

- assignments are used for assessment
- assignments relate to the teaching programme
- students should use and reference source materials, including what would constitute plagiarism.

The guide should also set out your centre's approach to operating assessments, such as how students must submit assignments/work and the consequences of submitting late work and the procedure for requesting extensions for mitigating circumstances.

6.2 Setting effective assessments

6.2.1 Setting the number and structure of assessments

In setting your assessments, you need to work with the structure of assessments shown in the relevant section of a unit. This shows the learning aims and outcomes and the criteria that you are expected to follow.

Pearson provides online EABs for a range of units to support you in developing and designing your own assessments.

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 of Learning Outcomes listed in the unit descriptor. However, you may choose to combine assignments, either to cover a number of Learning Outcomes or to create a single assignment for the entire 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 Outcomes are fully addressed in the programme overall. If you choose to take this approach you need to make sure that students are fully prepared, so that they can provide all the required evidence for assessment, and that you are able to track achievement in assessment records.
- A Learning Outcome must always be assessed as a whole and must not be split into two or more elements.
- The assignment must be targeted to the Learning Outcomes but the Learning Outcomes 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 Outcomes of a unit in setting assignments, but later Learning Outcomes often require students to apply the content of earlier Learning Outcomes and they may require students to draw their learning together.

Assignments must be structured to allow students to demonstrate the full range of achievement at all grade levels. Students 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 Outcomes. **The specified unit content must be taught/delivered.** The evidence for assessment need not cover every aspect of the teaching content, as students will normally be given particular examples, case studies or contexts in their assignments. For example, if a student 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.

6.2.2 Providing an assignment brief

A good assignment brief is one that, through providing challenging and authentic sector/work-related tasks, motivates students to provide appropriate evidence of what they have learnt.

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 student to apply their learning through the assignment
- clear instructions to the student 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.

6.2.3 Forms of evidence

Pearson BTEC Higher Nationals have always allowed for a variety of forms of assessment evidence to be used, provided they are suited to the type of Learning Outcomes being assessed. For many units, the practical demonstration of skills is necessary and, for others, students will need to carry out their own research and analysis, working independently or as part of a team.

The Example Assessment Briefs give you information on what would be suitable forms of evidence to give students the opportunity to apply a range of employability or transferable skills. Centres may choose to use different suitable forms of evidence to those proposed. Overall, students should be assessed using varied forms of evidence.

These are some of the main types of assessment:

- written reports, essays
- in-class tests
- examinations
- creation of design documents
- creation of implementation documents
- work-based projects
- academic posters, displays, leaflets
- PowerPoint (or similar) presentations
- recordings of interviews/role play
- working logbooks, reflective journals
- presentations with assessor questioning
- time-constrained assessment.

(Full definitions of different types of assessment are given in *Appendix 6*.) The form(s) of evidence selected must:

- allow the student to provide all the evidence required for the Learning Outcomes and the associated assessment criteria at all grade levels
- allow the student to produce evidence that is their own independent work
- allow a verifier to independently reassess the student 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 students are enabled to produce independent work. For example, if students are asked to use real examples, then best practice would be to encourage them to use examples of their own or to give the group a number of examples that can be used in varied combinations.

6.3 Making valid assessment decisions

6.3.1 Authenticity of student work

An assessor must assess only student work that is authentic, i.e. the student's own independent work. Students must authenticate the evidence that they provide for assessment through signing a declaration stating that it is their own work. A student declaration must state that:

- evidence submitted for the assignment is the student's own
- the student understands that false declaration is a form of malpractice.

Assessors must ensure that evidence is authentic to a student through setting valid assignments and supervising them during the assessment period. Assessors must also take care not to provide direct input, instructions or specific feedback that may compromise authenticity.

Centres may 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 student is not authentic. The assessor must then take appropriate action using the centre's policies for malpractice. (See *Section 3.7* for further information.)

6.3.2 Making assessment decisions using criteria

Assessors make judgements using the criteria. The evidence from a student 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 explanation of key terms in *Appendix 2*
- examples of verified assessed work
- your Programme Leader and assessment team's collective experience.

6.3.3 Dealing with late completion of assignments

Students must have a clear understanding of the centre's policy on completing assignments by the deadlines that you give them. Students may be given authorised extensions for legitimate reasons, such as illness, at the time of submission, in line with your centre policies (see also *Section 3.6 Administrative arrangements for internal assessment*).

For assessment to be fair, it is important that students are all assessed in the same way and that some students are not advantaged by having additional time or the opportunity to learn from others. Centres should develop and publish their own regulations on late submission; and, this should make clear the relationship between late submission and the centre's mitigating circumstances policy.

Centres may apply a penalty to assignments that are submitted beyond the published deadline. However, if a late submission is accepted, then the assignment should be assessed normally, when it is submitted, using the relevant assessment criteria; with any penalty or cap applied after the assessment. Where the result of assessment may be capped, due to late submission of the assignment, the student should be given an indication of their uncapped grade; in order to recognise the learning that has been achieved, and assessment feedback should be provided in relation to the uncapped achievement.

As with all assessment results, both the uncapped and capped grades should be recorded and ratified by an appropriate assessment board, taking into account any mitigating circumstances that may have been submitted.

6.3.4 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 students. The information given to the student:

- 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 but how to improve in the future.

6.3.5 Resubmission opportunity

An assignment provides the final assessment for the relevant Learning Outcomes and is normally a final assessment decision. A student who, for the first assessment opportunity, has failed to achieve a Pass for that unit specification **shall be expected to undertake a reassessment**.

- Only one opportunity for reassessment of the unit will be permitted.
- Reassessment for coursework, project or portfolio-based assessments shall normally involve the reworking of the original task.
- For examinations, reassessment shall involve completion of a new task.
- A student who undertakes a reassessment will have their grade capped at a Pass for that unit.
- A student will not be entitled to be reassessed in any component of assessment for which a Pass grade or higher has already been awarded.

6.3.6 Repeat units

A student who, for the first assessment opportunity and resubmission opportunity, still failed to achieve a Pass for that unit specification:

- at centre, and Assessment Board discretion, decisions can be made to permit a repeat of a unit
- the student must study the unit again with full attendance and payment of the unit fee
- the overall unit grade for a successfully completed repeat unit is capped at a Pass for that unit
- units can be repeated once only.

6.3.7 Assessment Boards

Pearson expects each centre to hold Assessment Boards for all of its Pearson BTEC Higher National programmes. The main purpose of an Assessment Board is to make recommendations on the following.

- The grades achieved by students on the individual units.
- Extenuating circumstances.
- Cases of cheating and plagiarism.
- Progression of students to the next stage of the programme.
- The awards to be made to students.
- Referrals and deferrals.

Assessment Boards may also monitor academic standards. The main boards are normally held at the end of the session, although if your centre operates on a semester system there may be (intermediate) boards at the end of the first semester. There may also be separate boards to deal with referrals.

Where a centre does not currently have such a process then the EE should discuss this with the Quality Nominee and Programme Leader, stressing the requirement for Assessment Boards by both Pearson and The Quality Assurance Agency (QAA), and that Assessment Board reports and minutes provide valuable evidence for QAA's Review of Higher Education process.

6.4 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 stakeholder's confidence in the assessment approach.

The Programme Leader should have an assessment plan. When producing a plan, the assessment team might wish to consider the following.

- The time required for training and standardisation of the assessment team.
- The time available to undertake teaching and carrying out of assessment, taking account of when students 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 through internal verification that covers all assignments, assessors and a range of students.
- How to manage the assessment and verification of students' work, so that they can be given formal decisions promptly.
- How resubmission opportunities can be scheduled.

The Programme Leader will also maintain records of assessment undertaken. The key records are:

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

Examples of records and further information are available in the *Pearson Quality Assurance Handbook* available in the support section of our website (<https://qualifications.pearson.com>).

6.5 Calculation of the final qualification grade

6.5.1 Conditions for the award

Conditions for the award of the HND

To achieve a Pearson BTEC Level 5 Higher National Diploma qualification, a student must have:

- completed units equivalent to 120 credits at Level 5
- achieved at least a pass in 105 credits at Level 5
- completed units equivalent to 120 credits at Level 4
- achieved at least a pass in 105 credits at Level 4.

Conditions for the award of the HNC

To achieve a Pearson BTEC Level 4 Higher National Certificate qualification, a student must have:

- completed units equivalent to 120 credits at Level 4
- achieved at least a pass in 105 credits at Level 4.

6.5.2 Compensation provisions

Compensation provisions for the HND

Students can still be awarded an HND if they have attempted but not achieved a Pass in one of the 15-credit units completed at Level 4, and similarly if they have attempted but not achieved a Pass in one of the 15-credit units at Level 5. However, they must complete and pass the remaining units for an HNC or HND as per the unit rules of combination of the required qualification.

Compensation provisions for the HNC

Students can still be awarded an HNC if they have attempted but not achieved a Pass in one of the 15-credit units completed but have completed and passed the remaining units.

6.5.3 Calculation of the overall qualification grade

The calculation of the **overall qualification grade** is based on the student's performance in all units. Students are awarded a Pass, Merit or Distinction qualification grade, using the points gained through all 120 credits, at Level 4 for the HNC or Level 5 for the HND, based on unit achievement. The overall qualification grade is calculated in the same way for the HNC and for the HND.

All units in valid combination must have been attempted for each qualification. The conditions of award and the compensation provisions will apply as outlined above. All 120 credits count in calculating the grade (at each level, as applicable).

The overall qualification grade for the HND will be calculated based on student performance in Level 5 units only.

Units that have been attempted but not achieved, and subsequently granted compensation, will appear as 'Unclassified', i.e. a 'U' grade, on the student's Notification of Performance, that is issued with the student certificate.

Points per credit

Grade	Points
Pass	4
Merit	6
Distinction	8

Point boundaries

Grade	Point boundaries
Pass	420–599
Merit	600–839
Distinction	840 +

6.5.4 Modelled student outcomes

Pearson BTEC Level 4 Higher National Certificate

				STUDENT 1		STUDENT 2		STUDENT 3		STUDENT 4		STUDENT 5	
	Credits	Level	Grade point	Grade	Unit points								
Core 1	15	4	4	P	60	P	60	P	60	D	120	D	120
Core 2	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 3	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 4	15	4	4	P	60	P	60	M	90	M	90	M	90
Core 5	15	4	6	M	90	P	60	M	90	M	90	M	90
Core 6	15	4	6	M	90	P	60	M	90	M	90	M	90
Opt 1	15	4	6	M	90	M	90	D	120	D	120	D	120
Opt 2	15	4	6	M	90	M	90	D	120	D	120	D	120
TOTAL	120				600			540		690		870	
GRADE					M			P		M		D	

Pearson BTEC Level 5 Higher National Diploma

				STUDENT 1		STUDENT 2		STUDENT 3		STUDENT 4		STUDENT 5	
	Credits	Level	Grade point	Grade	Unit points								
Core 1	15	4	0	P	0	P	0	P	0	D	0	P	0
Core 2	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 3	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 4	15	4	0	P	0	P	0	M	0	M	0	M	0
Core 5	15	4	0	M	0	P	0	M	0	M	0	P	0
Core 6	15	4	0	M	0	P	0	M	0	D	0	U	0
Opt 1	15	4	0	M	0	P	0	D	0	D	0	D	0
Opt 2	15	4	0	M	0	P	0	D	0	D	0	D	0
Core 7	30	5	6	M	180	M	180	M	180	P	120	D	240
Core 8	15	5	6	M	90	M	90	M	90	P	60	D	120
Opt 3	15	5	6	M	90	M	90	D	120	P	60	D	120
Opt 4	15	5	6	M	90	P	60	D	120	P	60	D	120
Opt 5	15	5	6	M	90	P	60	D	120	M	90	M	90
Opt 6	15	5	6	M	90	P	60	M	90	M	90	P	60
Opt 7	15	5	6	M	90	P	60	M	90	M	90	M	90
TOTAL	240				720			600		810		570	
GRADE					M			M		M		P	

7 Quality assurance

Pearson's quality assurance system for all Pearson BTEC Higher National programmes is benchmarked to Level 4 and Level 5 on the Quality Assurance Agency (QAA) Framework for Higher Education Qualifications (FHEQ). This will ensure that centres have effective quality assurance processes to review programme delivery. It will also ensure that the outcomes of assessment are to national standards.

The quality assurance process for centres offering Pearson BTEC Higher National programmes comprises five key components:

- 1 the approval process
- 2 monitoring of internal centre systems
- 3 independent assessment review
- 4 annual programme monitoring report
- 5 annual student survey.

7.1 The approval process

Centres new to the delivery of Pearson programmes will be required to seek approval initially through the existing centre approval process and then through the programme approval process. Programme approval for new centres can be considered in one of two ways:

- desk-based approval review
- review and approval visit to the centre.

Prior to approval being given, centres will be required to submit evidence to demonstrate that they:

- have the human and physical resources required for effective delivery and assessment
- understand the rules for independent assessment and agree to abide by these
- have a robust internal assessment system supported by 'fit for purpose' assessment documentation
- have a system to internally verify assessment decisions in order to ensure standardised assessment decisions are made across all assessors and sites.

Applications for approval must be supported by the head of the centre (Principal or Chief Executive, etc.) and include a declaration that the centre will operate the programmes strictly as approved and in line with Pearson requirements.

Centres seeking to renew their programme approval on expiry of their current approval period may be eligible for the Automatic Approval process, subject to the centre meeting the eligibility criteria set out by Pearson.

Regardless of the type of centre, Pearson reserves the right to withdraw either qualification or centre approval when it deems there is an irreversible breakdown in the centre's ability either to quality assure its programme delivery or its assessment standards.

7.2 Monitoring of internal centre systems

Centres will be required to demonstrate ongoing fulfilment of the centre approval criteria over time and across all Pearson BTEC Higher National programmes. The process that assures this is external examination, which is undertaken by External Examiners (EEs). Centres will be given the opportunity to present evidence of the ongoing suitability and deployment of their systems to carry out the required functions. This includes the consistent application of policies affecting student registrations, appeals, effective internal examination and standardisation processes. Where appropriate, centres may present evidence of their operation within a recognised code of practice, such as that of the QAA for Higher Education. Pearson reserves the right to confirm independently that these arrangements are operating to Pearson's standards.

Pearson will affirm, or not, the ongoing effectiveness of such systems. Where system failures are identified, sanctions (appropriate to the nature of the problem) will be applied, in order to assist the centre in correcting the problem.

7.3 Independent assessment review

The internal assessment outcomes reached for all Pearson BTEC Higher National programmes benchmarked to Level 4 and Level 5 of the QAA's FHEQ are subject to a visit from a Pearson appointed External Examiner EE. The outcomes of this process will be:

- to confirm that internal assessment is to national standards and allow certification, **or**
- to make recommendations to improve the quality of assessment outcomes before certification is released, **or**
- to make recommendations about the centre's ability to continue to be approved for the Pearson BTEC Higher National qualifications in question.

7.4 Annual Programme Monitoring Report

The Annual Programme Monitoring Report (APMR) is a written annual review form that provides opportunity for centres to analyse and reflect on the most recent teaching year. By working in collaboration with centres, the information can be used by Pearson to further enhance the quality assurance of the Pearson BTEC Higher National programmes.

7.5 Annual student survey

Pearson will conduct an annual survey of Pearson BTEC Higher National students. The purpose of the survey is to enable Pearson to evaluate the student experience as part of the quality assurance process, by engaging with students studying on these programmes.

7.6 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 qualifications.

- Staff involved in the assessment process must have relevant expertise and/or occupational experience.
- There must be systems in place to ensure continuing professional development for staff delivering the qualification.
- Centres must have in place appropriate health and safety policies relating to the use of equipment by staff and students.
- Centres must deliver the qualification in accordance with current equality legislation.
- Centres should refer to the individual unit descriptors to check for any specific resources required.

7.7 Continuing quality assurance and standards verification

We produce annually the latest version of the *Pearson Quality Handbook*. It contains detailed guidance on the quality processes required to underpin robust assessment and internal verification.

The key principles of quality assurance are that:

- a centre delivering Pearson BTEC Higher National 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 the assessment checking service. This is intended to exemplify the processes required for effective assessment and provide 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 Pearson BTEC Higher Nationals include:

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

An approved centre must make certification claims only when authorised by us and strictly in accordance with requirements for reporting. Centres that do not fully address and maintain rigorous approaches to quality assurance cannot seek certification for individual programmes or for all Pearson BTEC Higher National qualifications.

Centres that do not comply with remedial action plans may have their approval to deliver qualifications removed.

8 Recognition of Prior Learning and attainment

Recognition of Prior Learning (RPL) is a method of assessment (leading to the award of credit) that considers whether students can demonstrate that they can meet the assessment requirements for a unit through knowledge, understanding or skills they already possess, and so do not need to develop through a course of learning.

Pearson encourages centres to recognise students' previous achievements and experiences whether at work, home or at leisure, as well as in the classroom. RPL provides a route for the recognition of the achievements resulting from continuous learning. RPL enables recognition of achievement from a range of activities using any valid assessment methodology. Provided that the assessment requirements of a given unit or qualification have been met, the use of RPL is acceptable for accrediting a unit, units or a whole qualification. Evidence of learning must be valid and reliable.

For full guidance on RPL please refer to the *Recognition of prior learning policy and process* document, available in the support section of our website:
qualifications.pearson.com.

9 Equality and diversity

Equality and fairness are central to our work. The design of these qualifications embeds consideration of equality and diversity as set out in the qualification regulators' General Conditions of Recognition. Promoting equality and diversity involves treating everyone with equal dignity and worth, while also raising aspirations and supporting achievement for people with diverse requirements, entitlements and backgrounds. An inclusive environment for learning anticipates the varied requirements of students and aims to ensure that all students have equal access to educational opportunities. Equality of opportunity involves enabling access for people who have differing individual requirements as well as eliminating arbitrary and unnecessary barriers to learning. In addition, students with and without disabilities are offered learning opportunities that are equally accessible to them, by means of inclusive qualification design.

Pearson's equality policy requires all students to have equal opportunity to access our qualifications and assessments. It also requires our qualifications to be designed and awarded in a way that is fair to every student. We are committed to making sure that:

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

Pearson's policy regarding access to its qualifications is that:

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

Centres are required to recruit students to Higher National qualifications with integrity. This will include ensuring that applicants have appropriate information and advice about the qualifications, and that the qualification will meet their needs. Centres will need to review the entry profile of qualifications and/or experience held by applicants, considering whether this profile shows an ability to progress to a higher-level qualification. Centres should take appropriate steps to assess each applicant's potential and make a professional judgement about their ability to successfully complete the programme of study and achieve the qualification. This assessment will need to take account of the support available to the student in the centre during their programme of study and any specific support that might be necessary to allow the student to access the assessment for the qualification. Centres should consult our policy documents on students with particular requirements.

Access to qualifications for students with disabilities or specific needs

Students taking a qualification may be assessed in a recognised regional sign language where it is permitted for the purpose of reasonable adjustments. Further information on access arrangements can be found in the Joint Council for Qualifications (JCQ) document *Access Arrangements, Reasonable Adjustments and Special Consideration for General and Vocational Qualifications*. Details on how to make adjustments for students with protected characteristics are given in the document *Pearson Supplementary Guidance for Reasonable Adjustment and Special Consideration in Vocational Internally Assessed Units*. See the support section our website for both documents (<https://qualifications.pearson.com/>).

10 Units

Unit 1: Cloud Fundamentals

Unit code	T/618/4883
Unit level	4
Credit value	15

Introduction

The phrase ‘it’s in the cloud’ has become ubiquitous in computing over the last few years and has revolutionised the way we use computer services. The ability to store both data and services in a remote location on the internet has meant that availability has widened considerably as virtual services have proliferated. The growth in cloud adoption presents challenges for companies to source cloud expertise to support their business, particularly small- and medium-sized enterprises with limited resources, which means that people skilled in cloud technologies are in high demand.

The ability to access applications, storage, printing, server functions and data from almost anywhere on almost any type of device has become the expectation rather than the exception. The ability to scale computing resources in direct relation to demand has reduced the need to purchase and maintain central computing resources significantly.

This unit is designed to develop an understanding of the fundamental concepts of cloud computing and cloud deployment models, and the need for cloud computing. Students will develop an appreciation of the issues associated with managing cloud service architecture and develop critical awareness of the ramifications of cloud-computing-based projects.

Topics included in the unit are: the paradigms of networking, fundamentals of cloud computing, cloud computing architecture and frameworks, deployment models, service models, security, cloud specific technology, and review of Cloud Service Providers (CSPs).

On successful completion of this unit, students will understand the concept, architecture, and services of cloud computing. As a result, they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

This unit is designed to be studied as the first unit in the Cloud Computing qualifications as it explains the fundamentals of cloud computing and its infrastructure.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Examine the fundamentals of cloud computing in relation to areas of application, architecture and platform
- 2 Design a deployment model to be hosted in the cloud for a given scenario
- 3 Explain different Cloud Service Providers' (CSPs) approaches to providing a cloud architecture framework for business use
- 4 Assess the technical challenges and risks inherent in moving IT systems to the cloud.

Essential Content

LO1 Examine the fundamentals of cloud computing in relation to areas of application, architecture and platform

Cloud fundamentals:

Discuss cloud computing and cloud infrastructure.

Understanding of the Shared Responsibility Model, including virtualisation, hypervisors and security.

Email, social media, office applications, multiplayer games, entertainment, government services, backups, data storage, iCloud, OneDrive, Dropbox.

Describe total cost of ownership and general cloud benefits, e.g. trading capital for variable.

Processing (Compute in USA), storage and network environments:

Explain how to use virtual machines, cloud connectivity and availability, user data, meta data.

Understand different types of architecture and platforms Linux Windows, e.g. x86, ARM, Mac, cloud platforms, client-server.

Block storage and object storage.

Define virtual private networks and public networks, including routing, subnetting, network isolation, CIDR (Classless Inter-Domain Routing).

Migrating to the cloud:

Investigate service migration to the cloud by considering the management of cloud services, range of cloud service providers, cloud architecture, applications in the cloud and ascertaining if a service is a cloud service.

Identifying services to be migrated to the cloud, including email, office applications, data storage, data processing, backup, file sharing, security, server functions.

Benefits to end users, e.g. access from anywhere, multi-platform access.

Benefits to organisations, including cost, removal of data centre and requirement for excess capacity, availability on demand of storage and processing.

Disadvantages to end users, e.g. network access requirements, availability of service.

Disadvantages to organisations, e.g. legal aspects of different locations, control, levels of auditing and security concerns.

LO2 Design a deployment model to be hosted in the cloud for a given scenario

Cloud computing models:

Understanding cloud deployment models, including Infrastructure as a Service, (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS).

Differentiate between On-Premise, SaaS, PaaS, IaaS with a view to understanding when and how they are deployed.

Cloud deployment models:

Interpret the differences between public, private, hybrid and permutations of each.

Design of simple deployment model to include the application to be hosted, selection of IaaS, SaaS, PaaS, platform hosting option, management options.

LO3 Explain different Cloud Service Providers' (CSPs) approaches to providing a cloud architecture framework for business use

Cloud Service Providers (CSPs):

Review different CSP frameworks, including best practices, implementation recommendations and products and services offered.

Compare CSPs services in terms of cost, service management and availability.

CSPs, e.g. Amazon Web Services, Microsoft Azure, VMware, Digital Ocean, Kamatera, IBM Cloud, Oracle Cloud, Liquid Web.

Additional services and tools:

Review of platforms, e.g. Amazon Web Services for students.

Microsoft Azure for students, Google Cloud for Education and the support offered, e.g. free credits for students.

Consideration of tools provided by service providers for improving system performance, cost saving, threat detection, closing security gaps, managing storage, data analysis and identity and access management.

Review of open source directories, e.g. Docker, Kubernetes.

LO4 Assess the technical challenges and risks inherent in moving IT systems to the cloud.

Security aspects:

Understand the security risks and ways of minimising them, including data security, network access security, permissions, encryption, control and management, type of enforcement, layered security, service management in relation to security.

Legal requirements:

Identify different legal factors involved in commissioning a cloud system, including GDPR, data protection, data storage location, data storage access, governance and compliance.

Review of ISO standards, e.g. ISO/IEC 9126 standard, ISO/IEC 27017 Security controls for cloud services.

Technical aspects:

Explain scalability, availability, fault tolerance and disaster recovery, security threats.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Examine the fundamentals of cloud computing in relation to areas of application, architecture and platform		
P1 Explain the fundamental aspects of cloud computing services. P2 Investigate the value of cloud computing to both end users and organisations.	M1 Analyse the advantages and disadvantages to an organisation of migrating to a wholly cloud-based system.	D1 Evaluate the potential impact of cloud computing on both users and organisations when considering a migration to the cloud.
L02 Design a deployment model to be hosted in the cloud for a given scenario		
P3 Investigate the relationships necessary between different service models and cloud deployment models for them to be effective. P4 Design a simple deployment to include service models and technologies of cloud computing for a given scenario.	M2 Review how different deployment models, service models and technologies work together in a design for a given scenario.	
L03 Explain different Cloud Service Providers' (CSP) approaches to providing a cloud architecture framework for business use		
P5 Compare the services offered by a range of Cloud Service Providers (CSPs). P6 Explain cloud architecture frameworks and the tools offered by different CSPs.	M3 Analyse the relative cost of moving an application to the cloud in terms of service level, management and level of availability.	D2 Critically analyse the advantages and disadvantages of developing cloud applications with CSP tools.

Pass	Merit	Distinction
<p>LO4 Assess the technical challenges and risks inherent in moving IT systems to the cloud.</p> <p>P7 Investigate the security options available for cloud computing solutions.</p> <p>P8 Assess the technical challenges involved in managing and maintaining cloud-based computing solutions.</p>	<p>M4 Review the legal, security and practical risks to both users and organisations of using cloud-based technologies.</p>	<p>D3 Analyse the legal and security aspects of cloud-based computing and propose solutions for the risks identified.</p>

Recommended Resources

Textbooks

FAYNBERG I., LU, H., SKULER, D. (2016) *Cloud Computing: Business Trends and Technologies*. UK: John Wiley and Sons

ORBAN, S., JASSY, A., COCKROFT, A., SCHWARTZ, M. (2018) *Ahead in the Cloud. Best Practices for Navigating the Future of Enterprise IT*. South Carolina: CreateSpace Independent Publishing Platform

Web

www.opensource.com	Opensource.com Resources menu Cloud technology (general reference, research, tutorials)
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Links

This unit links to the following related units:

Unit 3: Security in the Cloud

Unit 13: Cloud Architecture Design

Unit 16: Information Security Management in the Cloud

Unit 17: Applied Security in the Cloud.

Unit 2: Networking in the Cloud

Unit code	A/618/4884
Unit level	4
Credit value	15

Introduction

Complex computer networking has connected the world via groups of smaller, linked networks to support global communications. These can be situated within ‘the cloud’, at home, with your employer or elsewhere. As a cloud computing professional, a question that must always be asked is ‘What remote and local networking infrastructure is supporting our cloud communication?’. The evolution of cloud computing is driven by all forms of network infrastructure allowing users to access data, hardware and services regardless of location. Being knowledgeable about the underlying principles of networking is of vital importance to all cloud professionals, whether they work in cloud support roles, cyber security or cloud software development.

The aim of this unit is to give students a wider background knowledge of cloud networking principles, operational principles, protocols, standards, security considerations and the systems associated with a range of networking technologies. This unit gives students the underpinning knowledge of the principles of networks and supports a range of other units in the qualification.

Students will explore a range of cloud solutions and will configure them to gain knowledge of networking systems. A range of networking technologies will be explored so that students gain a fundamental knowledge of Local Area Networking (LAN), Wide Area Networking (WAN) and their evolution, to form scalable systems.

On successful completion of this unit, students will have gained knowledge and skills to be able to successfully implement, operate and improve a cloud network and the operation of cloud-based data networks, including router, switching technologies, IP routing technologies, IP services and basic troubleshooting.

Students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, all of which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Examine commonplace networking principles used in a cloud infrastructure to support communication
- 2 Explain the operation of networking technologies within a cloud infrastructure
- 3 Design a networking solution for a cloud-based system for a business use case
- 4 Enhance network performance for a cloud-based system developed for a given business use case.

Essential Content

LO1 Examine commonplace networking principles used in a cloud infrastructure to support communication

Network architectures and standards:

Discuss network architectures, including CSD (Cloud Software Defined), WAN (Wide Area Network), LAN (Local Area Network).

Explore a range of technologies and standards, including TCP/IP model, theoretical OSI model, IEEE dot1q, IEEE 802.3.

Understanding and application of routing protocols, routed protocols, application layer protocols.

Awareness of security standards impacting on networks.

Network communication:

Operation and function of cloud-based routing, cloud-based switching, VLANs, network segmentation, access control lists, TCP/IP stack, IP (internet protocol) addressing (v4 and v6), NAT (network address translation), DHCP (dynamic host configuration protocol), transmission standards, physical layer security (on premises, within cloud).

Implementation solutions:

Understand the differences between on premises vs in-cloud vs hybrid systems.

Application of NaaS (Network as a Service) used in conjunction with PaaS (platform as a service), aPaaS (application PaaS) and SaaS (software as a service), VPN (virtual private network) solutions, BoD (bandwidth on demand) and virtualisation resources.

LO2 Explain the operation of networking technologies within a cloud infrastructure

Remote operating system services:

Explain application and implementation of Windows™-based resources, Linux-based resources, server solutions, desktop solutions, mobile applications, serverless lambda, web servers, application servers, storage servers, database servers and licencing constraints.

Operating system optimisation:

Optimisation techniques, including time utilisation, storage resource, processor resource, memory resource, up time, down time, capacity for service being provided, interfaces required, addressing resources and security resources.

Remote clients:

Utilisation of web clients, API interactions, remote desktop solutions, bespoke applications and storage-based integrations for a cloud-based system.

LO3 Design a networking solution for a cloud-based system for a business use case

Networked solution:

Establishing a purpose to support a cloud-based resource for a specific customer need, e.g. cloud-based application, cloud-based service, remote deployment, remote backup.

Create a WAN-based infrastructure, including combination hosted (hybrid), local hosted (private), public hosted (remote clouded).

Establishing a provisioning level, including understanding of cost, response, redundancy, location.

Setting up a LAN-based infrastructure, including addressing, scale, hosts, services, security, firewall and access control.

Design:

Contents of design documentation, e.g. network diagram showing key infrastructure, addressing and routing methodology.

Performance and scalability:

Setting performance metrics, including speed, bandwidth, resilience, throughput, adaption, failover, automation.

Setting scalability for number of hosts (clients), number of servers and services, address availability, resource availability, bandwidth, elastic storage, automation APIs.

LO4 Enhance network performance for a cloud-based system developed for a given business use case.

Testing methodology:

Establishing testing methodology, including divide and conquer, bottom up, top down, from the middle, load testing, resilience testing, penetration testing, vulnerability analysis, connectivity and reliability testing.

Network enhancements:

Agreeing improvements, including speed, bandwidth, security, scalability, performance, storage, response time, services, applications, features.

Network performance measurement parameters, to include latency, packet loss, jitter (ping spikes), throughput and bandwidth.

Use of tools for network monitoring, e.g. Amazon CloudWatch.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Examine commonplace networking principles used in a cloud infrastructure to support communication		
P1 Discuss the benefits and constraints of different network architectures and standards within the cloud. P2 Describe how network communication operates within the cloud.	M1 Compare common networking standards and how they facilitate cloud computing.	D1 Review how creating a cloud environment affects network implementation and overall performance.
L02 Explain the operation of networking technologies within a cloud infrastructure		
P3 Explain how remote operating system services are deployed within the cloud. P4 Explain how remote clients interact with cloud services.	M2 Explore the impact of remote operating system optimisation within the cloud on performance.	
L03 Design a networking solution for a cloud-based system for a business use case		
P5 Design a networked solution for a cloud-based system for a given business use case. P6 Implement the networking solution designed for a cloud system.	M3 Test the cloud-based network, for performance and scalability.	D2 Justify the effectiveness of your design, based on performance and scalability results from testing.
L04 Enhance network performance for a cloud-based system developed for a given business use case.		
P7 Recommend network enhancements based on cloud test results. P8 Implement network enhancements for a cloud system.	M4 Test network enhancements for further performance and scalability improvements.	D3 Justify the resulting networking improvements against the original network design.

Recommended Resources

Textbooks

DUTT, D. (2019) *Cloud Native Data-Center Networking: Architecture, Protocols, and Tools*. Sebastopol: O'Reilly

KUROSE, J., ROSS, K. (2016) *Computer Networking: A Top-Down Approach*. Harlow, Pearson

STALLINGS, W. (2015) *Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud*. Boston: Addison Wesley

Journals

IEEE/ACM Transactions on Networking

IEEE xPlore

Web

aws.amazon.com	Training AWS Academy
	AWS (Amazon Web Services) Academy (general reference and academic resources)
NetAcad.com	Cisco Networking Academy – resources for general networking principles reference

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 3: Security in the Cloud

Unit 13: Cloud Architecture Design

Unit 14: Operating Systems in the Cloud

Unit 17: Applied Security in the Cloud

Unit 3: Security in the Cloud

Unit code	F/618/4885
Unit level	4
Credit value	15

Introduction

A question always asked by all cloud computing professionals is 'Who is accessing my system?'. This question becomes more significant as infrastructure transitions from on-site systems to within the cloud. Where, once, systems would run on their own networked switches, routers and wireless access points, much is now being moved to the cloud, increasing the challenge of maintaining a secure system.

Organisations must maintain the security of their own local infrastructure to ensure that colleagues and customers can securely access the system, as well as ensuring the security of the remote service hosted in the cloud. Many computing and cloud infrastructure professionals need to have a broad understanding of applied cloud security principles as part of their core skills portfolio. Security considerations in the context of cyber security in the cloud ensures an essential element of end-to-end security within a corporate infrastructure.

This unit gives students the opportunity to design a cloud solution for a 'corporate system', with the aim of configuring and testing this system to ensure that it has reasonable defence capabilities. Students will examine commonplace security principles, in the context of a cloud-based infrastructure. They will design a secure solution that will work within the cloud-based system and then configure it, applying essential security skills and principles.

On successful completion of this unit, students will understand common security principles in designing cloud solutions, be able to configure security and cloud resilience resources and test their solution

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Explain commonplace security principles used in a cloud infrastructure for an organisation
- 2 Design a secure cloud solution based on requirements for a corporate environment
- 3 Configure cloud security measures based on requirements for a corporate environment
- 4 Implement a test plan based on an established testing methodology to improve cloud security.

Essential Content

LO1 Examine commonplace security principles used in a cloud infrastructure for an organisation

Security standards and compliance:

Review the following national and international standards and practices, e.g. ISO/IEC 27002, ISO/IEC 27032, when developing a secure cloud solution:

NCSC (UK National Cyber Security Centre) MCSS (Minimum Cyber Security Standard), PAS 555, CSA (Cloud Security Alliance) CCM (Cloud Controls Matrix), NIST (USA National Institute of Standards and Technology) CSF (Cybersecurity Framework).

Show awareness of location including how regional and national regulations impact cloud services and security.

Local system security vs cloud system security.

Cloud-based security services:

Explore a range of technologies, including on premises vs within cloud security solutions, firewall security, access control, region-based rights and access, IP address-based rights and access, organisation-based rights and access, Authentication, Authorisation, Accounting (AAA), physical vs virtualised networking devices/services, local network and security infrastructure constraints, cloud network security and infrastructure constraints.

Security principles:

Know how different security, communication and system management technologies affect the deployment of a secure system, including MD5, SSL, VPN, AES, SHA-1/2, RSA, DES, 3DES, IPSec, NAT, NTP, DNS, DHCP, HTTPS, SFTP, POP3, SMTP, IMAP, hashing, certification.

Be aware of multiple attack methods, including common adversary tactics, techniques, and procedures (TTPs) in assigned area of responsibility (hosting domain).

General attack stages, including foot printing and scanning, enumeration, gaining access, escalation or privileges, maintaining access, network exploitation, covering tracks.

LO2 Design a secure cloud solution based on requirements for a corporate environment

Planning a secure cloud solution:

Ensure provisioning level required, security services, utilisation level, following 5W1H principle.

Assuring regulatory compliance, including meeting security standards.

Systemically review security services, establishing what is and is not required.

Resource considerations:

Consider software, services, security technologies and protocols for a secure cloud solution.

Corporate environment:

Any system that is used to host a remote cloud-based infrastructure solution.

Corporate culture and cultural awareness, e.g. working from home.

Scope, including small to medium enterprises, local business, self-employed, corporations, public sector and private sector.

LO3 Configure cloud security measures based on requirements for a corporate environment

Cloud security measures:

Implement firewall and access-control services, encryption, VPN access, authentication services (password, identify, access, multi-factor), region-based access control, corporate level access control.

Cloud resilience:

Implement back-up and multi-location homing, synchronisation of services to assure continuity of secure access, access, event and protocol logging.

Complement a systemic review of cloud-based services, evaluating security and applied technologies.

LO4 Implement a test plan based on an established testing methodology to improve cloud security.

Testing methodology:

Understanding and selection of appropriate testing methodology and tests, e.g. bottom up, top down, from the middle, load testing, resilience testing, penetration testing, vulnerability analysis, connectivity and reliability testing.

Planning the testing:

Establish authorisation (who has the rights), ensuring sufficient and compliant encryption, assuring sufficient data retention and removal, security administration, security settings, access control, anti-malware solutions, benchmarking connectivity and reliability standards.

Presenting recommendations and enhancements:

Presenting critique and report, SWOT analysis of testing outcomes, critical assessment of outstanding vulnerabilities (if any).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Explain commonplace security principles used in a cloud infrastructure for an organisation		
P1 Explain the purpose of security standards and compliance. P2 Describe how security principles support cloud-based security services.	M1 Compare two different security standards, analysing their contribution to a secure cloud system.	D1 Evaluate the importance of security standards in cloud infrastructure development, for an organisation.
L02 Design a secure cloud solution based on requirements for a corporate environment		
P3 Explain how resource considerations affect the planning of a secure cloud solution. P4 Design a secure cloud solution based on resource considerations for a corporate environment.	M2 Justify the secure cloud solution design, based on the corporate environments' considerations.	D2 Evaluate your configured system against the original cloud security design and recommend improvements.
L03 Configure cloud security measures based on requirements for a corporate environment		
P5 Configure a range of cloud security measures for a cloud-based system. P6 Configure a range of cloud resilience resources, for a cloud-based system.	M3 Adapt the security configuration methods used for a cloud-based system, based on a systemic review.	
L04 Implement a test plan based on an established testing methodology to improve cloud security.		
P7 Design a cloud security focussed test plan for a cloud-based system. P8 Implement a testing methodology for a configured cloud-based system P9 Assess the results of the testing, giving recommendations to improve security.	M4 Analyse the results, from the cloud-based security testing, giving a SWOT analysis.	D3 Evaluate the results to provide evidenced-based recommendations for enhancing and improvements to cloud security.

Recommended Resources

Textbooks

ADKINS, H., BEYER, B., BLANKINSHIP, P., LEWANDOWSKI, P., OPREA, A., STUBBLEFIELD, A (2020). *Building Secure and Reliable Systems: Best Practices for Designing, Implementing, and Maintaining Systems*. Sebastopol: O'Reilly

DOTSON, C (2019) *Practical Cloud Security: A Guide for Secure Design and Deployment*. Sebastopol: O'Reilly

MCNAB, C. (2016) *Network Security Assessment: Know Your Network*. Sebastopol: O'Reilly

STALLINGS, W. (2016) *Network Security Essentials: Applications and Standards*, Global Edition 6th ed, Harlow: Pearson Publishing

Journal

IEEE xPlore

Web

aws.amazon.com

AWS Academy (Amazon Web Services)
(general reference and academic resources)

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 2: Networking in the Cloud

Unit 13: Cloud Architecture Design

Unit 14: Operating Systems in the Cloud

Unit 17 Applied Security in the Cloud.

Unit 4: Programming

Unit code	D/615/1618
Unit level	4
Credit value	15

Introduction

Programming involves describing processes and procedures that are derived from algorithms. The ability to program is what sets apart a developer and an end user.

Typically, the role of the developer is to instruct a device (such as a computer) to carry out instructions; the instructions are known as source code, which is written in a language that is converted into something the device can understand. The device executes the instructions it is given.

Algorithms help to describe the solution to a problem or task; by identifying the data and the process needed to represent the problem or task and the set of steps needed to produce the desired result.

Programming languages typically provide the representation of both the data and the process; they provide control constructs and data types (which can be numbers, words, and objects, and be constant or variable).

The control constructs are used to represent the steps of an algorithm in a convenient yet unambiguous fashion. Algorithms require constructs that can perform sequential processing, selection for decision making, and iteration for repetitive control. Any programming language that provides these basic features can be used for algorithm representation.

This unit introduces students to the core concepts of programming, with an introduction to algorithms and the characteristics of programming paradigms.

Among the topics included in this unit are introduction to algorithms, procedural, object-orientated and event-driven programming, security considerations, the integrated development environment and the debugging process.

On successful completion of this unit, students will be able to design and implement algorithms in a chosen language within a suitable Integrated Development Environment (IDE). This IDE will be used to develop and help track any issues with the code. As a result, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Define basic algorithms to carry out an operation and outline the process of programming an application
- 2 Explain the characteristics of procedural, object-orientated and event-driven programming
- 3 Implement basic algorithms in code using an IDE
- 4 Determine the debugging process and explain the importance of a coding standard.

Essential Content

LO1 Define basic algorithms to carry out an operation and outline the process of programming an application

Algorithm definition:

Writing algorithms to carry out an operation, e.g. Bubble sort, the relationship between algorithms and code.

The generation process of code; the roles of the pre-processor, compiler and linker, interpreter.

LO2 Explain the characteristics of procedural, object-orientated and event-driven programming

Characteristics of code:

Definitions of data types (the role of constants/variables), methods (including input/output), control structures, iteration, scope, parameter passing, classes, inheritance and events.

Key components of an IDE with a brief explanation each component.

Use of addition of advanced text editors to view code, such as Notepad++, Atom, Sublime Text.

LO3 Implement basic algorithms in code using an IDE

Implementation:

Developing simple applications that implement basic algorithms covered in LO1, using the features of a suitable language and IDE, consider possible security concerns and how they could be solved.

LO4 Determine the debugging process and explain the importance of a coding standard.

Review and reflection:

Documentation of the debugging process in the IDE, with reference to watch lists, breakpoints and tracing.

How the debugging process can be used to help developers fix vulnerabilities, defects and bugs in their code.

What a coding standard is and its benefits when writing code.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Define basic algorithms to carry out an operation and outline the process of programming an application		
P1 Provide a definition of what an algorithm is and outline the process in building an application.	M1 Determine the steps taken from writing code to execution.	D1 Evaluate the implementation of an algorithm in a suitable language and the relationship between the written algorithm and the code variant.
LO2 Explain the characteristics of procedural, object-orientated and event-driven programming		
P2 Give explanations of what procedural, object-orientated and event-driven paradigms are; their characteristics and the relationship between them.	M2 Compare and contrast the procedural, object orientated, and event driven paradigms used in given source code of an application	D2 Critically evaluate the source code of an application that implements the procedural, object-orientated and event driven paradigms, in terms of the code structure and characteristics.
LO3 Implement basic algorithms in code using an IDE		
P3 Write a program that implements an algorithm using an IDE.	M3 Use the IDE to manage the development process of the program.	D3 Evaluate the use of an IDE for development of applications contrasted with not using an IDE.
LO4 Determine the debugging process and explain the importance of a coding standard.		
P4 Explain the debugging process and explain the debugging facilities available in the IDE.	M4 Evaluate how the debugging process can be used to help develop more secure, robust applications.	D4 Critically evaluate why a coding standard is necessary in a team as well as for the individual.
P5 Outline the coding standard you have used in your code.		

Recommended Resources

This unit does not specify which program language should be used to deliver the content, this decision can be made by the tutor.

Examples of languages that are used in industry are C#, Python, Ruby and Java, but the use of any language that allows students to achieve the Learning Outcomes is acceptable.

Textbooks

AHO, A. V. et al. (1987) *Data Structures and Algorithms*. 1st Ed. Addison-Wesley

HUNT, A. et al. (2000) *The Pragmatic Programmer: From Journeyman to Master*. 1st Ed. Addison-Wesley

McCONNELL, S. (2004) *Code Complete: A Practical Handbook of Software Construction*. 2nd Ed. Microsoft Press

Links

This unit links to the following related units:

Unit 20: Application Development, Testing & Debugging

Unit 21: Applied Programming and Design Principles

Unit 24: Data Structures & Algorithms.

Unit 5: Database Design and Development in the Cloud

Unit code	J/618/4886
Unit level	4
Credit value	15

Introduction

Organisations depend on their databases to provide information that is essential for their day-to-day operations and to help them take advantage of today's rapidly growing and maturing e-commerce opportunities. An understanding of database tools and the related technologies is an essential skill for designing and developing systems so as to exploit them. The movement away from traditionally hosted on-site database systems to hosting in the cloud has significantly changed the way that databases are accessed and managed.

Most organisations collect and store large volumes of data, used for the operational running of their organisation, which is frequently mined and analysed for more esoteric purposes. Databases provide this back-end information service for most organisations and are essential for their operations. The use of a cloud-based system enhances accessibility by location but may have inherent latency in access owing to the quality of internet connection. The ability to design and develop effective and efficient databases is a fundamental skill, the ability to do this and host the database in the cloud is an even more valuable talent.

The aim of this unit is to give students the opportunity to develop an understanding of the concepts and issues involved in designing and developing databases for the cloud. The unit will also help students build the practical skills needed to be able translate this understanding into the design and creation of complex databases and host them in the cloud.

Topics included in this unit include: examination of different design tools and techniques, software options for database development, development tools and methods, system reports, testing the system and system documentation, including options for hosting the system in the cloud.

On successful completion of this unit, students will be able to use appropriate tools to design and develop a secure cloud-hosted relational database system for a substantial problem. They will be able to test the system to ensure that it meets user and system requirements and fully document the system by providing technical and user documentation. For practical purposes, this unit covers relational databases, the related tools and techniques and the choices for hosting them in the cloud.

Students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Design a cloud-based relational database system using appropriate design tools and methods for a substantial problem
- 2 Develop a fully functional relational database system, based on an existing system design and host it in the cloud
- 3 Perform system testing against user, technical and hosting requirements
- 4 Produce documentation to support the system and manage the hosting of it in the cloud.

Essential Content

LO1 Design a cloud-based relational database system using appropriate design tools and methods for a substantial problem

Comprehensive design:

The role of database systems, e.g. as back-end systems, in e-commerce, for data mining applications.

Understanding object-oriented databases and their design tools for developing a comprehensive design.

Design approaches, e.g. top down bottom up.

Determining user and system requirements to develop measurable design objectives.

Use of design tools and techniques for a relational database system, e.g. case tools, data flows, UML to create a design.

Logical design for relational databases, e.g. tables, data elements, data types, indexes, primary and foreign keys, entity relationship modelling, referential integrity, data normalisation to third normal form.

Designs for data integrity, data validations, data security and data controls.

User interface design and output designs for user requirements.

Cloud hosting:

Cloud-based platforms, cloud-based database services, open source, vendor provided, access latency, security, data crossing borders, relative cost.

LO2 Develop a fully functional relational database system, based on an existing system design and host it in the cloud

Database structure and development:

Consideration of database and platform options for system development.

Examination of different software development options for developing the relational database system.

Implementation of the physical data model based on the logical model.

Consideration and planning of storage options, including data stores, internal storage and external storage, e.g. the cloud.

Building interface controls, e.g. data validation using input masks, drop down lists, option buttons.

Consideration of user interface requirements looking at functionality, reliability, consistency and performance.

Consideration of interface links with other systems, e.g. internet-based applications.

Data manipulation using appropriate query tools, including complex queries to query across multiple tables, and using functions and formulae.

Database maintenance and data manipulation, e.g. inserts, updates, amendments, deletions, data backup and recovery.

Reporting:

Building system reports using report-writing tools and report generators, dashboards.

Cloud-hosting models, containers such as Docker, open source services, vendor services, e.g. Amazon Aurora, Microsoft Azure SQL Hyperscale, Ragic, Amazon Glacier.

Security considerations:

Implementation of security elements in a database, including permissions, access rights, network vulnerabilities, physical location of data, multi-tenancy and data separation, encryption.

Consideration of GDPR issues, including data crossing borders, other nations' data protection regulations.

LO3 Perform system testing against user, technical and hosting requirements

Test base:

Test plan to Identify all elements of the system that need to be tested against user and system requirements, including data that should be used to fully test the system.

Test procedures to include test plans, test models, e.g. white box, black box.

Functional and system testing and testing the robustness of the system, including help menus, pop-ups, hot-spots, data validation checks.

Geographical accessibility of the cloud-hosted database, latency of access owing to network connection quality, bandwidth, security, costs of the service, billing models, commercial viability

LO4 Produce documentation to support the system and manage the hosting of it in the cloud.

Documentation:

Technical and user documentation and their contents, e.g. diagrams or other illustrations showing the movement of data through the system, detail of the cloud-hosting structure and flowcharts describing how the system works for third party management.

Documentation should reflect maintenance and update processes to ensure integrity of the database and its deployment in the cloud.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	<p>LO1 Design a cloud-based relational database system using appropriate design tools and methods for a substantial problem</p> <p>P1 Design a cloud-hosted relational database system using appropriate design tools and techniques, with clear statements of user and system requirements.</p> <p>P2 Identify options for hosting your database in the cloud and ensuring its security.</p>	<p>D1 Evaluate the effectiveness of the design in relation to user and system requirements, and the chosen cloud-hosting method.</p>
	<p>LO2 Develop a fully functional relational database system, based on an existing system design and host it in the cloud</p> <p>P3 Develop the database system with evidence of user interface, output and data validations, and querying across multiple tables using a structured query language.</p> <p>P4 Host the database system in the cloud using a suitable method.</p>	<p>D2 Evaluate the effectiveness and security of the database solution in relation to user and system requirements, effectiveness of cloud-hosting method and suggest improvements.</p>

Pass	Merit	Distinction
LO3 Perform system testing against user, technical and hosting requirements		
P5 Produce a test plan that tests the system and its hosting on the cloud. P6 Test the system against user and system requirements. Document the results against your test plan.	M4 Assess the effectiveness of the testing, including an explanation of the choice of test data used.	D3 Critically evaluate the ramifications of basing the database solution in the cloud in relation to access times, security of data, viability due to cost and the original user and system requirements, suggesting improvements that will ensure the ongoing suitability of the system.
LO4 Produce documentation to support the system and manage the hosting of it in the cloud.		
P7 Produce technical and user documentation, identifying specific cloud-hosting implications.	M5 Produce detailed technical documentation and user documentation for the fully functional system, including documentation illustrating movement of data through the system, and descriptions of how the cloud system works.	

Recommended Resources

Textbooks

CHAO, L. (2013) *Cloud Database Development and Management*. Boca Raton: CRC Press

FAROOQ, T., AVANTSA, S., SHARMAN P. (2016) *Building Database Clouds in Oracle 12c*. Indiana: Pearson

Web

www.cloud.netapp.com/home	Application Driven Infrastructures <i>Cloud-Based Database Workloads: An Introduction</i> (general reference)
www.cloud4scieng.org/	Cloud Computing for Science and Engineering <i>Managing Data in the Cloud</i> (ebook)
www.opensource.com	Opensource.com <i>What is Cloud?</i> (general reference)

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 15: Cloud Systems Integration.

Unit 19: Software Development Methodologies for the Cloud

Unit 6: Deploying and Operating in the Cloud (Pearson Set)

Unit code	L/618/4887
Unit level	4
Credit value	15

Introduction

In order to successfully deploy a cloud-based solution it is important to understand key architectural principles, then use this understanding as a basis for designing and implementing a prototype in order to test and reflect on how it is meeting the original requirements. This process is fundamental to ensuring that client expectations are met in terms of deadlines, estimated cost and business needs.

The work to deliver new computer systems and services to business organisations, or to revamp the existing ones, is always organised in projects. Therefore, skilful, knowledgeable and experienced cloud developers are in demand.

This unit offers students an opportunity to demonstrate the foundational skills required for designing a small-scale technological solution for a cloud-based project and to develop a prototype based on the design. Students will be expected to implement their skills in the context of a business case scenario, which will reflect the annually set theme and topic.

Students will undertake independent investigation into the theme and topic selected, with a view to understanding how their investigation may impact on the business case scenario and the design to be developed.

On successful completion of this unit, students will have the confidence to engage in research activities, design and development, testing and problem solving. They will have the fundamental knowledge and skills to enable them to design, develop and deploy a solution to the cloud while examining current and topical computing concepts and their potential impacts on their project. This unit provides broad foundational knowledge for a number of units at Level 5, and specifically supports the Cloud Software Development pathway.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Discuss the cloud architectural principles used for designing a technological solution for an organisational move to the cloud
- 2 Develop a cloud-based prototype using an appropriate development methodology for a business case
- 3 Test the prototype solution against business case requirements
- 4 Discuss the value gained from developing a cloud-based solution to support sustainable organisational performance.

Essential Content

LO1 Discuss the cloud architectural principles used for designing a technological solution for an organisational move to the cloud

Business processes:

Explain business processes that lead to the use of the cloud, including strategic business management and transformation, business goal and strategy, business operating system, outsourcing, identifying workflows for particular processes, monitoring and updating processes, business benefits, service portfolio and technical challenges.

Architectural principles:

Explain operational excellence, e.g. perform operations, annotate documentation and small, reversible changes.

Security, e.g. confidentiality, possession of control and integrity.

Reliability, e.g. test recovery procedures, automatically recover from failure, scale horizontally to increase aggregate system availability.

Performance efficiency, e.g. using advanced technologies, deploy your system in multiple regions, use serverless architectures and virtual and automatable resource.

Cost optimisation, e.g. cost-effective resources, matching supply with demand, supply and demand, workloads and expenditure awareness, tracking usage, the pattern of expenditure, auto-scaling.

LO2 Develop a cloud-based prototype using an appropriate development methodology for a business case

Lifecycle stages and development methods:

Awareness of stages in typical development lifecycle, including feasibility study, analysis, design implementation, testing and review.

Understand Agile Development, e.g. decomposition, scrum, extreme programming.

Understand Rapid Application Development (RAD), e.g. focus on prototypes, speed, cost and development satisfaction.

Review the DevOps lifecycle, including continuous integration, continuous delivery, continuous deployment.

Design specification:

Develop design documentation, e.g. parent schema, cloud design object, info object, persons type of actor object, external system type of actor object, resources object, context object, components object.

Consideration of tools to generate the computing architecture, archiving tools to deploy it to the blockchain, auditing tools and other use cases.

Services to include in prototype:

Consider and apply the most suitable service features in the developed prototype, based on business case needs.

Performance features, e.g. auto-scaling, redundancy, global infrastructure, networking, content and delivery services.

Security features, e.g. security groups, access control lists, users, roles, policies and permissions.

Monitor and logging features, e.g. Amazon CloudWatch, EC2, e.g. monitoring, auto-scaling, and elastic load balancing, alarms, logs, metrics and events.

LO3 Test the prototype solution against business case requirements

Developing a test plan and methodology:

Include features to be tested, e.g. list of all the functionality to be tested.

Explain features not to be tested, e.g. list elements not part of the verification.

Consider testing approach, e.g. methods and number of iterations of testing, defect tracking process and list of tools to be used.

Produce test deliverables, e.g. list of documents to be created during the cycle, test cases, bug report, test summary report.

Explain schedule, e.g. timelines, referencing, and activities.

Types of cloud testing:

SaaS or cloud-oriented testing, e.g. integration, functional, security, system function validation and regression testing.

Online-based application testing, e.g. performance and functional testing of cloud services.

Cloud-based application testing over clouds, e.g. check quality across different clouds.

LO4 Discuss the value gained from developing a cloud-based solution to support sustainable organisational performance.

Value propositions:

Understanding that a value proposition is the value a company promises to deliver.

Discuss cloud computing's value proposition, including predicted demand for IT infrastructure elements, variability in potential demand, flexibility to buy only what you need and to scale, marketplace strategy that leverages technology innovation as an essential approach to adding value.

Benefits of the cloud value proposition:

Cloud value proposition delivering agility, including speed of implementation of services, experimentation and innovation.

Elasticity, including scale on demand and eliminate wasted capacity.

Flexibility, including broad set of products and low or no cost to entry.

Security, including automated cloud acquired certifications as part of the shared responsibility model.

Pass	Merit	Distinction
LO1 Discuss the cloud architectural principles used for designing a technological solution for an organisational move to the cloud		
<p>P1 Explain the business processes that lead to organisations adopting cloud-based systems.</p> <p>P2 Discuss cloud architectural principles in relation to designing an efficient, secure, scalable and cost-effective cloud solution.</p>	<p>M1 Analyse how business process improvements have an important impact on the successful design and development of a cloud solution.</p>	<p>D1 Evaluate how architectural principles and services are used for designing solutions in the cloud.</p>
LO2 Develop a cloud-based prototype using an appropriate development methodology for a business case		
<p>P3 Produce a design specification, selecting an appropriate development methodology, for a prototype solution for a given business use case.</p> <p>P5 Build the cloud prototype, considering its essential characteristics and utilising available services suitable for the business case requirements.</p>	<p>M2 Justify the decisions made in designing the cloud prototype, including the chosen methodology.</p>	
LO3 Test the prototype solution against business case requirements		
<p>P5 Develop a test plan for conducting tests on the solution against the core testing components.</p> <p>P6 Carry out testing of the solution against your test plan.</p>	<p>M3 Analyse the testing results against the requirements set out from the business case</p>	<p>D2 Evaluate the different test strategies that are used for testing a prototype solution.</p>

Pass	Merit	Distinction
<p>LO4 Discuss the value gained from developing a cloud-based solution to support sustainable organisational performance.</p> <p>P7 Review how the solution developed meets organisational objectives.</p>	<p>M4 Assess how the developed solution could be improved in terms of how it can deliver value to the organisation.</p>	<p>D3 Evaluate how a cloud-based solution can add value to an organisation's objectives, as well as the challenges posed.</p>

Recommended Resources

Textbooks

BAHGA, A., MADISSETTI, V. (2014) *Cloud Computing: A Hands-On Approach*

BUYYA, R., VECCHIOLA, S., SELVI S.T. (2013), *Mastering Cloud Computing. Foundations and Applications Programming*. USA: Morgan Kaufmann

ERL, T. (2013). *Cloud Computing: Concepts, Technology & Architecture*. UK: Prentice Hall

KAVIS, M. J. (2014). *Architecting the Cloud. Design Decisions for Cloud Computing Service Models* (SaaS, PaaS, and IaaS). USA: Wiley

RAFAELS, R (2015) *Cloud Computing from Beginning to End*. CreateSpace Independent Publishing Platform. ISBN 978-1511404587

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 13: Cloud Architecture Design

Unit 19: Software Development Methodologies for the Cloud

Unit 20: Application Development Testing & Debugging.

Unit 7: Website Design and Development in the Cloud

Unit code	R/618/4888
Unit level	4
Credit value	15

Introduction

Many organisations rely on websites for a range of purposes and they may even have a number of websites, which they must manage and host in the cloud. The scripting involved in the development of websites has become increasingly important. Website developers need to cultivate the skills required to create compelling websites that work on different devices and platforms.

As part of this process, organisations must consider how to deploy their websites in the cloud. The most common method refers to running workloads remotely over the internet in a commercial provider's data centre, also known as the 'public cloud' model. Popular public cloud offerings (Amazon Web Services (AWS), Salesforce's CRM system, and Microsoft Azure) all exemplify this familiar notion of cloud computing. Today, most businesses take a multi-cloud approach, which simply means that they use more than one cloud service.

In this unit, students will review websites to compare how effective they are. They will learn how to use design documentation to design a website. They will then learn how to use HTML, Cascading Style Sheets (CSS), JavaScript and PHP to develop a website that can be hosted in the cloud.

This unit introduces students to developing a website, focusing on the underpinning services required to host, manage and access a secure website in the cloud. It also explores the methods used by designers and developers using different service models, to help ensure new designers can design and deliver a site that offers an outstanding User Experience (UX) supported by an innovative User Interface (UI). This unit covers discussion of the reasons, requirements, relationships, capabilities and features of the systems students will be using and allows them to explore various tools, techniques and technologies with 'good design' principles in order to plan, design and review a multipage website.

On successful completion of this unit, students will be able to explain cloud and other server technologies and management services associated with the hosting and management of secure websites, categorise website technologies, tools and software used to develop websites, utilise website technologies, tools and techniques with ethical design principles to create a multipage website and track its performance in the cloud through a test plan.

Learning outcomes

By the end of this unit, students will be able to:

- 1 Discuss cloud technologies and management services associated with hosting websites for specific organisational need
- 2 Design a cloud-based website, including tools, technologies and software for a business case
- 3 Build a multipage cloud-based website, based on a design for a given business case
- 4 Review the cloud-hosted website against the requirements of the business case.

Essential Content

LO1 Discuss cloud technologies and management services associated with hosting websites for specific organisational need

Identify characteristics of cloud services:

Recognise and be able to explain the characteristics of cloud services, including on-demand usage, ubiquitous access, multi-tenancy, resiliency, measured usage, elasticity and scalability.

The n-tier architecture:

Explain various use of client platforms, including mobile phone and tablets and desktop client.

Define the representation layer, e.g. understand the modification of outputs from the applications layer.

Define the application layer, e.g. business logic, communication with the database layer.

Understand how the authentication and authorisation works between representation and application layers.

Establish the difference between nonrelational and relational databases, and define the database layer.

Consider different service models in terms of benefits, drawbacks, and functionality for organisational need:

Review SaaS (software as a service), including web access to commercial software, centrally managed software, software delivered in a 'one to many' model, centrally managed software upgrades and patches and integration via Application Programming Interfaces (APIs).

Consider PaaS (Platform as a Service) and IaaS (Infrastructure as a Service) for further developmental activities such as testing, deploying and supporting applications, public and private infrastructure.

LO2 Design a cloud-based website, including tools, technologies and software for a business case

Establish the client and end user requirements:

Differentiate client requirements from actual behaviours to determine appropriate user requirements.

Consider how audience and purpose could influence the look and feel of a website.

Review accessibility standards and guidelines and their possible impact on design and aesthetics.

Comprehensive design:

Plan design plans for a selected business case, e.g. storyboard, data dictionary, schema.

Implement a testing methodology, e.g. regression testing, functional and non-functional testing.

Select appropriate software for developing a website, e.g. PHP interactive websites, JavaScript, CSS frameworks and packages, MySQL and NoSQL, use of API.

Consider server-side programming used to enable personalisation and deliver dynamic content.

Tools, techniques and software used to develop websites:

Consider User Experience (UX) through the Rich Internet Application (RIA).

Using front-end technologies to build an appropriate user interface using selected software.

Use relevant tools to back-end programming (client-side) to build a User Interface (UI).

LO3 Build a multipage cloud-based website, based on a design for a given business case

Build tools and techniques:

Select an appropriate database for back end-processing, e.g. SQL.

Select appropriate external data for customisation and enhancement of the user experience, e.g. APIs.

Implement security to encourage user confidence, e.g. authentication, hashing.

Hosting considerations:

Selecting an appropriate cloud vendor service based on the business case.

Creating a hosting account from a selected vendor.

Select add-ons based on business case objectives.

Testing:

Conduct testing, e.g. alpha, beta, white box, black box.

Carry out testing against user requirements, e.g. test scripts, test data, test cases and defects.

LO4 Review the cloud-hosted website against the requirements of the business case.

Performance:

Review performance, including retaining users, improving conversions, cost, audit resources, limiting data sent, compressing resources, optimise images, use video instead of animated GIFs.

Website review:

Evaluate the website in terms of meeting client's requirements, including suitability for intended purpose and audience, quality in comparison with other similar websites, strengths and any improvements made and review of data analytics and metrics.

Hosting on the cloud:

Demonstrate how to host in the cloud by assigning an IP address, enabling SSH Access, testing Apache configuration, image preparation, image scrubbing, image creation, reusing and sharing content, building an image crawler, using utility functions and processing pipeline.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Discuss cloud technologies and management services associated with hosting websites for specific organisational need	
P1 Discuss the core characteristics of cloud technologies, architectures and service models for hosting websites. P2 Discuss the n-tier architecture in relation to designing and building a website for organisational need.	M1 Analyse the impact of hosting a website and developing frameworks with regard to functionality and management in the cloud.	D1 Evaluate the technologies, service models and characteristics for hosting a website based on organisational needs.
	LO2 Design a cloud-based website, including tools, technologies and software for a business case	
P3 Design a multipage website based on user requirements for a business case. P4 Discuss the range of tools and techniques used to develop the design and how they meet the requirements of the business case.	M3 Produce a comprehensive design for a fully functional website, discussing the potential issues and constraints during the development process.	D2 Evaluate the design and development process against design documentation, commenting on any technical challenges and how they were overcome.
	LO3 Build a multipage cloud-based website, based on a design for a given business case	
P5 Develop the website based on the designs for the identified user requirements. P6 Deploy the developed website to the cloud, selecting appropriate hosting services. P7 Test the multi-page website against the test plan developed.	M4 Compare the multipage website created to the design document and justify changes that have been made as a result of testing.	

Pass	Merit	Distinction
LO4 Review the cloud-hosted website against the requirements of the business case.		
P7 Review the performance of the hosted website against the original user requirements, based on metric data.	M5 Analyse the suitability of the hosting service selected, using the metric data collected, in meeting the user requirements.	D3 Evaluate the web analytic data and include a review of the overall success of the multipage website; use this evaluation to explain any areas of success and provide justified recommendations for areas that require improvement.

Recommended Resources

Textbooks

ERL T., MAHMOOD Z., PUTTINI R. (2013) *Cloud Computing: Concepts, Technology & Architecture*. USA: Prentice Hall

FRAIN, B. (2012) *Responsive Web Design with HTML5 and CSS*. UK: Packt Publishing

KAVIS M. J. (2014) *Architecting the Cloud*. USA: Wiley

KRUG, S. (2014) *Don't Make Me Think, Revisited: A Common Sense Approach to Web Usability*. USA: New Riders

LIDWELL, W., HOLDEN, K. AND BUTLER, J. (2010) *Universal Principles of Design, Revised and Updated: 115 Ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions and Teach Through Design*. USA: Rockport Publishers

RAFAELS R. (2015) *Cloud Computing from Beginning to End*. CreateSpace Independent Publishing Platform

Web

azure.microsoft.com	Microsoft Azure <i>What is Cloud Computing?</i> (general reference)
W3schools.com	W3Schools.com <i>HTML – The language for building web pages</i> (general reference)

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 3: Security in the Cloud

Unit 19: Software Development Methodologies for the Cloud.

Unit 8: Professional Practice

Unit code	Y/615/1620
Unit level	4
Credit value	15

Introduction

The need to be effective as a communicator, critical thinker, analyser, team worker and interpreter is essential. Within the workplace these skills are needed on a daily basis to show proficiency in designated tasks as part of a job role. The development of academic competence, and also the continuation of life-long learning and Continuing Professional Development (CPD), is required to ensure that individuals have a valued set of interpersonal skills that can be applied to any situation or environment.

This unit provides a foundation for good practice in a variety of contexts. The ability to communicate effectively using different tools and mediums will ensure that practical, research, design, reporting and presentation tasks are undertaken professionally and in accordance with various communication conventions. In everyday life the ability to apply critical reasoning and solve problems are necessary skills to enable task resolution and facilitate effective decision-making. Working with others in a group environment academically or within the workplace is an integral part of everyday life. Therefore, understanding the dynamics of teams in terms of culture, roles and responsibilities will ensure that there is a better understanding and awareness of the importance and value of teamwork. Continuing professional development, self-improvement and working towards various goals is an area that is encouraged in the workplace through the appraisals framework. In addition, professional development extends into higher levels of learning and the need to demonstrate effective research skills and academic reporting skills is also required.

Among the topics included in this unit are: the development of communication skills and communication literacy; the use of qualitative and quantitative data to demonstrate analysis, reasoning and critical thinking; and tasks that require the integration of others within a team-based scenario and planning and problem-solving.

On successful completion of this unit students will be able to demonstrate leadership skills through the dynamics of team working, and through reflective practice be able to evaluate the contributions made as an individual and of others. As a result, they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Demonstrate a range of interpersonal and transferable communication skills to a target audience
- 2 Apply critical reasoning and thinking to a range of problem-solving scenarios
- 3 Discuss the importance and dynamics of working within a team and the impact of team working in different environments
- 4 Examine the need for Continuing Professional Development (CPD) and its role within the workplace and for higher level learning.

Essential Content

LO1 Demonstrate a range of interpersonal and transferable communication skills to a target audience

Effective communication:

Verbal and non-verbal e.g. awareness and use of body language, openness and responsiveness, formal and informal dialogue and feedback to a range of different stakeholders; academic report writing; use of IT to enhance communication; use of source information to undertake research.

Interpersonal skills:

Soft skills e.g. personal effectiveness, working with others, use of initiative, negotiating skills, assertiveness skills and social skills.

Time management skills:

Prioritising workloads; setting objectives; using time effectively; making and keeping appointments; planning and scheduling tasks and activities.

LO2 Apply critical reasoning and thinking to a range of problem-solving scenarios

Specification of the problem:

Definition of the problem; analysis and clarification.

Identification of possible outcomes:

Identification and assessment of various alternative outcomes. Tools and methods:

Use of problem-solving methods and tools.

Plan and implement:

Sources of information; solution methodologies; selection and implementation of the best corrective action e.g. timescale, stages, resources, critical path analysis.

Evaluation:

Evaluation of whether the problem was solved or not; measurement of solution against specification and desired outcomes; sustainability.

LO3 Discuss the importance and dynamics of working within a team and the impact of team working in different environments

Working with others:

Nature and dynamics of team and group work; informal and formal settings; purpose of teams and groups e.g. long-term corporate objectives/strategy; problem-solving and short-term development projects; flexibility/adaptability; team player.

Teams and team building:

Selecting team members e.g. specialist roles, skill and style/approach mixes; identification of team/work group roles; stages in team development e.g. team building, identity, loyalty, commitment to shared beliefs, team health evaluation; action planning; monitoring and feedback; coaching skills; ethics; effective leadership skills e.g. setting direction, setting standards, motivating, innovative, responsive, effective communicator, reliability, consistency.

LO4 Examine the need for Continuing Professional Development (CPD) and its role within the workplace and for higher level learning.

Responsibilities:

Own responsibilities e.g. personal responsibility, direct and indirect relationships and adaptability, decision-making processes and skills, ability to learn and develop within the work role; other e.g. employment legislation, ethics, employment rights and responsibilities.

Performance objectives:

Setting and monitoring performance objectives, measurement tools for success and achievement.

Continuing Professional Development: lifelong learning, training and development, personal development, professional development.

Evidence criteria:

Production data, personnel data, judgmental data; rating methods e.g. ranking, paired comparison, checklist, management by objectives; skills audit (personal profile using appropriate self-assessment tools); evaluating self-management; personal and interpersonal skills.

Motivation and performance:

Application and appraisal of motivational theories and techniques, rewards and incentives; manager's role; self-motivational factors.

Development plan:

Current performance; future needs; opportunities and threats to career progression; aims and objectives; achievement dates; review dates; learning programme/activities; action plans; personal development plans.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Demonstrate a range of interpersonal and transferable communication skills to a target audience	
P1 Demonstrate, using different communication styles and formats, that you can effectively design and deliver a training event for a given target audience. P2 Demonstrate that you have used effective time management skills in planning an event.	M1 Design a professional schedule to support the planning of an event, to include contingencies and justifications of time allocated.	D1 Evaluate the effectiveness and application of interpersonal skills during the design and delivery of a training event.
	LO2 Apply critical reasoning and thinking to a range of problem-solving scenarios	
P3 Demonstrate the use of different problem-solving techniques in the design and delivery of an event. P4 Demonstrate that critical reasoning has been applied to a given solution.	M2 Research the use of different problem-solving techniques used in the design and delivery of an event. M3 Justify the use and application of a range of solution methodologies.	D2 Critique the process of applying critical reasoning to a given task/activity or event.
	LO3 Discuss the importance and dynamics of working within a team and the impact of team working in different environments	
P5 Discuss the importance of team dynamics in the success and/or failure of group work. P6 Work within a team to achieve a defined goal.	M4 Analyse team dynamics, in terms of the roles group members play in a team and the effectiveness in terms of achieving shared goals.	D3 Provide a critical evaluation of your own role and contribution to a group scenario.

Pass	Merit	Distinction
<p>LO4 Examine the need for Continuing Professional Development (CPD) and its role within the workplace and for higher level learning.</p> <p>P7 Discuss the importance of CPD and its contribution to own learning.</p> <p>P8 Produce a development plan that outlines responsibilities, performance objectives and required skills, knowledge and learning for own future goals.</p>	<p>M5 Compare and contrast different motivational theories and the impact they can have on performance within the workplace.</p>	<p>D4 Evaluate a range of evidence criteria that is used as a measure for effective CPD.</p>

Recommended Resources

Textbooks

COTTRELL, S. (2001) *Critical Thinking Skills: Developing Effective Analysis and Argument*. 2nd Ed. Palgrave Macmillan.

FORDE, C. (2006) *Professional Development, Reflection and Enquiry*. Sage Publications.

MEGGINSON, D. and WHITAKER, V. (2007) *Continuing Professional Development*. 2nd Ed. Chartered Institute of Personnel and Development.

WINSTANLEY, D. (2005) *Personal Effectiveness: A guide to action*.

Chartered Institute of Personnel and Development.

Journals

Journal of Group Dynamics Professional Development in Education

Websites

ipda.org.uk	International Professional Development Association (General Reference)
www.thinkwatson.com	Critical Thinking Resources “Critical Thinking Correlation Studies” (Research)

Links

This unit links to the following related units:

Unit 6: Deploying and Operating in the Cloud (Pearson set)

Unit 12: Cloud Computing Research Project

Unit 9: Maths for Computing

Unit code	D/615/1635
Unit level	4
Credit value	15

Introduction

In 1837 English mathematicians Charles Babbage and Ada Lovelace collaboratively described a machine that could perform arithmetical operations and store data within memory units. This design of their ‘Analytical Engine’ is the first representation of modern, general-purpose computer technology. Although modern computers have advanced far beyond Babbage and Lovelace’s initial proposal, they are still fundamentally relying on mathematics for their design and operation.

This unit introduces students to the mathematical principles and theory that underpin the computing curriculum. Through a series of case studies, scenarios and task-based assessments students will explore number theory within a variety of scenarios; use applicable probability theory; apply geometrical and vector methodology; and finally evaluate problems concerning differential and integral calculus.

Among the topics included in this unit are prime number theory, sequences and series, probability theory, geometry, differential calculus and integral calculus.

On successful completion of this unit students will be able to gain confidence with the relevant mathematics needed within other computing units. As a result they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Use applied number theory in practical computing scenarios
- 2 Analyse events using probability theory and probability distributions
- 3 Determine solutions of graphical examples using geometry and vector methods
- 4 Evaluate problems concerning differential and integral calculus.

Essential Content

LO1 Use applied number theory in practical computing scenarios

Number theory:

Converting between number bases (Denary, Binary, Octal, Duodecimal and Hexadecimal).

Prime numbers, Pythagorean triples and Mersenne primes. Greatest common divisors and least common multiples.

Modular arithmetic operations.

Sequences and series:

Expressing a sequence recursively.

Arithmetic and geometric progression theory and application. Summation of series and the sum to infinity.

LO2 Analyse events using probability theory and probability distributions

Probability theory:

Calculating conditional probability from independent trials. Random variables and the expectation of events.

Applying probability calculations to hashing and load balancing.

Probability distributions:

Discrete probability distribution of the binomial distribution.

Continuous probability distribution of the normal (Gaussian) distribution.

LO3 Determine solutions of graphical examples using geometry and vector methods

Geometry:

Cartesian co-ordinate systems in two dimensions. Representing lines and simple shapes using co-ordinates. The co-ordinate system used in programming output device.

Vectors:

Introducing vector concepts.

Cartesian and polar representations of a vector. Scaling shapes described by vector co-ordinates.

LO4 Evaluate problems concerning differential and integral calculus.

Differential calculus:

Introduction to methods for differentiating mathematical functions. The use of stationary points to determine maxima and minima.

Using differentiation to assess rate of change in a quantity.

Integral calculus:

Introducing definite and indefinite integration for known functions. Using integration to determine the area under a curve.

Formulating models of exponential growth and decay using integration methods.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Use applied number theory in practical computing scenarios		
P1 Calculate the greatest common divisor and least common multiple of a given pair of numbers. P2 Use relevant theory to sum arithmetic and geometric progressions.	M1 Identify multiplicative inverses in modular arithmetic.	D1 Produce a detailed written explanation of the importance of prime numbers within the field of computing.
LO2 Analyse events using probability theory and probability distributions		
P3 Deduce the conditional probability of different events occurring within independent trials. P4 Identify the expectation of an event occurring from a discrete, random variable.	M2 Calculate probabilities within both binomially distributed and normally distributed random variables.	D2 Evaluate probability theory to an example involving hashing and load balancing.
LO3 Determine solutions of graphical examples using geometry and vector methods		
P5 Identify simple shapes using co-ordinate geometry. P6 Determine shape parameters using appropriate vector methods.	M3 Evaluate the co-ordinate system used in programming a simple output device.	D3 Construct the scaling of simple shapes that are described by vector co-ordinates.
LO4 Evaluate problems concerning differential and integral calculus.		
P7 Determine the rate of change within an algebraic function. P8 Use integral calculus to solve practical problems involving area.	M4 Analyse maxima and minima of increasing and decreasing functions using higher order derivatives.	D4 Justify, by further differentiation, that a value is a minimum.

Recommended Resources

Textbooks

STROUD, K. A. (2009) *Foundation Mathematics*. Basingstoke: Palgrave Macmillan.

Journals

Journal of Computational Mathematics. Global Science Press.

Links

This unit links to the following related units:

Unit 4: Programming

Unit 21: Applied Programming and Design Principles

Unit 24: Data Structures & Algorithms

Unit 10: Computer Systems Architecture

Unit code	J/615/1628
Unit level	4
Credit value	15

Introduction

As technology develops, it is important to have a working foundation on which to build your knowledge. Despite hardware and software being constantly updated and seemingly becoming more complex, students with a solid, underpinned knowledge about computer systems architecture will not only be able to answer questions like, "How does a central processor work?", "What does an operating system do?", "How is information stored?", "What is an instruction set?" and "How do I actually connect to the internet?", but will also be able to transfer and apply their knowledge and skill to many other areas.

This unit introduces students to the foundations of computer systems architecture together with the integrated hardware and software components and subsystems that enable and allow data to be input, processed and output. The unit further explores the concepts of operating systems, hardware management and computer networks together with the practical skills needed to diagnose, troubleshoot and maintain computer systems taking the security of these systems into consideration.

Among the topics included in this unit are: CPUs, memory, input & output devices, ALU operations, program execution, operating systems (including kernel, file systems, API and system calls), hardware management, installation, firmware, device drivers, networking (including OSI and TCP/IP models), error and information gathering, fault diagnostics, security and problem resolution.

On successful completion of this unit, students will be able to explain the purpose and role of operating systems, the relationship between the subsystems embedded within a central processing unit, the core hardware and software components associated with computer operations and be able to configure the hardware and systems needed to establish a computer network together with practical diagnostic and troubleshooting techniques. As a result they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Explain the relationships between hardware components and the subsystems used in a computer system
- 2 Categorise the key features and services provided by different computer operating systems and hardware
- 3 Use network communication technology and the associated services to connect computer systems
- 4 Demonstrate diagnostic and troubleshooting skills to solve hardware, software and networking related issues.

Essential Content

LO1 Explain the relationships between hardware components and the subsystems used in a computer system

Hardware components and subsystems:

Computers consist of four main subsystems (Von Neumann Architecture, Memory, CPU (Arithmetical & Logic Unit (ALU) and Control Unit), Input and output Systems).

Review Memory subsystems regarding programs and data (variable) storage (ROM, RAM, size, speed, operation and structure).

Explore Input/output systems and structure (communicating with other devices (screen, keyboard, printers, etc.), storage (Hard Disk Drives (HDD), DVD's, etc.), IO controllers & data transfer (speed, buffers, interrupts, etc.).

Discuss ALU subsystems (mathematical & logical operations, registers, bus, etc.).

Investigate how the Control Unit works (program code & language, fetch, decode, execute, halt) including an introduction to machine language instructions (reduced instruction and complex instruction sets: arithmetic, compare, branch, control, Program Counter (PC), Instruction Register (IR) and Instruction decoder.

LO2 Categorise the key features and services provided by different computer operating systems and hardware

Operating system types and hardware:

Introduce different operating systems and types (desktop & server/network, mobile, embedded systems (e.g. Windows 10, Windows Server 2012/2016, Linux, Unix, MacOS, IOS, Android, etc.).

Hardware management and connections including the hardware abstraction layer, firmware and device drivers (network cards, video cards, optical drives, magnetic disks, solid state drives, RAID, etc.).

Installing and configuring common peripheral devices (mouse, keyboard, scanners, biometrics, webcams, smartcards, motion sensor, printers, speakers, display devices, etc.).

Features and services:

Introduce Operating Systems Architecture (Kernel, File Systems, API).

Review how operating systems function and provide services (user interface, memory management (Direct Memory Access), file management).

LO3 Use network communication technology and the associated services to connect computer systems

Networking technology and services:

Network protocols HTTP, SMTP, TCP, UDP, etc.

Layers of the TCP/IP Model: Application layer, transport layer, internet layer, network access layer.

7 layer OSI Model: purpose, architecture, functionality.

Hardware and network addresses: physical/MAC addresses, forward frame using MAC address tables, address resolution protocol (ARP), logical/IP addresses.

Network devices and components: network interface cards (NIC), network cables, switches, wireless access points, routers, network services.

Connecting computer systems to a network:

Introduce topologies including physical and logical: bus, star (extended star), ring and mesh.

Establishing network connections including wired/wireless client configuration. Security of networking systems and the importance of this.

LO4 Demonstrate diagnostic and troubleshooting skills to solve hardware, software and networking related issues.

Hardware, software & networking issues and maintenance:

Different hardware and software related problems and the implication of choices with regards to system administration, impact on users and business operations.

Explore methods of maintenance with regard to hardware and software.

Diagnostic and troubleshooting skills:

Discuss information gathering methods and techniques (such as: system documents, user information, error codes, error messages, failure domain, problem history, etc.).

Consider solutions to security problems.

Analyse evidence and establish possible problem domains, complexity, priority and impact; introduce 'Research, Determine, Implement, Review, Document (and Repeat)'.

Creating and updating system documentation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain the relationships between hardware components and the subsystems used in a computer system		
P1 Identify the main subsystems of a computer and explain how they are organised and connected. P2 Explain the purpose of the Central Processing Unit (CPU) and include details on its operation.	M1 Review the operation of the CPU and assess its dependency and performance with regards to associated systems and subsystems.	D1 Evaluate the structure and functions of an operating system including memory, processor, device, file, security, performance and error management with regards to functionality, operation and dependency.
LO2 Categorise the key features and services provided by different computer operating systems and hardware		
P3 Describe a range of different operating systems including the purpose, use and hardware requirements of each. P4 Discuss the key features associated with the architecture of an operating system.	M2 Analyse the services provided by an operating system with regards to user interaction, memory management, file management and hardware support.	
LO3 Use network communication technology and the associated services to connect computer systems		
P5 Explain the relationships between hardware and network addresses including their use with regards to networking devices and components.	M3 Compare common physical and logical networking topologies and explain the differences and purposes of each.	D2 Evaluate the OSI and TCP/IP models with regards to hierarchy, layers and services including information on the associated protocols and hardware.

Pass	Merit	Distinction
	LO4 Demonstrate diagnostic and troubleshooting skills to solve hardware, software and networking related issues.	
<p>P7 Use information gathering methods to assess, troubleshoot and document solutions to a number of different technical hardware, software and networking issues.</p> <p>P8 Conduct and document a range of maintenance activities with regards to computer hardware and software.</p>	<p>M4 Review different diagnostic and troubleshooting skills including data gathering methods and techniques.</p>	<p>D3 Assess any future improvements that may be required to ensure the continued effectiveness of a computer system.</p>

Recommended Resources

Textbooks

DOCTER, Q., DULANEY, E. and SKANDIER, T. (2015) *CompTIA A+ Complete Study Guide: Exams 220-901 and 220-902*. USA: John Wiley & Sons Inc.

MUELLER, S. (2015) *Upgrading and Repairing PCs*. USA: Que Publishing.

PATTERSON, D. and HENNESSY, J. (2013) *Computer Organization and Design: The Hardware/Software Interface*. USA: Elsevier.

Links

This unit links to the following related units:

Unit 2: Networking in the Cloud

Unit 17: Applied Security in the Cloud

Unit 11: Strategic Information Systems

Unit code	A/615/1626
Unit level	4
Credit value	15

Introduction

Information is the most valuable resource that an organisation possesses. The effective gathering, protection, analysis, processing and dissemination of information is vital to the success of any organisation. As globalisation and the 24-hour economy develop and increase, organisations must ensure that their information systems are reliable, efficient and able to cope with rapid change.

This unit introduces students to the importance of information to organisations. It will examine how systems can be used to support core business functions and enable organisations to be more productive and competitive within the global marketplace.

Students will be required to analyse the information needs of an organisation at different levels and within different functional areas. It is important that computing professionals can understand how an organisation works and how it uses information in order to be able to design, implement, maintain and manage secure information systems to support its operations.

Among the topics included in this unit are understanding organisations in terms of their information needs and the variances within different functional areas.

Examination of different information systems at the operational, tactical and strategic levels will be required, in addition to evaluating their effectiveness and role in terms of decision making and gaining competitive advantage.

On successful completion of this unit students will have an insight into the types of systems and technologies available for effective information processing. Critical analysis will also be used to examine the integrated role that each of these play in contributing to the efficiency and competitiveness of organisations.

As a result, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Analyse the information requirements of organisations
- 2 Discuss the types of information systems that are used within all levels of an organisation
- 3 Demonstrate the use of an information system to produce management information
- 4 Evaluate the effectiveness of strategic information systems.

Essential Content

LO1 Analyse the information requirements of organisations

Functional area information requirements:

Finance and accounts for payroll, pensions, supplier payments and invoicing etc., human resources e.g. employee records, personnel data, appraisals, CPD etc., stock control, sales, marketing, research and development, production, distribution, IT, customer service and administration.

Information needs:

How different functional areas use and process data effectively; the integration of data and information within an organisation.

Requirements analysis:

The inputs, outputs and processing activities; information distribution requirements e.g. by location, department, individual/customer.

LO2 Discuss the types of information systems that are used within all levels of an organisation

Information systems types:

Business information systems, decision support systems, management information systems, strategic/executive information systems, office information systems, transaction processing systems, expert systems, global information systems, data warehouse systems, enterprise systems, enterprise resource planning systems, integrated information systems.

Categories of information systems:

Operational, tactical and strategic information systems.

Information and data:

Definition of information and data, sources of information, information requirements and the needs for information at different levels within an organisation; storing information and its importance with regard to security, accuracy and relevance; outputs e.g. payroll, invoicing, ordering, bookings, stock control, personnel records, goods tracking, decision-making, marketing, customer service.

LO3 Demonstrate the use of an information system to produce management information

Management information:

Reports e.g. sales report, college enrolment statistics, marketing analysis (brick v click), trends in the market, competition and market share.

Gathering information:

Defining requirements; establishing sources of information; defining other factors to be considered e.g. constraints and access to information.

Selecting information:

Analysis of information in terms of validity, accuracy, currency and relevancy; identifying and rationalising meaningful information from data sets.

Uses:

Proficiency in terms of accessing quality information that can be used for decision-making, problem-solving, predictions, trending and forecasting.

LO4 Evaluate the effectiveness of strategic information systems.

Models for strategic information systems:

Porter's Competitive Advantage and Wiseman's Strategic Planning Process.

Competitive advantage:

How can competitive advantage be measured and attributed to the implementation of a strategic information system?

Gaining competitive advantage:

Delivering a differentiated product or service; delivering a product or service at a lower cost; specific segmentation of the market e.g. targeted marketing to specific target audiences; innovative product or service design and implementation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse the information requirements of organisations		
P1 Discuss the information needs and requirements for the functional departments of an organisation. P2 Produce an input/output (I/O) diagram to represent the data and information requirements of a functional department.	M1 Compare and contrast different processing activities that occur within functional departments within an organisation.	D1 Evaluate the inputs, outputs and processing activities of a selected organisation.
LO2 Discuss the types of information systems that are used within all levels of an organisation		
P3 Describe the function of different information systems. P4 Discuss the information needs required at differing levels within an organisation.	M2 Analyse the effectiveness of information systems at the operational, tactical and strategic levels within an organisation.	D2 Differentiate between the function and purpose of information systems at different levels within an organisation.
LO3 Demonstrate the use of an information system to produce management information		
P5 Demonstrate the use of an information system for management reporting purposes. P6 Discuss the importance of an organisation having data and information that is current, valid and accurate.	M3 Analyse the constraints that an organisation can face when gathering data and information.	D3 Critique, with examples, how a given organisation can use information for effective decision-making and forecasting.
LO4 Evaluate the effectiveness of strategic information systems.		
P7 Identify different models that can be applied to strategic information systems.	M4 Justify the ways in which an organisation can obtain competitive advantage within a global market.	D4 Evaluate how strategic information systems can contribute to the competitiveness of organisations.

Recommended Resources

Textbooks

PEPPARD, J. (2016) *The Strategic Management of Information Systems: Building a Digital Strategy*. 4th Ed. John Wiley & Sons.

ROBSON, W. (1997) *Strategic Management and Information Systems: An Integrated Approach*. 2nd Ed. Financial Times/ Prentice Hall.

WARD, J. (2002) *Strategic Planning for Information Systems*. 3rd Ed. John Wiley & Sons.

WHITELY, D. (2013) *An Introduction to Information Systems*. Palgrave Macmillan.

Journals

The Journal of Strategic Information Systems *Information Systems Journal*

Websites

it.toolbox.com	ToolBox.com
	"Strategic Information System Toolbox" (Wiki)
www.mbaknol.com	MBA Knowledge Base
	"Strategic Information Systems" (Article)

Links

This unit links to the following related units:

Unit 5: Database Design & Development in the Cloud

Unit 15: Cloud Systems Integration

Unit 28: Business Intelligence

Unit 12: Cloud Computing Research Project (Pearson Set)

Unit code	Y/618/4889
Unit level	5
Credit value	30

Introduction

This unit is assessed through a Pearson-set assignment. Students will choose their own project, based on a theme provided by Pearson (the theme will change annually). The project must be related to their specialist pathway of study. This will enable students to explore and examine a relevant and current topical aspect of computing in a business context within their chosen specialist pathway.

The aim of this unit is to offer students the opportunity to engage in sustained research in a specific field of study. The unit enables students to demonstrate the capacity and ability to identify a research theme, to develop research aims, objectives and outcomes, and to present the outcomes of such research in both written and verbal formats. Students will be encouraged to reflect on their engagement in the research process, during which recommendations for future personal development are key learning points.

On successful completion of this unit, students will have the confidence to engage in problem-solving and research activities, which are part of the function of a manager. Students will have the fundamental knowledge and skills to enable them to investigate workplace issues and problems, determine appropriate solutions and present evidence to various stakeholders in an acceptable and understandable format. As a result, they will develop skills such as communication literacy, critical thinking, analysis, synthesis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Examine appropriate research methodologies and approaches as part of the research process
- 2 Conduct and analyse research relevant to a computing research project
- 3 Communicate the outcomes of a research project to identified stakeholders
- 4 Reflect on the application of research methodologies and concepts.

Essential Content

LO1 Examine appropriate research methodologies and approaches as part of the research process

Developing a research proposition:

The importance of developing methodical and valid propositions as the foundation for a research project.

Rationale: the purpose and significance for research question or hypothesis.

The value of the philosophical position of the researcher and the chosen methods.

Use of Saunders' research onion as a guide to establishing a methodological approach.

Literature review:

Conceptualisation of the research problem or hypothesis.

The importance of positioning a research project in context of existing knowledge.

Significance and means of providing benchmarks by which data can be judged.

Qualitative, quantitative and mixed method research:

Key theoretical frameworks for research.

Advantages and limitations of qualitative and quantitative research approaches and methods.

LO2 Conduct and analyse research relevant for a business research project

Research as a process:

Research has distinct phases, which support a coherent and logical argument. This includes using secondary research to inform a primary, empirical, study.

Selecting a sample:

The importance of gathering data and information (qualitative or quantitative) to support research analysis.

Selecting sample types and sizes that are relevant to the research.

Considering sampling approaches and techniques, including probability and non-probability sampling.

Ethics, reliability and validity:

Research should be conducted ethically. How is this achieved and reported?

Research should also be reliable (similar results would be achieved from a similar sample) and valid (the research measures what it aimed to measure).

Analysing data:

Using data collection tools such as interviews and questionnaires. Using analytical techniques such as trend analysis, coding or typologies.

LO3 Communicate the outcomes of a research project to identified stakeholders

Stakeholders:

Who are they?

Why would they be interested in the research outcomes? What communication method do they expect?

Communicating research outcomes:

Consideration of different methods of communicating outcomes (e.g. written word, spoken word) and the medium (e.g. report, online, presentation).

The method and medium will be influenced by the research and its intended audience.

Convincing arguments:

No matter what the method/medium, all research should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the research process.

The importance of developing evaluative conclusions.

LO4 Reflect on the application of research methodologies and concepts.

Reflection for learning and practice:

Difference between reflecting on performance and evaluating a research project. The former considers the research process; the latter considers the quality of the research argument and use of evidence.

Reflection on the merits, limitations and potential pitfalls of the chosen methods.

The cycle of reflection:

To include reflection in action and reflection on action.

Considering how to use reflection to inform future behaviour and future considerations.

Reflective writing:

Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Examine appropriate research methodologies and approaches as part of the research process	
P1 Produce a research proposal that clearly defines a research question or hypothesis supported by a literature review. P2 Examine appropriate research methods and approaches to primary and secondary research.	M1 Evaluate different research approaches and methodology, and make justifications for the choice of methods selected, based on philosophical/theoretical frameworks.	D1 Critically evaluate research methodologies and processes in application to a computing research project to justify chosen research methods and analysis.
	LO2 Conduct and analyse research relevant for a business research project	
P3 Conduct primary and secondary research using appropriate methods for a computing research project that consider costs, access and ethical issues. P4 Apply appropriate analytical tools, analyse research findings and data.	M2 Discuss merits, limitations and pitfalls of approaches to data collection and analysis.	
	LO3 Communicate the outcomes of a research project to identified stakeholders	
P5 Communicate research outcomes in an appropriate manner for the intended audience.	M3 Communicate outcomes to the intended audience demonstrating how outcomes meet set research objectives.	D2 Communicate critical analysis of the outcomes and make valid, justified recommendations.

Pass	Merit	Distinction
<p>LO4 Reflect on the application of research methodologies and concepts.</p> <p>P6 Reflect on the effectiveness of research methods applied for meeting objectives of the computing research project.</p> <p>P7 Consider alternative research methodologies and lessons learnt in view of the outcomes.</p>	<p>M4 Analyse results in recommended actions for improvements and future research considerations.</p>	<p>D3 Demonstrate reflection and engagement in the research process, leading to recommended actions for future improvement.</p>

Recommended Resources

Textbooks

CORNFORD, T. (2005) *Project Research in Information Systems: A Student's Guide.* Paperback. Macmillan

COSTLEY, C., ELLIOT, G. and GIBBS, P. (2010) *Doing Work Based Research: Approaches to Enquiry for Insider-researchers.* London: SAGE

FINK, A. (2009) *Conducting Research Literature Reviews: From the Internet to Paper.* 3rd Ed. Sage Inc

FLICK, U. (2011) *Introducing Research Methodology: A Beginner's Guide to Doing a Research Project.* London: SAGE

GRAY, D. (2009) *Doing Research in the Real World.* 2nd Ed. London: SAGE

SAUNDERS, M, LEWIS, P and THORNHILL, A. (2012) *Research methods for Business Students.* 6th Ed. Harlow: Pearson

WELLINGTON, J. (2000) *Educational Research: Contemporary Issues and Practical Approaches.* Continuum International Publishing Group Ltd

Journals

International Journal of Quantitative and Qualitative Research Methods

Qualitative Research Journal

Links

This unit links to the following related units:

Unit 6: Deploying and Operating in the Cloud Project (Pearson Set)

Unit 8: Professional Practice

Unit 19: Software Development Methodologies for the Cloud.

Unit 13: Cloud Architecture Design

Unit code	R/618/4891
Unit level	5
Credit value	15

Introduction

Cloud computing has revolutionised the way that IT services are delivered and it has become an important part of the computing sector. Cloud computing is internet-hosted computing, which means that it uses the internet to deliver data and other IT services, such as storage, printing and server facilities.

Cloud architecture is how individual technologies are integrated to create clouds and how all the components and capabilities necessary to build a cloud are connected to deliver an online platform on which applications can run. The entire cloud architecture is aimed at providing users with high bandwidth, allowing them to have uninterrupted access to data and applications, on-demand agile network with possibility to move quickly and efficiently between servers or even between clouds and, most importantly, network security.

This unit is designed for students to produce a cloud feasibility assessment, develop an understanding of the architectural design principles and to design an infrastructure for a substantial problem. Students will examine the services and resources required for development of a solution and understand the fundamentals of testing a solution.

On successful completion of this unit, students will be able to define a solution for a defined problem using architectural design principles, develop an infrastructure solution based on the design and be able to test the solution against requirements. As a result, they will develop skills such as communication literacy, critical thinking, analysis, problem solving, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Produce a cloud feasibility assessment for a defined problem for a small-to-medium-sized organisation
- 2 Use appropriate architectural design principles to design an infrastructure for a defined problem
- 3 Implement an infrastructure solution using cloud architectural design principles based on defined requirements
- 4 Analyse the metric monitoring and alert system to baseline the health of your cloud environment.

Essential Content

LO1 Produce a cloud feasibility assessment for a defined problem for a small-to-medium-sized organisation

Elements of a defined problem:

Medium-sized enterprise, including both business and technical cloud feasibility options.

Exploration of background and current infrastructure issues of selected business scenario.

Feasibility assessment:

Consider what processes the business carries out, e.g. sales, marketing, making payments, stock management.

Current IT infrastructure of the organisation, e.g. hardware and software, network capabilities.

Criteria to consider for a business case, including vision and goals, cost-benefit analysis,

Legal, economic, technical, operational, timeframes, organisational culture and security considerations.

LO2 Use appropriate architectural design principles to design an infrastructure for a defined problem

Design principles:

Analysis of design principles, to include Operational Excellence, Security, Reliability, Performance Efficiency, Cost Optimization and their importance in relation to cloud architecture design.

Core principles:

Understanding why core principles are essential when designing cloud architecture, including elasticity and scalability.

Cloud computing architecture diagrams:

Cloud-deployment diagrams, to include application, platform and infrastructure.

On-premise resources, e.g. servers, storage, routers.

Cloud resources, to include, for example, cloud servers, virtual desktop, applications, cloud storage.

LO3 Implement an infrastructure solution using cloud architectural design principles based on defined requirements

Implementation of services:

Implementation of cloud infrastructure, to include foundational services virtualisation.

Compute components to consider, e.g. Amazon EC2, Amazon Virtual Private Cloud (VPC), Azure cloud services, Azure traffic manager, Rackspace cloud servers.

Storage services e.g. Amazon Simple Storage Service (S3), Amazon Glacier, Rackspace cloud content delivery network.

Database types and vendors to be considered for the cloud, e.g. relational, NoSQL, data warehouse, Amazon Relational Database Service (RDS), Percona Server, MariaDB, Microsoft SQL server.

Open source tools as an alternative:

Consideration of Open Source Tools for PaaS, Open Source Tools for SaaS, Distributed Computing Tools, e.g. Cassandra, Hadoop, MongoDB.

Operating system:

Selection of an appropriate operating system, e.g. Microsoft Windows Server, Linux, Unix, Oracle Solaris.

Distributed systems and application integration:

Consideration and selection, e.g. Amazon Simple Queue Service (SQS), Amazon Simple Email Service (SES), Amazon CloudSearch.

LO4 Analyse the metric monitoring and alert system to baseline the health of your cloud environment.

Gather monitoring logs and metrics of the cloud environment:

Host-based metrics, e.g. CPU, memory processes and disk space.

Application metrics, e.g. error and success rates, service failures and restarts and performance and latency of responses and resource usage.

Server pool metrics, e.g. connectivity, error rates and packet loss, latency, and bandwidth utilisation.

External dependency metrics, e.g. pooled resource usage, scaling adjustment indicators, degraded instance.

Network and connectivity metrics, e.g. service status and availability, success and error, rates run rate and operational costs, and resource exhaustion.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Produce a cloud feasibility assessment for a defined problem for a small- to-medium-sized organisation.		
P1 Produce a cloud feasibility assessment for an infrastructure problem by analysing the business requirements.	M1 Justify the decisions made in the cloud feasibility assessment and how they help to address the business requirements.	D1 Critically evaluate why architectural design and core principles were important in the designs.
L02 Use appropriate architectural design principles to design an infrastructure for a defined problem		
P2 Analyse the importance of architectural design and core principles for cloud infrastructure design. P3 Produce diagrams with consideration for the core and design principles for a substantial problem.	M2 Evaluate the impact of architectural design and core principles on the designs developed for the defined problem.	
L03 Implement an infrastructure solution using cloud architectural design principles based on defined requirements		
P4 Implement a cloud-based infrastructure solution based on a set of defined requirements.	M3 Analyse how the developed solution meets the defined requirements.	D2 Critically evaluate the implemented solution in meeting the defined requirements and supporting efficiency.
L04 Analyse the metric monitoring and alert system to baseline the health of your cloud environment.		
P5 Analyse the logs, the metrics and monitoring report data on the health and performance of the cloud environment against baseline expectations.	M4 Critically analyse the findings from the monitoring review to recommend ways of improving efficiency.	

Recommended Resources

Textbooks

ERL, T. (2013) *Cloud Computing: Concepts, Technology & Architecture*. London: Prentice Hall

HIRAN, K.K., DOSHI, R., FAGBOLA, T., MAHRISHI, M. (2019) *Cloud Computing: Master the Concepts, Architecture and Applications with Real-world examples and Case studies*. Delhi: BPB Publications

KAVIS, M.J. (2014) *Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, and IaaS)*. New Jersey: John Wiley & Sons Inc

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 15: Cloud Systems Integration

Unit 16: Information Security Management in the Cloud.

Unit 14: Operating Systems in the Cloud

Unit code	H/618/4894
Unit level	5
Credit value	15

Introduction

In its simplest form, an Operating System (OS) provides a core set of software commands to control a computer system. Among other things, these commands allow the computer system to boot and control connected hardware, provide the user with a means to interact with the system, and provide a link between applications and other parts of the system. In cloud computing, a user may encounter, sometimes without realising it, a number of different Operating Systems that make the use of cloud-based technologies possible.

This unit introduces students to different Operating Systems that enable cloud computing to be effectively utilised. Whether it is a customised Linux Operating system utilised by a smart TV, a smartphone Operating System such as Android and iOS, Microsoft Windows on a PC or a server Operating System, a computing professional must understand the role each plays in order to successfully deploy cloud-based solutions.

Amongst the topics covered are Operating Systems for different system types and uses, virtual environments and the cloud and implementation and testing of a cloud-based Operating System.

On successful completion of this unit, students will be able to select and justify the use of different Operating Systems for different devices and tasks and deploy and maintain a cloud-based solution to meet an identified client need.

Students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Examine the different Operating Systems and the processes they manage for a cloud environment
- 2 Discuss how virtual environments and the cloud deployment stack can meet the needs of organisations
- 3 Produce a technical specification for a cloud deployed Operating System based on a business case
- 4 Deploy a virtualised environment to meet the needs of an identified user.

Essential Content

LO1 Examine the different Operating Systems and the processes they manage for a cloud environment

Operating Systems management:

The role of the Operating System in controlling the main processes and functions of a system, including memory management, job and process scheduling, concurrent processing, device management, file management, security, and networking.

Operating Systems for different systems and use:

Operating Systems used on different devices, including smartphones, internet-enabled devices, e.g. smart TVs, personal computers, cloud/web servers.

The functions and features of different Operating Systems for different devices, e.g. Windows, Linux, Android, Chrome OS, Apache.

How they support the use of local and cloud computing in a way that is suitable for the identified device, e.g. user interface, installation footprint, system settings, local vs remote resources, compatibility, performance.

How and why local and remote devices and platforms are used in combination to create larger systems in the cloud.

The role the Operating System plays in supporting these larger systems.

LO2 Discuss how virtual environments and the cloud deployment stack can meet the needs of organisations

Virtual environments for the cloud:

Discuss how virtualisation (including Type1 and Type 2 hypervisors, and hosts), emulation and containers (para-virtualisation), are used to provide cloud services.

Cloud deployment stack:

Discuss the role of the Operating System and related virtual environments in relation to the cloud deployment stack (Applications, Data, Runtime, Middleware, OS, Virtualisation, Servers, Storage, Networking).

The role Infrastructure of Service (IaaS) in developing a 'Private Cloud'.

Understand how responsibility and ownership of resources distributed between the subscriber and service provider differ from other cloud delivery models (e.g. Platform as a service (PaaS), Software as a Service (SaaS) and Data as a Service (DaaS)).

Additional considerations of cloud deployment:

The wider considerations when selecting and deploying virtual environments to provide cloud-based services, including the benefits and drawbacks of the chosen model (OS), load and resource balancing, cloud sourcing, portability, and scalability.

LO3 Produce a technical specification for a cloud deployed Operating System based on a business case

Investigating and defining a client's needs:

The purpose and contents of a technical specification

Functional requirements, e.g. what the complete system should do.

Data requirements, e.g. velocity, volume, value, variety, and veracity, environmental requirements, e.g. the circumstances that relate to the context, use and operation of the product.

User requirements, including the characteristics of the target user group.

Key performance and acceptance criteria for the cloud deployed Operating System, e.g. user feedback measures, benchmarking statistics in relation to the wider functional and non-functional requirements of a cloud deployed system.

Refining the proposal:

Methods of gaining feedback from a client and prospective users on an initial technical specification, e.g. face-to-face meetings, video conference, questionnaires to ascertain the appropriateness of the proposed cloud deployed OS and explore potential alternatives.

LO4 Deploy a virtualised environment to meet the needs of an identified user.

Implementation:

Deployment of a cloud-based virtualised environment, including installation of an appropriate Operating System.

Configure the Operating System, including setting up appropriate security protocols, connection to and configuration of client devices, configuring access and user permissions.

Testing and refinement:

Purpose and use of a testing strategy to test the performance, functionality, security, and usability of the deployed solution.

Testing tools and methods of testing, including functional and automatic testing tools to identify issues or areas of improvement and confirm a working OS deployment.

Formal documentation of a testing strategy and its implementation, including a clear description of each planned test, specific test data to be used where appropriate, the expected outcomes, results of the test, remedial actions, and details of any regression testing.

Testing and monitoring over time to identify areas of further development, e.g. ongoing user feedback, automated testing tools, benchmarking, importance of refining the solution based on monitoring to improve the effectiveness and efficiency of the system.

Critical evaluation:

The extent to which the deployed solution meets the identified needs of the client.

Use of feedback and test outcomes, including manually recorded results and data produced by automated testing tools.

Use of key performance and acceptance criteria to support justification of quality and appropriateness of a deployed operating system.

Developments or refinements made during the planning and deployment phases.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	L01 Examine the different Operating Systems and the processes they manage for a cloud environment	
P1 Examine the role of the Operating System in controlling the main processes and functions of computer systems. P2 Discuss the Operating Systems used on different devices to support use of local and remote resources.	M1 Analyse how different Operating Systems support the use of local and cloud computing appropriate for the identified devices.	D1 Critically evaluate the extent to which the features and use of Operating Systems, virtual environments, and cloud deployment stack based systems meet different organisational needs.
	L02 Discuss how virtual environments and the cloud deployment stack can meet the needs of organisations	
P3 Discuss how virtualisation, emulation and containers are used to meet different business needs. P4 Discuss how the use of cloud deployment models support the development of a 'private cloud' in relation to Infrastructure as a Service (IaaS).	M2 Analyse how additional considerations of cloud deployment impact on the choice of virtual environment, and deployment stack, to meet different organisational needs.	

Pass	Merit	Distinction
LO3 Produce a technical specification for a cloud deployed Operating System based on a business case		
P5 Produce a technical specification that clearly defines a user's needs in a business case. P6 Refine the technical specification on feedback received during a formal review process to ensure that the solution effectively meets user needs.	M3 Justify how recommendations made in the technical specification best meet the needs of the business case in comparison to other possible solutions.	D2 Critically evaluate the extent to which the deployed Operating System meets the needs of the identified users, providing justification for choices and refinements made throughout planning and deployment.
LO4 Deploy a virtualised environment to meet the needs of an identified user.		
P7 Deploy a cloud-based Operating System to meet identified user needs. P8 Implement a suitable testing strategy to ensure the Operating System works as expected and meets the needs of the user.	M4 Refine the deployed cloud-based Operating System through ongoing testing and monitoring to improve the efficiency and performance of the service to meet user needs more effectively.	

Recommended Resources

Textbooks

ARPACI-DUSSEAU, R., ARPACI-DUSSEAU, A. (2018) *Operating Systems: Three Easy Pieces*. Arpaci-Dusseau Books

ERL, T., COPE, R., NASERPOUR, A. (2015) *Cloud Computing Design Patterns*. USA: Prentice Hall

HOLT, A., HUANG, C. (2018) *Embedded Operating Systems: A Practical Approach (Undergraduate Topics in Computer Science)*. Switzerland: Springer International Publishing

Links

This unit links to the following related units:

Unit 2: Networking in the Cloud

Unit 3: Security in the Cloud

Unit 6: Deploying and Operating in the Cloud Project (Pearson Set)

Unit 13: Cloud Architecture Design.

Unit 15: Cloud Systems Integration

Unit code	K/618/4895
Unit level	5
Credit value	15

Introduction

Many large organisations and businesses rely on a range of IT systems to support different functional areas such as finance, human resources, customer management, engineering services, product manufacturing, storage and warehousing. Increasingly, these systems are cloud based as applications, platforms, or services. Making all these systems work together to provide support for customers, processes and consistent view of data is essential for a modern enterprise. However, integrating these IT systems can be challenging because of differences in the hardware and software platforms that these systems are built on, and the dissimilar understanding of the core elements of the system such as customer profiles or product details. Cloud offers unique opportunities by reducing the complexity of hardware and platforms, while increasing the choices of applications, services, and platforms. Creating an integrated IT system requires understanding of the business requirements, the cloud-based integration practices and the current existing choices of cloud elements.

This unit introduces students to enterprise business requirements for integrating different systems from the cloud and on-premise. They will learn about the different functional and non-functional aspects of requirements gathering and will be expected to apply this knowledge to a given business case by producing a requirements document, risk assessment and feasibility analysis. Students are expected to design a solution based on this initial review that meets functional and non-functional requirements such as security, availability, manageability and customisability. As part of the design, students are required to explore various cloud technologies and best practices to incorporate in the solution.

Finally, students are expected to align their designed solution to the available cloud vendor options. In this practical step, students are expected to understand the choices that exist in the market and map the solution to a specific deployment architecture.

Among the topics included in this unit are enterprise business objectives, system integration specification documents, feasibility analysis, risk assessments, architectural development, systems integration design framework, development and deployment of a systems integration solution, quality assurance, best practices in cloud integration, cloud service models such as SaaS, PaaS and IaaS and different deployment models, such as private and public cloud services.

On successful completion of this unit, students will be able to analyse systems integration requirements with regard to business objectives, investigate various public and private cloud options, prepare a suitable integrated solution based on a set of business requirements and select from a range of available cloud options.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Analyse system integration requirements for businesses considering cloud-based integration
- 2 Plan a systems integration strategy to satisfy a business case
- 3 Design a solution that meets the business case requirements, using appropriate cloud elements
- 4 Illustrate the designed solution by mapping selected vendor products to planned deployment architecture.

Essential Content

LO1 Analyse system integration requirements for businesses considering cloud-based integration

Purpose and operation of cloud-based integration:

The standard analysis of integration from multiple system perspectives, including data, processes and user experience.

Data items to consider include formats, schemas, semantics, data transformations, data real-time vs. batch.

Processes to consider include business processes, integration of lines of businesses (e.g. point to point, publish-subscribe and on demand), automations, process hand offs, process exceptions, alerts, and metrics.

User experience, to include portals, integrated view of the processes and data for users from different functional areas and departments.

The concept of non-functional requirements, including security, availability, scalability, and manageability.

Understand wider strategic business objectives including digitalisation strategy, cloud roadmap, partnership plans, and target operating model for systems.

Review of standard methods and elements to collect requirements, e.g. systems and interface descriptions, service level agreement (SLA), data SLA, availability and ownership and responsibility of system.

Review a range of patterns, e.g. point to point integration, publish subscribe pattern and on demand.

LO2 Plan a systems integration strategy to satisfy a business case

Specifying a business case:

Business case to specify the strategic objectives, purpose and success criteria for the program to integrate many systems, technical constraints, budgetary constraints and growth plans for the solution.

Developing system integration plan:

The plan should include existing systems and interfaces, formats, and semantics.

Transformations of data, automation and integration of data, process, and user experience.

Appropriate risk mitigation strategy, including assuming and accepting some risk, avoidance of risk, control of risk, transference of risk and watching and monitoring risk.

LO3 Design a solution that meets the business case requirements, using appropriate cloud elements

System design:

System design to include data schemas with cloud elements that comprise the solution, connectivity of cloud element, system security setup, system installation and updates and test plan.

Cloud elements:

Solution to make use of appropriately selected cloud elements, e.g. cloud storage, cloud compute servers, cloud network services, cloud applications, and other cloud services.

Selection of appropriate deployment architecture which will specify the IaaS, PaaS, SaaS or on-premises choices.

LO4 Illustrate the designed solution by mapping selected vendors' products to planned deployment architecture.

Align the solution to cloud providers:

Produce a set of diagrams showing planned deployment architecture.

Selection of specific cloud provider products and how they will meet individual elements of the designed solution based on services offered, including security, availability, manageability, and customisability and privacy.

Map the hardware requirements to IaaS (Infrastructure as a Service) that includes provisioning, managing, and supporting the services.

Identify suitable PaaS (Platform as a Service) that meets the business requirements as well as strategic objectives.

Research and propose SaaS (Software as a Service) that meets the business requirement from functionality, integration, and customisation perspectives.

Evaluation risks and mitigation plans, including migration:

Consider issues of security, privacy, manageability and customisation.

Addressing budgets and risks:

Planning the system evolution to support the strategic growth plans through scaling, customisation, migration plans and budgetary constraints of the vendor.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Analyse system integration requirements for businesses considering cloud-based integration	
P1 Discuss the purpose and operation of cloud-based integration, using business examples. P2 Analyse the methods and templates used for capturing non-functional requirements, including security, availability, and manageability.	M1 Critically analyse the best practices, patterns, and techniques used in analysing non-functional requirements.	D1 Evaluate how wider strategic objectives can add additional scope and constraints to a cloud integration strategy.
	LO2 Plan a systems integration strategy to satisfy a business case	
P3 Develop a systems integration plan, documenting the functional, non-functional requirements and mitigation strategy for a given business case.	M2 Critically analyse the risks and mitigation strategy, specifically addressing migration from different clouds and on-premise systems.	D2 Evaluate the unstated functional and non-functional requirements of a given business case and their impact on the overall integration plan.

Pass	Merit	Distinction
LO3 Design a solution that meets the business case requirements, using appropriate cloud elements		
P4 Design a solution with appropriate cloud elements and deployment architecture, meeting functional and non-functional requirements. P5 Prepare a system test plan validating the system design from a functional and non-functional perspective.	M3 Produce a comprehensive design that includes details on deployment architecture, describing backups, connectivity, availability, and migration plans.	D2 Critically evaluate deployment architecture and cloud elements selected for meeting the current business requirements, future growth, and strategic objectives of digitalisation.
	LO4 Illustrate the designed solution by mapping selected vendor products to planned deployment architecture.	
P6 Illustrate, using a set of diagrams, how the designed solution can be realised by mapping to selected vendor products and services to support the objectives identified in the systems integration plan.	M4 Justify the choices made of cloud providers and how they meet the non-functional requirements.	

Recommended Resources

Textbooks

ERL, T., MAHMOOD, Z. AND PUTTINI, R. (2014) *Cloud Computing: Concepts, Technology & Architecture*. USA: Prentice Hall

JAMES BOND (2015) *The Enterprise Cloud: Best practices for Transforming Legacy IT*. O'Reilly Media

MOE ABDULA, INGO AVERDUNK, ROLAND BARCIA, KYLE BROWN, AND NDU EMUCHAY (2018) *The Cloud Adoption Playbook: Proven Strategies for Transforming Your Organization*. USA: John Wiley & Sons, Inc.

PAUL, D., YEATES, D. AND CADLE, J. (2010) *Business Analysis*. UK: BCS

POULTON, N. (2016) *CompTIA Server+ Study Guide: Exam SK0-004*. USA: John Wiley & Sons Inc

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 6: Deploying and Operating in the Cloud Project (Pearson Set)

Unit 13: Cloud Architecture Design.

Unit 16: Information Security Management in the Cloud

Unit code	T/618/4897
Unit level	5
Credit value	15

Introduction

As organisations move to cloud platforms, an understanding of security is more important than ever. It is often inferred that Cloud Service Providers (CSPs) are solely responsible for security risks. In reality, security risks in the cloud are a shared responsibility with the organisation and its users. The question organisations need to be asking is not 'How secure is the cloud?' but rather 'Are we using the cloud securely?'. Through an understanding of security best practices and requirements, organisations can implement security controls and threat protection in a cloud environment that supports established governance and compliance frameworks. Jobs in cloud security entail the development and execution of the organisation's security initiatives, designing and documenting security solutions in line with standards, work with CSPs to secure best practices, carry out audit activities and identify risk-based needs for decision making.

This unit introduces students to the principles of information security governance and explores key principles of ISO standards for meeting assurance, quality and performance standards. Students are expected to investigate the use of an Information Security Management System (ISMS) and how cloud service providers support solutions for protecting data in organisations. Students are also expected to analyse the challenges of using cloud-based ISMS solutions and design a Security Posture Assessment to use in a cloud environment. Among the topics included in this unit are security threats and risks, ISO 27000 series, risk treatment planning, ISMS and concept of CIA, cloud-based ISMS solutions, Security Posture Assessment, risk assessment methodologies and governance frameworks.

On successful completion of this unit, students will be able to explore security standards and certifications, and the process of establishing and maintaining an ISMS. Students will prepare a business case for a cloud-based ISMS solution and recommend a suitable risk management framework to ensure security governance and compliance in the cloud. As a result, they will develop technical knowledge alongside skills such as communication and decision making, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Explore the basic principles of information security governance for meeting assurance, quality and performance standards in the cloud
- 2 Investigate the use of Information Security Management Systems (ISMS) in organisations
- 3 Develop a business case for a cloud-based ISMS solution for a given business scenario
- 4 Design a Security Posture Assessment for a cloud environment, identifying risks.

Essential Content

LO1 Explore the basic principles of information security governance for meeting assurance, quality and performance standards in the cloud

Identification of threats that lead to breach of organisational compliance:

Review of threats that can impact security, e.g. malware, botnets, brute force attacks, account hijacking, data loss, insecure application programming interfaces (APIs), denial-of-service attacks (DDoS).

Explore standards for assurance in the cloud:

Rules and etiquette to be followed when adhering to ISO 27000 series with focus on ISO 27002 and 27017.

Understand the role of Service Organisation Controls (SOC) report in relation to security, availability, processing integrity, confidentiality and privacy.

Expectations and operational requirements of end-user license agreements and service-level agreements.

Examination of standards for assurance, i.e. ISO, SOC and client-provider agreements, and their impact on organisational compliance.

Measures of quality and performance of security solutions:

Asset identification of critical components, including type, owner, classification, location and impact levels, for building information asset register.

Use of Computer Aided Integration of Requirements and Information Security (CAIRIS) to assess stakeholder requirements.

Understand how risk assessment and risk treatment planning (RTP) is used.

Understand policy and procedure development in relation to developing security solutions.

Senior management buy-in to assure quality and performance.

Review of audit process including internal, external, and performance monitoring.

LO2 Investigate the use of Information Security Management Systems (ISMS) in organisations

Review of organisational policies:

Policies that consider definition of roles and responsibilities such as segregation of duties and least privilege.

Policies that consider operational objectives such as policy enforcement, privacy and acceptable use.

Policies that consider information security, including identification of risks, actions to address risk and staff training needs.

Establishing and maintaining an ISMS:

Explain what an ISMS is and why it is important.

Apply the CIA triad, confidentiality, integrity and availability to define security aims.

Benefits of effective ISMS use in organisations, e.g. reputation, financial, strategic and security.

Process of developing ISMS to include Plan Do Check Act (PDCA) cycle.

Maintaining of ISMS, including review of risk, monitoring, internal audits, management review and corrective actions.

Business scenario considerations:

Consider the organisation and its context, including stakeholders and expectations of interested parties, determining ISMS scope, leadership commitment, policy and compliance, organisational roles and responsibilities, information security objectives, financial flexibility and cost savings, scalability and ease of access for permitted users.

Distinguishing between Cloud Service Provider (CSP) and client responsibilities such as business continuity management, network strategy, security logs and incident reporting.

Challenges that lead to increased threat to information security, including access to data and applications, visibility of data, data controls, configuration, disaster recovery, and legal requirements such as data protection act and GDPR.

LO3 Develop a business case for a cloud-based ISMS solution for a given business scenario

Cloud-based ISMS solutions:

Explore cloud-based ISMS solutions in the market, e.g. AWS Security Hub, Microsoft Cloud Infrastructure and Operations (MCIO) ISMS, Alliantist ISMS, online and SureCloud ISMS manager.

Challenges of using ISMS solution in the cloud, including capturing content from existing systems and new systems, security, privacy, user experience and controls, governance and framework compliance.

Requirements of business case and business impact analysis:

Business case for a cloud-based ISMS solution to include executive summary, identify the business problem or opportunity, define how the project supports the organisation's strategic objectives, description of solution, including alternative options, SWOT analysis, recommendations for a preferred solution and description of implementation approach.

Business impact analysis in relation to security solution, e.g. who is involved, interruption costs, cost of failure analyses, worst-case scenario, possibility of new impacts or vulnerabilities.

LO4 Design a Security Posture Assessment for a cloud environment, identifying risks.

Design of Security Posture Assessment:

Explain what Security Posture Assessment is and why it is important.

Security Posture Assessment to include identifying value of assets, defining threat exposure and risks, evaluating security measures, recommendations for action plan and improving security posture.

Process for ensuring security policy management lifecycle.

Benefits for implementing and improving security posture, including staff training and awareness, security measures, incident response management and user access.

Risk management principles and governance frameworks:

Measuring risk, including impact, likelihood, quantitative, qualitative, vulnerabilities and threats.

Use of risk assessment methodologies to identify the severity of identified risks and prioritise required actions, e.g. asset-based, scenario-based, IT information risk assessment methodology 2 (IRAM2).

Actions to address risks, including measuring, analysis, evaluation, nonconformity, and continual improvement.

Risk treatment, including avoid, transfer, accept and mitigate.

Governance frameworks to support risk management and compliance in the cloud, e.g. ISO 27000 series, COBIT, ITIL, SOA, Risk IT from IT Governance Institute.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the basic principles of information security governance for meeting assurance, quality and performance standards in the cloud		
P1 Examine the key principles of ISO 27000 series and the key clauses of ISO 27017.	M1 Assess the advantages and disadvantages of certification against the ISO standards.	D1 Critically evaluate your choice of ISO 27000 series and ISMS solution for an organisation that uses the cloud.
LO2 Investigate the use of Information Security Management Systems (ISMS) in organisations		
P2 Explore the process of establishing and maintaining an ISMS.	M2 Analyse the benefits an effective ISMS can have on organisational security.	
P3 Investigate a specific cloud service provider's ISMS solution and its capabilities for protecting data in organisations.	M3 Evaluate the strengths and weaknesses of using a specific cloud security provider as a security solution.	
LO3 Develop a business case for a cloud-based ISMS solution for a given business scenario		
P4 Prepare a business case, including business impact analysis, for a cloud-based ISMS solution.	M4 Analyse the challenges of using a cloud-based ISMS solution for the given business scenario.	D2 Critically review how the business case provides the most suitable cloud-based ISMS solution for the business scenario.
LO4 Design a Security Posture Assessment for a cloud environment, identifying risks.		
P5 Design a Security Posture Assessment to use in a cloud environment.	M5 Recommend a suitable risk management framework, supporting your design of Security Posture Assessment, to ensure governance and compliance.	
P6 Summarise the key benefits of using a Security Posture Assessment to identify security risks.		D3 Evaluate risk management principles and how they support security governance and compliance in a cloud environment.

Recommended Resources

Textbooks

ALEXANDER, D., FINCH, A., SUTTON, D., TAYLOR, A. (2013) *Information Security Management Principles*. 2nd Ed. UK: BCS The Chartered Institute for IT

BALACHANDRAN, M.J. (2020) *Cloud Engineering and Architecture Design Patterns*. Chennai: Notion Press

CALDER, A., WATKINS, S. (2015) *IT Governance: An International Guide to Data Security and ISO27001/ISO27002*. 5th Ed. UK: Kogan Page

DAVIS, C., SCHILLER, M., WHEELER, K. (2019) *IT Auditing Using Controls to Protect Information Assets*. 3rd Ed. USA: McGraw Hill Professional

GOYAL, D., BALAMURUGAN, S., PENG, S.L., VERMA, O.P. (2020) *Design and Analysis of Security Protocol for Communication*. USA: John Wiley & Sons

SMALLWOOD, R.F. (2019) *Information Governance: Concepts, Strategies and Best Practices*. USA: John Wiley & Sons

VOEHL, C.F. (2017) *Making the Case for Change: Using effective business cases to minimise project and innovation failures*. USA: Productivity Press

WILSON, S., VANDERBURG, E.A. (2018) *CompTIA Cloud+ Certification Study Guide*. 2nd Ed. USA: McGraw Hill Professional

Journals

International Journal of Network Security, Online

Information Security Journal: A Global Perspective

Journal of Cloud Computing

Web

aws.amazon.com/training	AWS Training and Certification (general reference)
cloudsecurityalliance.org	Cloud Security Alliance (general reference)
docs.microsoft.com/en-us/learn	Microsoft Learn (general reference)
iso.org	International Organisation for Standardization (general reference)
itgovernance.co.uk	IT Governance (general reference)

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 3: Security in the Cloud

Unit 17: Applied Security in the Cloud

Unit 18: Applied Cryptography in the Cloud

Unit 23: Forensics in the Cloud.

Unit 17: Applied Security in the Cloud

Unit code	A/618/4898
Unit level	5
Credit value	15

Introduction

The challenge of securing systems is ever present regardless of where the system is situated, whether in premises or the cloud the opportunities and threats are the same. This issue affects customers, corporate partnerships, governments and educational institutions. Streaming services, ecommerce solutions and mobile applications rely heavily on cloud provisioning, so a secure solution is essential.

Whilst traditional 'on site' security risks still exist and must be managed, the approach to security in a professional setting must be different. Professional working in this field must adapt to the remote situation and understand how secure cloud services operate and understand the potential behaviours of cybersecurity threat actors. Any security configuration must be responsive and must not impede the functionality and performance of the cloud environment. In the culture of cloud defence there is a need to continually assess and review threats – exploring vulnerabilities and mitigating them whenever feasible.

Many computing and cloud infrastructure professionals require a broad understanding of applied cloud security principles as part of their core skills portfolio. In the context of cyber security, cloud security assures an essential element of end-to-end security in a corporate infrastructure.

This unit gives students the opportunity to implement security in a cloud-based infrastructure. They will explore common threats and how to defend a cloud system. Students will design security policies, ensuring that their cloud-based system has effective security management.

Before taking this unit, students should have experience of security in a cloud or associated context.

It is highly recommended that students complete Unit 3: Security in the Cloud before studying this unit.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Analyse common threats and defence practices with a view to improving security within a cloud infrastructure
- 2 Design defence-based security policies, ensuring effective cloud security management for a business case
- 3 Deploy security solutions to mitigate threats in a cloud environment to meet the needs of the business case
- 4 Evaluate how secured cloud infrastructure mitigates potential vulnerabilities through monitoring strategies.

Essential Content

LO1 Analyse common threats and defence practices with a view to improving security within a cloud infrastructure

Common cyber security threats:

Analysis of threats, including an understanding of awareness of how cloud security attacks sit at different levels.

Application level attacks, including SQL injection, guest hopping, side channel, malicious insider, traffic based (DDoS, probe and scan).

Network level attacks, including domain name system (DNS), domain hijacking, IP spoofing, denial of service (DoS), database exploits such as data loss and weak back-up method.

User level attacks, including phishing, user exploit (employee negligence, social engineering).

Impact of security threats on a cloud infrastructure,

Defence practices:

Apply effective system monitoring, e.g. traffic, service performance, memory, processor utilisation, database performance, establishing responsibilities, managing access control.

Develop routine testing methodology, e.g. penetration tests.

Continually review access requirements.

Maintain and manage data encryption, maintain sufficient data deletion policies.

Ensure effective data backup and recovery.

Ensure effective border controls, e.g. firewalls, signature management, access control lists, resource visibility, employee training, CERT-UK, OWASP.

LO2 Design defence-based security policies, ensuring effective cloud security management for a business case

Scope of the security solutions:

Agreeing scope, including what systems should be protected and are in professional responsibility domain.

Tenancy monitoring including who has access to what, where and within what boundaries.

Establish and review user rights assuring prompt revocation.

Understanding of how to assure confidentiality, setting acceptable use parameters, compliance standards, e.g. meeting national, international, legal and industry regulatory requirements.

Managing system breaches and communicating risk.

Understand security principles including defence-in-depth, layered security principles, data security.

Cloud security management:

Implement effective user management, e.g. maintain users, use and level of rights according to resource, identity management and access control.

Analysis of risk management, compartmentalisation, auditing, logging, monitoring, critical testing, patching systems, evaluating known system vulnerabilities, malware management and system scanning, running cloud-based security APIs.

LO3 Deploy security solutions to mitigate threats in a cloud environment to meet the needs of the business case

Benchmark:

Establishing a range of pre-test or pre-configuration system baselines, including penetration testing benchmarks.

Application of security solutions:

Access controls, e.g. authentication, user management, privileged insiders.

Data management, e.g. migration, integrity, confidentiality and warehousing methods.

Configure networking devices, e.g. routers, switches, firewalls in the cloud to meet service capacity.

Tools:

Cloud Service Provider Tools (CSP) to include intrusion detection and prevention, core reporting tools, configuration rules, identity and access managements (IAM) and troubleshooting

Measurements of security responsiveness:

Passes penetration testing benchmarks or show improvement against benchmarks.

Managing and maintaining optimal data access and retrieval performance, assuring service uptime and availability at 99.91% or better.

Service responsiveness, e.g. HTTP request time, remote server latency.

Mean time between security issue and resolution, ensuring security solution does not impede performance.

LO4 Evaluate how secured cloud infrastructure mitigates potential vulnerabilities through monitoring strategies.

Monitoring strategies:

Consider a range of risk assessment tools offered by Cloud Service Providers (CSPs) for system monitoring.

Systematic review of all logged data using risk assessment tools for benchmarking norms, reviewing anomalies, positives, false positives, negatives, false negatives.

Taking account of user or customer access feedback, malware scanning results, known system issues, e.g. operating system, hardware, services, servers.

Review of database access integrity analysis, e.g. data breaches, account hijack, data loss.

Security patching and awareness of commonplace attack stages.

Mitigation:

Using risk assessment tools and applying techniques that will sufficiently resolve any known or discovered vulnerability, domain-based risks of multi-homed systems, working within assigned responsibilities.

Vulnerabilities:

Exploring a range of vulnerabilities, including network based, database based, operating system based, user access based, hardware based, malware based, software, service based.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Analyse common threats and defence practices with a view to improving security within a cloud infrastructure	
P1 Analyse common security threats and their impact on a cloud infrastructure. P2 Assess how defence practices can improve the security of a cloud infrastructure.	M1 Evaluate how defence practices can be adapted to mitigate common security threats.	D1 Critically justify how the designed security solutions will mitigate common threats and maintain defence practices for the given business case.
	LO2 Design defence-based security solutions, ensuring effective cloud security management for a business case	
P3 Design a range of security solutions, to support cloud infrastructure management. P4 Describe how the designed cloud security solutions will affect the management of a cloud infrastructure for the given business case.	M2 Analyse proposed security solutions against the requirements of the business case.	

Pass	Merit	Distinction
LO3 Deploy security solutions to mitigate threats in a cloud environment to meet the needs of the business case		
P5 Develop a range of benchmarks, including penetration benchmarks for the cloud security solutions. P6 Apply the designed security solutions using a range of custom tools in a cloud-based environment.	M3 Adapt the security solution based on benchmarked response measurements.	D2 Justify the effectiveness of the implemented security solutions against the initial requirements of the business case.
LO4 Evaluate how secured cloud infrastructure mitigates potential vulnerabilities through monitoring strategies.		
P7 Evaluate suitable monitoring strategies for mitigating cloud-based vulnerabilities. P8 Implement a range of monitoring strategies on a cloud infrastructure.	M4 Analyse the effectiveness of the monitoring strategies, when implemented on a cloud infrastructure.	

Recommended Resources

Textbooks

- ADKINS, H., BEYER, B., BLANKINSHIP, P., LEWANDOWSKI, P., OPREA, A., STUBBLEFIELD, A (2020). *Building Secure and Reliable Systems: Best Practices for Designing, Implementing, and Maintaining Systems*. Sebastopol: O'Reilly
- AI, S. (2020) *Building a Future-proof Cloud Infrastructure: A unified architecture for Network, Security and Storage Services*. Boston: Addison Wesley
- DOTSON, C (2019): *Practical Cloud Security: A Guide for Secure Design and Deployment*. Sebastopol: O'Reilly
- KANIKATHOTTU, H (2020): *AWS Security Cookbook: Practical solutions for managing security policies, monitoring, auditing, and compliance with AWS*. Mumbai: Packt Publishing

Journal

IEEE xPlore

Web

aws.amazon.com/training/	AWS (Amazon Web Services) Academy
awsacademy/	(general reference and academic resources)

Links

This unit links to the following related units:

- Unit 1: Cloud Fundamentals*
- Unit 2: Networking in the Cloud*
- Unit 3: Security in the Cloud*
- Unit 13: Cloud Architecture Design*
- Unit 14: Operating Systems in the Cloud.*

Unit 18: Applied Cryptography in the Cloud

Unit code	F/618/4899
Unit level	5
Credit value	15

Introduction

Almost every interaction we make with an electronic device will involve cryptography in some form. Cryptography is an indispensable tool for protecting information in computer systems. Applied cryptography for cloud services uses encryption techniques that protect data used, shared and stored in the cloud. Cryptography underpins many aspects of security and is a crucial component in protecting the confidentiality and integrity of information. The dangers of uploading data into this new environment require cryptographers and cryptanalysts to protect the cloud environment using a variety of technologies, processes and forms of encryption. The complexity with how cloud computing manages data secrecy and information security is a reason why people avoid the cloud. As a result, despite the hype surrounding cloud computing, some users remain reluctant to deploy their personal information or to deploy commercial enterprises into the cloud. Understanding cloud security issues, the application of crypto algorithms and ensuring that data is secured are vital to its continued functionality, longevity and sustainability.

This unit introduces students to the applied principles of cryptography and looks at its practical applications and methods, many of which are fundamental to secure data in the cloud. Students are expected to analyse fundamental symmetric, asymmetric and hashing encryption methods, and investigate examples of these in practice. Students are expected to demonstrate the use of cryptography and cryptanalysis tools, methods and their applications. Students are also expected to appraise the inner workings of cryptographic protocols and principles, including transport layer security (TLS) and blockchain, and evaluate how they can be used by organisations to enhance security when considering a move to a cloud environment. Among the topics included in this unit are: the mathematical algorithms used in cryptography, the mechanisms by which cryptographic and cryptanalysis work, hashing and salting, cloud-hosted Public Key Infrastructure (PKI), benefits of encryption techniques, quantum cryptography, secure multi-party computation, security risks and issues with public key encryption, practical applications of cryptography and Cryptography as a Service (CaaS).

On successful completion of this unit, students are expected to understand the differences in the roles and responsibilities of a cryptographer and a cryptanalyst.

They will be able to analyse functions of stream ciphers and block ciphers, produce code implementing ciphers, analyse methods such as KEM, DEM and PKEs to secure data in a cloud environment. Students will design a security case and implement it. As a result, they will develop skills such as critical thinking, analysis and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Analyse encryption ciphers and algorithms as methods to secure data in a cloud environment
- 2 Discuss security risks and issues related to public key encryption in practice
- 3 Demonstrate the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network
- 4 Evaluate advanced encryption protocols and their application for an organisation considering a move to the cloud.

Essential Content

LO1 Analyse encryption ciphers and algorithms as methods to secure data in a cloud environment

Symmetric encryption:

Use of ciphers for, e.g., secure messages, cloud storage.

Symmetric to include Transposition Cipher, Substitution Cipher, Lorenz Cipher.

Feistel Cipher, including Data Encryption Standard (DES).

Triple Data Encryption (3DES).

Rijndael Cipher, e.g. Advanced Encryption standard (AES).

Stream cipher, e.g. Rivest Cipher 4.

Block Cipher Mode, e.g. Blowfish, Twofish, Rivest Cipher 5.

Message Authentication Code (MAC).

One-time pad.

Asymmetric encryption:

Use of algorithms for, e.g., authenticity using digital signatures, website security, withdraw or transfer bitcoin.

Asymmetric, to include digital signature algorithm (DSA), public key encryption algorithms such as Rivest Shamir Adleman (RSA) algorithm, e.g. RSA cryptosystem, Diffie-Hellman, El Gamal, Elliptic Curve Cryptography (ECC), ECSTR for Efficient and Compact Subgroup Trace (XTR).

Hashing:

Use of hashing for, e.g., sharing documents, database encryption, safeguarding passwords.

Hashing, to include message digest, secure hashing algorithm. Galois/Counter mode (GCM), MD5, Secure Hash Algorithm 1 (SHA-1), Secure Hash Algorithm 2 (SHA-2), RIPE Message Digest (RIPEMD), homomorphic encryption.

LO2 Discuss security risks and issues related to public key encryption in practice

Attacks on public key schemes:

Exploring most common attacks on public key encryption schemes using a range of examples, e.g. Wiener's attack on RSA, lattice-based attacks on RSA, partial key exposure attacks, Meet-in-the-Middle (MITM) attack, Distributed Denial of Service (DDoS) bots, and fault analysis.

Different definitions of security:

Examining security of encryption, security of actual encryption algorithms, semantically secure systems, security of signatures.

Analysing provable security, explaining random oracles, security of encryption algorithms and encryption algorithms with random oracles.

Explaining provable security without random oracles, using examples such as strong RSA assumption, provable security-absolute assurance, signature and encryption schemes.

Analysing encryption techniques to include Key Encapsulation Mechanisms (KEMs), Data Encapsulation Mechanisms (DEMs), and hybrid public key encryption (PKE), for security.

LO3 Demonstrate the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network

Cryptographic tools, methods and applications:

Secret Key to include secret key distribution, key exchange and signature schemes, Diffie-Hellman key exchange, digital signatures and authenticated key agreement.

Public Key to include one-way functions, obtaining authentic public keys, confidentiality and integrity, digital certificates and Public Key Infrastructure (PKI), analysing examples of PKI.

Hash functions, to include designing hash functions, using hash functions in signature schemes, analysing hash functions.

Cryptographer role, responsibilities and continual professional development.

Cryptanalysis tools, methods and applications:

Attacking methods to include brute force, chosen plaintext, SQL injection, dictionary and rainbow tables.

Solving ciphers to include linear (i.e. Fast data Encipherment Algorithm); non-linear (i.e. linear masking), differential (i.e. mixed integer linear programming), block (i.e. simplified Tiny Encryption Algorithm).

Frustrating statistical cryptanalysis, including confusion and diffusion.

Impact of high-performance computing and quantum cryptography.

Web-based tools, e.g. CrypTool, EverCrack, AlphaPeeler.

Cryptanalyst role, responsibilities and continual professional development.

Security case and system response:

Security case to include design of a system at network layer, crypto to meet defined security objectives, key management plan, evidence of system with required security controls, format, e.g. Common Criteria Protection Protocol.

System response to include security objectives and common threats, assumptions, functional requirements and security controls, e.g. technical, implementation, policy or process.

LO4 Evaluate advanced encryption protocols and their application for an organisation considering a move to the cloud.

Assessing advanced encryption protocols and their applications:

Exploring access structures for secret sharing schemes for cloud security, general secret sharing, Reed-Solomon codes, Shamir sharing scheme.

Applying RSA key generation, SecurID and strategy in popular cloud environments.

Analysing Zero-Knowledge proofs, Sigma protocols, electronic voting systems.

Examining secure multi-party computation, the two-party case, multi-party cases, including honest-but-curious adversaries and malicious adversaries.

Evaluating different applications of cryptography and hybrid cryptosystems to include Cryptography as a Service (CaaS), digital cash, bitcoin, Transport Layer Security (TLS) protocol, including configuration such as ciphersuites, Blockchain, Blockcloud and zkSNARKS.

Influencing factors affecting choice of cryptographic techniques for an organisation's move to the cloud:

Cost, e.g. implementing encryption, network support, resourcing.

General considerations, including suitability for business needs, infrastructure, scaling, reliability, support, storage capacity, content delivery, protection, user access and training.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse encryption ciphers and algorithms as methods to secure data in a cloud environment		
P1 Analyse the functions of stream cipher and block cipher, using a range of appropriate examples in practice. P2 Produce code that implements mathematical ciphers and algorithms to encrypt and decrypt data.	M1 Critically analyse the operational differences between stream cipher and block cipher, using a range of appropriate examples in practice.	D1 Justify improvements introduced by stream ciphers compared to block ciphers for public and private key encryption.
LO2 Discuss security risks and issues related to public key encryption in practice		
P3 Discuss risks and issues in security of public key encryption schemes, using a range of appropriate examples in practice.	M2 Analyse key benefits of encryption techniques including KEMs, DEMs and PKEs and the importance of securing public key systems.	D2 Provide justified recommendations, synthesising different definitions of provable security, suitable for securing public key systems.
LO3 Demonstrate the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network		
P4 Illustrate, using a diagram, encryption and decryption process functions in a PKI environment for a business scenario. P5 Design a security case, representative of a business scenario, to solve a security threat.	M3 Assess security risks and challenges of using cloud-hosted PKI in a private network. M4 Implement the system designed, in response to a security case, using cryptographic and cryptanalysis methods or tools.	D3 Provide a critical review of the implemented system in terms of how it meets defined security objectives and make suggestions for improvement.

Pass	Merit	Distinction
<p>LO4 Evaluate advanced encryption protocols and their application for an organisation considering a move to the cloud.</p> <p>P6 Evaluate the key benefits of using a range of cryptography and hybrid cryptosystems to improve cloud security.</p> <p>P7 Assess common factors influencing an organisation's choice of cloud solution(s) to improve security.</p>	<p>M5 Critically analyse the use of selected cryptography and hybrid cryptosystems in protecting data in an organisation.</p>	<p>D4 Justify the use of different cryptographic applications, for an organisation, that will inform their move to the cloud.</p>

Recommended Resources

Textbooks

BALACHANDRAN, M.J. (2020) *Cloud Engineering and Architecture Design Patterns*. Chennai: Notion Press

CARLET, C. (2020) *Boolean Functions for Cryptography and Coding Theory*. Cambridge: Cambridge University Press

CHAUBEY, N.K., PRAJAPATI, B.B. (2020) *Quantum Cryptography and the Future of Cyber Security*. USA: IGI Global

GOYAL, D., BALAMURUGAN, S., PENG, S.L., VERMA, O.P. (2020) *Design and Analysis of Security Protocol for Communication*. USA: John Wiley & Sons

MENEZES, A.J., VAN OORSHOT, P.C., VANSTONE, S.A. (2018) *Handbook of Applied Cryptography*. 2nd Ed. Boca Raton: CRC Press, Taylor & Francis

NIELSON, S.J., MONSON, C.K. (2019) *Practical Cryptography in Python: Learning Correct Cryptography by Example*. USA: Apress

PACHGHARE, V.K. (2019). *Cryptography and Information Security*. 3rd Ed. Delhi: PHI Learning

SCHMEH, K. (2006) *Cryptography and Public Key Infrastructure on the Internet*. UK: Wiley

STALLINGS, W. (2013) *Cryptography and Network Security: Principles and Practice*. UK: Pearson

STINSON, D.R., PETERSON, M.B. (2018) *Cryptography: Theory and Practice*. 4th ed. Boca Raton: CRC Press, Taylor & Francis

SWAMMY, S., THOMPSON, R., LOH, M. (2019) *Crypto Uncovered: The Evolution of Bitcoin and the Crypto Currency Marketplace*. (eBook) Palgrave Macmillan

Journals

International Association for Cryptologic Research, Online

International Journal of Applied Cryptography, Online

International Journal of Network Security, Online

Journal of Emerging Trends in Computing and Information Sciences, Online

Web

ncsc.gov.uk

National Cyber Security Centre
(general reference)

Links

This unit links to the following related units:

Unit 3: Security in the Cloud

Unit 16: Information Security Management in the Cloud

Unit 17: Applied Security in the Cloud

Unit 23: Forensics in the Cloud.

Unit 19: Software Development Methodologies for the Cloud

Unit code	K/618/4900
Unit level	5
Credit value	15

Introduction

Software development methodologies are integrated processes that promote building good quality software throughout the entire development process. The aim of this unit is to give students the knowledge and skills they need to understand modern software development methods and to demonstrate their knowledge by implementing a cloud-based solution using a suitable software development lifecycle and the DevOps Pipeline.

This unit introduces students to lifecycle decision making at different stages of the software development process. Students will examine various lifecycle models and appreciate their particular characteristics to understand the project environments for which they are most appropriate. Theoretical understanding will be translated into practical skills through the use of DevOps pipelines as well as associated DevOps and collaboration tools.

Among the topics included in this unit are iterative and linear development models, project management considerations, DevOps pipelines and the use of collaboration tools.

As a result, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

This unit is designed to be undertaken alongside a practical unit where students will undertake a software development project.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Discuss the impact of different software development lifecycles on project outcomes
- 2 Develop a project management proposal for an identified project to implement a cloud-deployed solution
- 3 Implement a cloud-based solution using a DevOps Pipeline to meet project requirements
- 4 Demonstrate the use of collaborative software development when implementing a cloud-based solution for an identified project.

Essential Content

LO1 Discuss the impact of different software development lifecycles on project outcomes

Linear and iterative Software Development Lifecycles (SDLC):

Key stages of a software development lifecycles, including research and familiarisation, planning and requirement analysis, user analysis, product design, development and testing, maintenance.

The uses, benefits and drawbacks of linear Software Development Lifecycle Methodologies, e.g. waterfall.

The uses, benefits and drawbacks of iterative Software Development Lifecycle Methodologies, e.g. Scaled Agile, Rapid Application Development (RAD) and LEAN.

Project scope:

Choice of software development methodology and impact on project scope, including levels of client interaction and involvement, progress measures, product completion rate, product quality, documentation produced.

Understand the use of ‘spike testing’ to establish requirements and determine the extent and scope of a computing project.

LO2 Develop a project management proposal for an identified project to implement a cloud-deployed solution

Project proposal:

Define functional requirements of a cloud-based solution, including the inputs required, the data needed, the data processing that must take place, the logic of the system, the deployment and usage platforms for the software.

Define non-functional requirements of a cloud-deployed solution, including security, accessibility, scalability requirements, key performance metrics, acceptance criteria.

Consideration of appropriate SDLC, costs, timescales, resources, number of staff, skills of staff, size and complexity of project, business critical functions and business continuity.

Technical documentation:

Develop technical documentation for the DevOps Pipeline to include language selection, version control systems, application types, deployment targets and package formats.

LO3 Implement a cloud-based solution using a DevOps Pipeline to meet project requirements

DevOps Pipeline:

Understand the concept of 'Continuous Integration – Continuous Deployment' (CI/CD) and its use to build and deliver software solutions.

Apply the DevOps Pipeline to support deployment and use of cloud micro-services and containers.

Tools:

Selection and use of appropriate tools at each stage of the DevOps Pipeline, including source code control, build automation, unit test automation, deployment automation and monitoring.

LO4 Demonstrate the use of collaborative software development when implementing a cloud-based solution for an identified project.

Collaborative work processes:

Understand importance of working as part of a team, determining collaboration versus independent activities and allocation of project tasks.

Selection and use of technologies to aid communication and co-collaboration, e.g. code repositories, content management systems, version control systems, professional discussion forums.

Collaborative working:

Collaborative working opportunities, e.g. joint working on elements of a larger project, sharing code, testing, offering feedback and reviews.

The positive and negative impacts of collaborative working on the outcomes of a project, including development time, focus/mission creep, communication, development of skills, sharing of knowledge, code and project reviews.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the impact of different software development lifecycles on project outcomes		
P1 Discuss the key stages of software development lifecycles in a business context. P2 Discuss the benefits and drawbacks of linear and iterative software development life cycles in a business context.	M1 Analyse how different software development lifecycles impact on project outcomes in a business context.	D1 Evaluate the appropriateness of different software development lifecycle models against the requirements of an identified project.
LO2 Develop a project management proposal for an identified project to implement a cloud-deployed solution		
P3 Develop a project management proposal for a cloud-deployed solution for an identified project. P4 Develop technical documentation for an identified project which considers the DevOps Pipeline.	M2 Justify the project management decisions made in relation to the business requirements of the identified project.	
LO3 Implement a cloud-based solution using a DevOps Pipeline to meet project requirements.		
P5 Deploy a cloud-based solution using appropriate DevOps Pipeline tools to meet identified project requirements.	M3 Optimise the deployed cloud-based solution to ensure its performance against the project requirements.	D2 Evaluate the use of DevOps Pipeline and collaborative working against the project requirements for an identified project
LO4 Demonstrate the use of collaborative software development when implementing a cloud-based solution for an identified project.		
P7 Demonstrate use of collaborative technologies to support team working during the development of a cloud-based solution.	M4 Justify use of collaborative technologies and team working during the development of a cloud-based solution.	

Recommended resources

Textbooks

CAMPBELL, A. (2020) *Agile: Essentials of Team and Project Management. Manifesto for Agile Software*. Independent Publishing: Kindle

FERGUSON, J. (2014) *BDD in Action: Behaviour-driven development for the whole software*. New York: Manning Publication Co

HUMBLE, J. FAREY, D (2010) *Continuous Delivery: Reliable Software Releases through Build, Test, and Deployment Automation*. Indiana: Pearson Education Inc

WATTS, G. (2013) *Scrum Mastery: From Good to Great Servant-Leadership*. Cheltenham: Inspect & Adapt Ltd

Web

agilealliance.org	Agile lifecycle methodology resources and information
docs.microsoft.com	Azure Pipelines Documentation

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 5: Database Design and Development in the Cloud

Unit 6: Deploying and Operating in the Cloud (Pearson Set)

Unit 13: Cloud Architecture Design

Unit 20: Application Development, Testing & Debugging

Unit 22: Financing the Cloud.

Unit 20: Application Development, Testing & Debugging

Unit code	M/618/4901
Unit level	5
Credit value	15

Introduction

This unit is designed to allow students to develop an application for a particular purpose, using separate modules for different functional elements of the project. The unit emphasises the testing and debugging stages of the development process and the value of this being fully integrated into the overall process, especially when a fast application development methodology is being used. The unit aims to cover these two processes while working through the whole development cycle, with especial emphasis on the specific needs of cloud applications. The unit will be of use to those who aspire to become software developers, systems analysts, programmers and IT project managers.

A major part of any application development is ensuring that it does what it is supposed to do without errors. This relies on effective testing and, when issues are identified, accurate debugging. Testing verifies the correct behaviour of the application or component module and can and should be done at all stages of module development, for example requirements analysis, interface design, algorithm design, implementation, integration with other modules. Frequently, attention will be directed at implementation testing, which should not be restricted to execution testing. An implementation can also be tested using correctness proofs, code tracing and peer reviews.

Debugging is a cyclic activity involving continuous execution testing and code correction throughout the process of developing an IT system and has a different aim than final module testing. This difference has a significant effect on the choice of testing strategies. The term 'fix the cause not the problem' should run through the debugging process. Testing should run through the whole process of development and this unit is designed to help students develop this understanding in a complete software development lifecycle and to develop an awareness of the value of rigorous testing to a successful outcome.

On successful completion of this unit, students will understand the importance of testing and debugging code they have developed for a cloud-based application. As a result, they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Develop a modular application for the cloud using a fast development method
- 2 Test the modules of a cloud application based on a testing plan
- 3 Perform functional and acceptance testing of a completed modular application
- 4 Assess the effectiveness of formal testing processes for application development.

Essential Content

LO1 Develop a modular application for the cloud using a fast development method

Design and build application:

Modular design content to include input module, execution module(s), output module.

Design document to include individual module designs, inputs, functions, actions, outcomes, variables, features, parameters between modules, test data, algorithm(s), code pathways.

Build each module from the designs using a fast application development method, e.g. Rapid Application Development, Agile, DevOps, Extreme Programming Method.

Investigate debugging preconditions, including understanding the design and algorithm(s), check correctness and acceptable proof of correctness, code tracing, peer reviews, anticipating errors and availability of automated testing tools.

Investigate testing standards:

ISO/IEC/IEEE 29119 Software and systems engineering – Software testing, IEEE 1008 Unit Testing, BS 7925-2 software component testing.

LO2 Test the modules of a cloud application based on a testing plan

Test planning and methods:

Incremental testing, including breaking code into subroutines, white box testing.

Conduct sanity checks ensuring high-level code correctly implements algorithms, invalid data and ‘impossible’ null values for variables and parameters.

Develop stub code that allows a module to be quality tested before integration with the rest of the system, provides inputs and receives outputs for analysis against expectations

Principles of debugging:

Differences between testing and debugging, including immediate error reporting, maximise useful information, clear information to ease interpretation, minimise distracting information, eliminate useless information, avoid complex single use testing code, keep test data/routines as simple as feasible.

Debugging to include addition of ‘invisible’ debugging code, use of Boolean parameter as latch, stages of testing, error variables, execution state, outcomes of execution, use calls to stage tests, terminating sanity checks and traceback techniques.

LO3 Perform functional and acceptance testing of a completed modular application

Functional testing:

Conduct functional testing to meet specification, including mainline testing, black box testing, basic usability, accessibility for users, error conditions with suitable messaging.

Acceptance testing:

Conduct acceptance testing to meet user needs, including compliance with business requirements, acceptability, internal acceptance testing, external acceptance testing and customer acceptance testing.

LO4 Assess the effectiveness of formal testing processes for application development.

Effective testing:

Understand how user acceptance and final stage testing should include client trials, client acceptance testing, pre commissioning, coverage of all functional scenarios and random tests.

Ensure software is usable by clients.

Fast application development methodologies:

Investigate methods and features of Rapid Application Development (RAD), including iteration testing, model testing, regular client involvement, flexible test data to meet changing system.

Investigate methods and features of Agile Development method, including dynamic development, multiple developing versions, welcomes changing requirements, sustainable development.

Investigate methods and features of DevOps, including short lead time between fixes, minimum disruption maximum reliability, continuous deployment,

Investigate methods and features of Extreme Programming Methodology with high customer involvement.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	<p>LO1 Develop a modular application for the cloud using a fast development method</p> <p>P1 Design a modular application consisting of input, execution, output modules and test data, suitable for the cloud.</p> <p>P2 Build the modules of the application from predetermined modular designs.</p>	<p>D1 Critically analyse the effectiveness of your testing and debugging as documented throughout the development process.</p>
	<p>LO2 Test the modules of a cloud application based on a testing plan</p> <p>P3 Develop suitable test plans for each individual module of a modular application.</p> <p>P4 Create stub code to allow the effective individual testing of each module in a modular application.</p> <p>P5 Carry out testing on individual modules of a modular application using individual test plans.</p>	<p>M2 Review the outcomes of modular testing against the module designs.</p>
	<p>LO3 Perform functional and acceptance testing of a completed modular application</p>	
	<p>P6 Consolidate the modules developed into one complete application.</p> <p>P7 Plan suitable functional and acceptance testing for a completed modular application.</p> <p>P8 perform functional and acceptance testing on a completed modular application.</p>	<p>M3 Justify the choice of testing methods and test data chosen to determine a modular application's suitability for its intended purpose.</p>

Pass	Merit	Distinction
LO4 Assess the effectiveness of formal testing processes for application development.		
P9 Assess how effective user acceptance testing can ensure an application is fit for purpose.	M4 Justify why a structured testing and debugging process is necessary when using a fast application development method.	D2 Evaluate how the testing and debugging process has enhanced application development with your chosen methodology and suggest improvements.

Recommended Resources

Textbooks

BLACK R., WALSH M., COLEMAN G., CORNANGUER B., FORGÁCS I., KAKKONEN K., SABAK J. (2017). *Agile Testing Foundations: An ISTQB Foundation Level Agile Tester guide*. UK: British Computer Society

FISHPOOL B., FISHPOOL M. (2020). *Software Development in Practice*. UK: British Computer Society

FORGÁCS I., KOVÁCS A. (2019). *Practical Test Design: Selection of traditional and automated test design techniques*. UK. British Computer Society

HAMBLING B., MORGAN P., SAMAROO A., THOMPSON G, WILLIAMS P. (2019).
Software Testing, An ISTQB-BCS Certified Tester Foundation guide - 4th edition.
UK: British Computer Society

HAMBLING B., VAN GOETHEM P. (2013) *User Acceptance Testing: A step-by-step guide*. UK: British Computer Society

Journal

IT Now. Journal of Computational Design and Engineering – online.

Web

www.softwaretestingnews.co.uk *Software Testing News*
(general reference)

Links

This unit links to the following related units:

Unit 4: Programming

Unit 6: Deploying and Operating in the Cloud (Pearson Set)

Unit 19: Software Development Methodologies for the Cloud

Unit 21: Applied Programming and Design Principles

Unit 30: Risk Analysis & Systems Testing.

Unit 21: Applied Programming and Design Principles

Unit code	T/618/4902
Unit level	5
Credit value	15

Introduction

The advanced features of programming languages are used to develop software that is efficient, robust and can be mathematically proven to work. Well-designed code can positively impact the performance of an application as well as the readability and extensibility of the code, thereby improving productivity and reducing cost.

Effective object orientated programming (OOP) should have low coupling, high cohesion and strong encapsulation, which is something that the SOLID principles help to obtain. The idea is that by applying those principles together, it makes it easier to write better quality code with greater diversity and robustness. The system created becomes easy to maintain, to reuse and to extend over time. SOLID principles help software developers to achieve scalability and avoid creating code that breaks every time it needs a change. Clean coding maintains the readability of the programs produced by encouraging descriptive naming of objects and keeping to a single purpose model for each entity. Programming patterns work to ensure that designs produced are language independent, encapsulate ideas and are reusable in multiple circumstances.

The development of an application to process a large data set is a practical example of how to solve a problem that can be used in many different situations, can help deepen the understanding of OOP and help improve software design and reusability.

The aim of this unit is to familiarise students with these concepts and their best practices to ensure that their code is in line with industry standards. Among the topics included in this unit are object-orientated programming, introduction to design patterns and SOLID, including its version of five principles of object-oriented programming and automated software testing.

The unit is especially useful for those intending to move into computer science, software development, programming, systems analysis and software testing.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Investigate the impact of SOLID development principles on the OOP paradigm
- 2 Design a large dataset processing application using SOLID principles and clean coding techniques
- 3 Build a data processing application based on a developed design
- 4 Perform automatic testing on a data processing application.

Essential Content

LO1 Investigate the impact of SOLID development principles on the OOP paradigm

Object-orientated programming (OOP) paradigm characteristics:

Understand the OO characteristics and their application in developing code, including encapsulation, polymorphism, constructors and destructors, sub-objects, abstraction, interface, method overriding and redefinition, templates and containers.

Object-orientated class relationships:

Understand the elements of the OO relationships, including generalisation and inheritance, realisation, dependency, aggregation and composition.

Design patterns:

Aims and benefits of reusable design patterns, e.g. general reusable solution, represent an idea and language independent.

Grouping of design patterns into creational, structural and behavioural groups.

Clean coding techniques:

Simple design, e.g. keeping configurable data at high levels, polymorphism, consistency in methods, meaningful variable and constant names and encapsulate boundary conditions.

Creating small functions by including single action, minimal parameters, descriptive names, comments to explain code and warn of consequences.

Structure source code to separate concepts vertically, declare variables close to usage and keep lines short.

Develop objects and data structures for one action so that they are small.

Understand why non-static methods are preferable to static methods.

Design tests to ensure they are readable, fast and independent.

Understand bad test design, e.g. rigid, fragile, immobile, complex, repetitive.

SOLID design principles:

Understand and apply the component parts of SOLID design principles to make software understandable, flexible and maintainable, including Single-responsibility principle, Open-closed principle, Liskov substitution principle, Interface segregation principle and Dependency inversion principle.

LO2 Design a large dataset processing application using SOLID principles and clean coding techniques

Large datasets (public domain):

Design of application that can accommodate pre-existing large (500+) datasets, e.g. list of members of parliament, register of members' interests (Commons and Lords), list of public domain films (e.g. in the USA), list of public domain books, list of public domain music.

Data structures:

Use of data structures in application development, e.g. stack, array, multi-dimensional array, set, queue, list and linked list.

Apply tree types, including active, passive and recursive.

Operations:

Use of operations in application development, e.g. hash functions and pointers.

Utilise sorts, e.g. insertion, quick, merge and heap.

Utilise searches, e.g. linear, binary tree and recursive.

LO3 Build a data processing application based on a developed design

Implementation:

Utilise an appropriate language and development tools.

Produce program code that implements a design based on SOLID principles, clean coding techniques and programming patterns.

LO4 Perform automatic testing on a data processing application.

Types of automatic testing:

Understand the uses of automation in setting up regression tests, data set up generation, product installation, GUI interaction, defect logging, unit testing and integration testing of main application.

Tool automation parameters:

Understand the meaning of data driven capabilities, debugging and logging capabilities, platform independence, extensibility and customisability, email notifications, version control friendly.

How automated testing features support unattended test runs.

Understanding of testing logic and updates code to make testing easier through the use of stubbing/patching

Common frameworks:

Understand the circumstances where different frameworks perform best, Data Driven Automation Framework, Keyword Driven Automation Framework, Modular Automation Framework and Hybrid Automation Framework.

Tools:

Investigate a range of tools that are commercially available.

Functional, e.g. QuickTest Professional (HP), Coded UI (Microsoft), Selenium, Open IT (open source).

Non-functional, e.g. LoadRunner (HP), JMeter (Apache), Burp Suite (PortSwigger).

Self-built testing tools:

Investigate the value of developer-designed and built tools to test features and functions of a specific application.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Investigate the impact of SOLID development principles on the OOP paradigm	
P1 Investigate the characteristics of the object-orientated paradigm, including class relationships and SOLID principles. P2 Explain how clean coding techniques can impact on the use of data structures and operations when writing algorithms.	M1 Analyse, with examples, each of the creational, structural and behavioural design pattern types.	D1 Evaluate the impact of SOLID development principles on object-orientated application development.
	LO2 Design a large dataset processing application using SOLID principles and clean coding techniques	
P3 Design a large data set processing application, utilising SOLID principles, clean coding techniques and a design pattern. P4 Design a suitable testing regime for the application, including provision for automated testing.	M2 Refine the design to include multiple design patterns.	

Pass	Merit	Distinction
LO3 Build a data processing application based on a developed design		
P5 Build a large dataset processing application based on the design produced.	M3 Assess the effectiveness of using SOLID principles, clean coding techniques and programming patterns on the application developed.	D2 Analyse the benefits and drawbacks of different forms of automatic testing of applications and software systems, with examples from the developed application.
LO4 Perform automatic testing on a data processing application.		
P6 Examine the different methods of implementing automatic testing as designed in the test plan. P7 Implement automatic testing of the developed application.	M4 Discuss the differences between developer-produced and vendor-provided automatic testing tools for applications and software systems.	

Recommended Resources

Textbooks

CLARKE JILL, (2020) *Software Developer*, London: BCS

FISHPOOL B & FISHPOOL M, (2020) *Software Development in Practice*, BCS

FREEMAN E., FREEMAN E., SIERRA K., BATES B. (2004) *Head First Design Patterns*, London: O'Reilly

GAMMA E, HELM R, JOHNSON R, VLISSIDES J, (1994) *Design Patterns: elements of reusable object-oriented software*, Addison Wesley

MARTIN, RC, (2017) *Clean Architecture: A Craftsman's Guide to Software Structure and Design*. London Pearson, Addison Wesley

Journal

academic.oup.com

Oxford Academic

ITNow: British Computer Society *(general reference)*

Web

baeldung.com

Baeldung

A Solid Guide to SOLID Principles

(general reference)

tutorialspoint.com

Software Testing Dictionary

(general reference)

Links

This unit links to the following related units:

Unit 4: Programming

Unit 19: Software Development Methodologies for the Cloud

Unit 20: Application Development Testing & Debugging.

Unit 22: Financing the Cloud

Unit code	A/618/4903
Unit level	5
Credit value	15

Introduction

This unit is designed to give an insight into how to address the issues involved in establishing whether a particular application is suitable and a viable option for hosting in the cloud.

Students will examine the contracting of an agreement to provide a service from a cloud service provider (CSP) and the different components of a cloud service and their relative costs. The unit addresses the financial viability of a particular project and vendor options are cost compared to open source options and outsourcing. Students will explore the legal aspects of contracting for cloud services and will draft a contract. Students will also examine the many different options for hosting different systems running on different platforms.

Students will look at the options involved with private, hybrid and public cloud. The unit also covers security of network, security of the cloud platform, security of information about individuals and the different rules across different countries. Students will investigate the financial and technical ramifications of migrating to the cloud.

On successful completion of this unit, students will understand the issues involved in developing a cloud computing contract, the legal aspects of data hosting in different jurisdictions and the risks involved in migration to the cloud as opposed to other options. As a result, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

This unit aligns to job roles that include computer systems engineer, hybrid (business/computing) manager, data services manager and any role with responsibility for commissioning computing services.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Assess the financial elements to be considered when commissioning a cloud-based service
- 2 Create a cloud service contract, selecting elements based on a given organisation need
- 3 Investigate the financial impact of legal obligations involved in utilising cloud service provision in the home country and internationally
- 4 Review the financial risks and benefits to an organisation of moving to use cloud services.

Essential Content

LO1 Assess the financial elements to be considered when commissioning a cloud-based service

Types of service that need to be considered:

Understand the different components that could be potentially included in a service contract, based on requirements including computation (compute in USA), network, storage, management, security, databases, analytics, artificial intelligence, Internet of Things (IoT), mobile, developer tools, blockchain, integration, migration, logging and monitoring, games, simulation, web (site) services.

Contract elements:

Research contract elements that are relevant for a specific business need, including banded pricing, multiple vendor offers, early termination fees, data egress at contract end, service level agreement, penalties for not meeting SLA, safeguards on data in the cloud (HIPAA or PCI DSS), encryption method, actual usage pricing or stated level (per month), cost and speed of moving data around zones and between storage, performance metrics, in-contract changes to service by provider, security arrangements and levels.

Cloud types:

Be aware of which cloud type is being commissioned, e.g. private, public, hybrid.

Charging services:

An awareness of chargeable items in a Cloud Service Provider (CSP) contract, including storage space, network bandwidth, latency, computational resources, security, auditing, logging transaction, data movement, service level guarantee.

LO2 Create a cloud service contract, selecting elements based on a given organisation need

Contract terms:

Cloud service contract proposal to include examples of clauses, e.g. CSP in-contract modification clauses, forensic clauses third party audit.

Selecting a range of contract elements relevant for organisational need.

CSP responsibilities versus own responsibilities.

Provider services:

Identify which cloud provider services are relevant to business need, e.g. migration services, application integration, analytics, cost management, containers, network and content delivery, machine learning, game technologies, robotics, developer tools, management and governance, security and compliance.

Provider options:

Consideration of different cloud service providers for their cloud services, e.g. Amazon Web Services, Microsoft Azure, IBM Cloud, Kamatera, ScienceSoft, Cloudways, pCloud, VMware, Rackspace, Red Hat, Oracle Cloud, SAP, NaviSite.

Cost analysis:

Performing a cost analysis using a business tool to include elements selected for a cloud service contract and comparing pricing with similar options available from multiple providers.

Consideration of cost optimisation options, length of contract, reserved versus on-demand resources, application of volume discounts, cost forecasting (dynamic forecasting)

LO3 Investigate the financial impact of legal obligations involved in utilising cloud service provision in the home country and internationally

Contractual elements:

A review of elements in contracts, including multi-tenancy, chain of custody, probity of CSP, Service Level Agreements (SLA).

General areas of legislation:

Awareness of legislative issues, including locale of zones, cross-border data flows, surveillance, government access for law enforcement, copyright, data protection.

Legislation worldwide:

Review of relevant legislation and legal frameworks worldwide that can impact cloud-based systems and services, e.g.:

Computer Misuse Act (1990), GDPR (2018) in the UK

G-Cloud framework, Federal Rules of Civil Procedure (FRCP), Clarifying Lawful Overseas Use of Data (CLOUD) Act (2018) in the USA.

Digital Single Market Strategy for Europe and GDPR in Europe.

Golden Shield Project in China.

'Halal Internet' in Iran.

The Personal Information Protection Act (PIPA) (2020) in South Korea.

Financial implications of a cloud-based service:

A general awareness of elements that will have an implication on cost, including security, resources utilised, governance and control, compliance, managing multiple clouds, building a private cloud, entry, migration and exit, contract lock-in, contract termination and suspension charges, contract term, insurance, liabilities, migration from premises to cloud, auditing costs, transaction logging costs, network bandwidth costs, storage access levels, user access levels, data availability management, staff training and employment of staff.

Awareness of tools for managing cloud spend, e.g. Cloudyn (Azure), Cloudability, QStack.

LO4 Review the financial risks and benefits to an organisation of moving to use cloud services.

Types of computing service provision:

Understand the differences in service provision, including:

In-house system physically located in a data centre and full control resides with the organisation.

Cloud-hosted located in the cloud with a service provider but elements of control reside with the organisation, e.g. applications

Outsourced service is completely overseen by external provider and no control of the computer system by the organisation.

Risks:

Review of risks, including data residency causing dispersed copies of core data to be vulnerable to attack and synchronisation failure, local legislation variations affecting operational requirements, contract scaling errors, change of service demands, limits on user numbers at one time, integrity of service provider, CSP contract precludes third party auditing, higher costs per unit of flexible usage contracts.

Benefits:

Review of benefits, including data residency ensures the availability of multiple copies of core data to allow for faster user access across multiple continents, allows flexibility of demand, reduced costs of 'fixed provision contracts', pay only for what you use contracts, transparent user access, service provider provides forensic services.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Assess the financial elements to be considered when commissioning a cloud-based service		
P1 Investigate the different elements required in the provision of a cloud-computing service. P2 Assess how the different elements need to be defined in a cloud service contract, based on organisational need.	M1 Analyse the costs of specific cloud service contract elements as offered by different cloud service providers against an open source solution.	D1 Perform a cost analysis of options, using currently published financial data, for a specific cloud-based service contract, using information from two or more cloud service providers.
L02 Create a cloud service contract, selecting elements based on a given organisation need		
P3 Create a cloud service contract based on organisation need selecting financially viable elements.	M2 Justify the cloud service contract created in relation to the financial viability of it effectively providing a specific cloud service.	
L03 Investigate the financial impact of legal obligations involved in utilising cloud service provision in the home country and internationally		
P4 Assess the legal requirements involved in utilising a cloud-based system in your home country and outside your home country.	M3 Evaluate the options involved in taking advantage of a cloud-based system hosted outside your home country.	D2 Critically evaluate the legal and financial issues that may cause a computer system which has moved to the cloud to fail and suggest ways of mitigating against this.
L04 Review the financial risks and benefits to an organisation of moving to use cloud services.		
P5 Review the financial risks directly related to migrating to a cloud-based service contract from an in-house system.	M4 Contrast the basic cost elements involved in the utilisation of a cloud-hosted system against that of outsourcing the same system.	

Recommended Resources

Textbooks

MILLARD, C. (2013) *Cloud Computing Law*. Oxford: Oxford University Press

STORMONT J.R., FULLER, M. (2019) *Collaborative, Real-Time Financial Management*. Sebastopol: O'Reilly

Web

<http://www.kempitlaw.com/wp-content/uploads/2019/06/Cloud-Contracting-White-Paper-Kemp-IT-Law-v1.0-20190609.pdf>

Legal Aspects of Cloud Computing:
Cloud Contracting
Richard Kemp June 2019

Links

This unit links to the following related units:

Unit 1: Cloud Fundamentals

Unit 15: Cloud Systems Integration

Unit 29: E-commerce and Strategy.

Unit 23: Forensics in the Cloud

Unit code	F/618/4904
Unit level	5
Credit value	15

Introduction

When an individual or an organisation chooses to move computing resources into the cloud, they will have largely given up knowing where and on what device that data and resource is stored. Even when using a private cloud this can be problematic, with data stored on disparate and geographically different devices. In the case of multinationals this can potentially mean on different continents. This reality makes it unlikely, after an incident, that the network path or storage device can be investigated in the normal way. When issues arise, malicious or accidental, investigating and resolving them can prove to be much more problematic. One essential component of achieving a successful outcome as a result of incidents on the cloud, is a detailed and effective cloud forensics policy as part of the overall cloud service provider contract, with an appropriate service level agreement.

On successful completion of this unit, students will understand the issues involved in producing a cloud computing contract for services that includes provision for post-incident forensics. They will gain practical knowledge of the tools available to carry out forensic analysis of system logs, how to identify malicious activity and understand the legalities of cloud systems and the components of a cloud forensic contract. This knowledge will be relevant to employment as a systems administrator, network administrator, software developer and computer systems engineer.

As a result of studying this unit, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

This unit is best studied after units such as Database Development and Deployment in the Cloud or Applied Security in the Cloud so that students can ‘instigate’ attacks (LO3) on each other’s cloud-based applications.

Learning Outcomes

By the end of this unit, students will be able to:

- 1 Discuss the specific features required of a forensic tool for it to work effectively in the cloud
- 2 Develop a cloud forensics policy that considers legal and commercial implications for a given organisational scenario
- 3 Instigate attacks on a cloud-based system using appropriately selected tools
- 4 Investigate the result of attacks on a cloud-based system and identify improvements.

Essential Content

LO1 Discuss the specific features required of a forensic tool for it to work effectively in the cloud

Cloud tools:

Describe the application of forensic tools that are of specific use in the cloud.

Use a range of tools to investigate different aspects of a cloud system, e.g. ElcomSoft Phone Breaker, FROST toolkit, UFED Cloud Analyzer, Wireshark, Guidance EnCase, Access Data FTK, VIX tools, OpenStack project.

Forensic tool options:

Investigate a range of provider options for forensic tools and understand the services they offer, e.g. Microsoft Azure Security Centre, Bitdefender, Google Cyber Forensicator.

Compare commercial and open source tools, e.g. Slack, Zendesk, AccessData AD eDiscovery, Oxygen Forensic Cloud Extractor, Digital Forensics Compute Cluster (DFORC2), Autopsy, Rapid Forensic Acquisition of Large Media with Sifting Collectors (aka Sifting Collectors).

Understanding cloud services:

Develop an awareness of the differences between public cloud, private cloud, community cloud and hybrid cloud.

Individual cloud user services for data storage and use of cloud-based applications, e.g. Google Drive, Dropbox, OneDrive and Media Fire.

Investigate and consider a range of commercial Cloud Service Providers (CSPs) in relation to their offer of forensic tools and other cloud services, e.g. Amazon Web Services (AWS), Google Web Service.

Methods:

Actively monitor network traffic.

Identify malicious or potentially malicious activity by analysing system and applications logs, network logs and security logs.

Track user interaction with the system.

Managing and track storage and resource usage.

Forensic analysis:

Understanding how forensic analysis requires specific techniques to capture data and extract information including snapshot analysis (of a VM), remote data acquisition, management plane, live forensics, auditing logs, virtual introspection and alerts to warn of dubious activity.

LO2 Develop a cloud forensics policy which considers legal and commercial implications for a given organisational scenario

Data breaches:

CSP notification timescale, e.g. immediately, within 24 hours.

Types of breach or compromise, e.g. suspected or confirmed.

Consider the extent of the breach and ongoing reviews to detect breaches.

Consideration of sensitive data and homomorphic encryption.

Forensic data collection and investigation:

Access to the servers or system so you can self-collect.

Type of data the CSP collects, how long it is held and storage of this data.

Forensic services that CSP offers as normal, e.g. access to transaction logs, JSON file export and metadata.

Understanding of how CSP owns and controls the servers, rents out space provided, and the platforms used to access cloud service.

Awareness of how during an investigation CSP can compel disclosure of data, seizure of physical devices, virtual machines, hypervisor, logs, event definitions and events.

Understanding the role of the service provider to collect and preserve data, Organisation's ability to access that data when required.

The chain of custody and audit trail.

Business continuity:

Contents of business continuity and disaster recovery planning, including necessary procedures to be followed, employee contact information if incident occurs, types of data required for forensic investigation.

Contents of plan determined by previous breach experience.

Location and legal issues:

In what jurisdiction (state or country) data is stored, and which laws apply, including GDPR, data protection, copyright e.g. Computer Misuse Act (UK 1990), Harmful Digital Communications Act (NZ 2015), Clarifying Lawful Overseas Use of Data (CLOUD) Act (USA 2018).

Consideration of multi-tenancy, chain of custody, probity of CSP, Service Level Agreements (SLAs) in developing a forensic policy and the choice of region in which the data will be held.

Role of ISO standards, e.g. 17025:2017, ISO 27001:201, ISO/IEC 27050:2016.

LO3 Instigate attacks on a cloud-based system using appropriately selected tools

Auditing tools:

Put in place auditing tools to track and identify changes on your cloud-based system, with a view to later assessing if there has been an attack ,e.g. Microsoft Auditing on NTFS, Microsoft Security & Compliance Center, Windows Defender Security ATP Center (WDATP), Intelligent Discovery, Lacework.

Attack tools:

Use a tool to perform different types of attack appropriate to the system involved, e.g. Infection Monkey, Nessi2, Caldera, foreseeti, AttackIQ, Scythe, XM Cyber, Randori, Picus, Low Orbit Ion Cannon, High Orbit Ion Cannon, SlowLoris, R.U.D.Y. Cloud Container Attack Tool.

Attack techniques:

Research and select an appropriate range of attack techniques to test the system, e.g. DDoS Attacks, Amplification Attack, SSDP Attack, Low and Slow Attack, Application Layer Attack, Layer 3 Attacks, Cryptocurrency Attacks.

Research and select an appropriate range of flooding attacks, e.g. DNS Flood, HTTP Flood, SYN Flood Attack, UDP Flood Attack, Ping (ICMP) Flood Attack, ACK Flood Attack, QUIC Flood Attack.

LO4 Investigate the result of attacks on a cloud-based system and identify improvements.

Forensic analysis and methods:

Analyse changes in the system, including missing, corrupted or changed items, e.g. files, permissions, items added to expected list of items.

Review logs for events that indicate unexpected activities, audit log, system log, network log, security log, event log, application log.

Examine data breaches, data changes and data deletion, system hijacking, extraneous applications running in the cloud space, other indicators of malpractice.

Ethics involved in forensic investigations.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Discuss the specific features required of a forensic tool for it to work effectively in the cloud		
P1 Discuss a range of forensic tools suitable for use in the cloud. P2 Examine the differences between a private cloud system and a system provided by a Cloud Service Provider (CSP), in meeting the requirements for forensic analysis.	M1 Analyse the specific features of a chosen forensic tool for it to be effective in the cloud.	D1 Evaluate a cloud forensics policy and identify suitable action in areas where a CSP's non-cooperation would be detrimental to its effectiveness.
L02 Develop a cloud forensics policy which considers legal and commercial implications for a given organisational scenario		
P3 Investigate the legal and commercial implications to be considered when developing a cloud forensics policy. P4 Develop a cloud forensics policy for a given organisational scenario.	M2 Refine the cloud forensics policy to consider the ramifications of storing data and resources on a multinational cloud system.	

Pass	Merit	Distinction
LO3 Instigate attacks on a cloud-based system using appropriately selected tools		
P5 Implement selected auditing tools and techniques to a cloud-based system for system monitoring.	M3 Assess the effectiveness of different attack tools chosen, in identifying the vulnerabilities of a cloud-based system.	D2 Evaluate the suitability of a CSP's forensic services and suggest enhancements that would be beneficial to a corporate user.
P6 Use suitable tools and techniques to perform a series of attacks on a cloud-based system.		
LO4 Investigate the result of attacks on a cloud-based system and identify improvements.		
P7 Perform a forensic analysis on a cloud-based system, post attack, to identify outcomes for improvement.	M4 Justify the methods and tools chosen to analyse the state of a cloud-based system and determine if there has been a data breach or other attack.	

Recommended Resources

Textbook

BLOKDYK, G. (2019) *Cloud Resources A Complete Guide*. Emereo Pty Ltd

Journals

NIST Cloud Computing Forensic Science Working Group Information Technology Laboratory, Draft NISTIR 8006

NIST Cloud Computing Forensic Science Challenges

NIST Cloud Computing Standards Roadmap

Web

www.computer.org	IEEE Computer Society (general reference)
www.forensicsfocus.com	Forensic Focus for Digital Forensics and E-Discovery Professionals (general reference)
isbe.org.uk	The Institute for Small Business and Entrepreneurship (ISBE) (general reference)

Links

This unit links to the following related units:

Unit 3: Security in the Cloud

Unit 16: Information Security Management in the Cloud

Unit 17: Applied Security in the Cloud

Unit 18: Applied Cryptography in the Cloud.

Unit 24: Data Structures & Algorithms

Unit code	D/615/1649
Unit level	5
Credit value	15

Introduction

The knowledge to implement algorithms and data structures that solve real problems, and knowing the purpose, complexity and use of algorithms is part of an essential toolkit for software engineers. An algorithm is a sequence of instructions used to manipulate data held in a structured form and together constitute design patterns for solving a diverse range of computer problems, including network analysis, cryptography, data compression and process control.

This unit introduces students to data structures and how they are used in algorithms, enabling them to design and implement data structures. The unit introduces the specification of abstract data types and explores their use in concrete data structures. Based on this knowledge, students should be able to develop solutions by specifying, designing and implementing data structures and algorithms in a variety of programming paradigms for an identified need.

Among the topics included in this unit are abstract data types specification, formal data notations, data encapsulation, complex data structures, programming language implementations using handles, pointers, classes and methods, algorithm types, data structure libraries, algorithm complexity, asymptotic testing and benchmarking.

On completion of this unit the student should be able to identify program data requirements, specify abstract data types using a formal notation, translate into concrete data structures and be able to develop, using a programming paradigm, different sorting, searching and navigational algorithms that implement complex data structures and evaluate their effectiveness.

As a result of studying this unit students will develop skills such as communication literacy, critical thinking, analysis, synthesis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of the unit students will be able to:

- 1 Examine abstract data types, concrete data structures and algorithms
- 2 Specify abstract data types and algorithms in a formal notation
- 3 Implement complex data structures and algorithms
- 4 Assess the effectiveness of data structures and algorithms.

Essential Content

LO1 Examine abstract data types, concrete data structures and algorithms

Abstract Data Types (ADTs):

Specification of ADTs with formal notation.

Data structures:

Array; set; stack; queue; list; tree; types e.g. active, passive, recursive.

Algorithm types:

Recursive, backtracking, dynamic, divide & conquer, branch & bound, greedy, randomised, brute force.

Algorithms:

Sort; insertion, quick, merge, heap, bucket, selection; search linear, binary, binary search tree, recursive e.g. binary tree traversals; find path; travelling salesman.

LO2 Specify abstract data types and algorithms in a formal notation

Design specification:

Specify ADTs using formal notation e.g. ASN.1; use non-executable program specification language e.g. SDL, VDM; issues e.g. complexity in software development; design patterns, parallelism; interfaces; encapsulation, information hiding, efficiency.

Creation:

Pre-conditions, post-conditions, error-conditions.

LO3 Implement complex data structures and algorithms

Implementation:

Data structures; multidimensional arrays, linked lists, stacks, queues, trees, hash table, heap, graph Algorithms; sorting, searching, tree traversal, list traversal, hash functions, string manipulation, scheduling and recursive algorithms; using handle, pointer, class, methods; using an executable programming language.

LO4 Assess the effectiveness of data structures and algorithms.

Use of data structure libraries (DSL):

Limitations of DSL; manual selection of data structures; theoretical analysis; asymptotic analysis; size of N, Big O notation.

Algorithm effectiveness:

Run time benchmark, compiler/interpreter dependencies, resource usage, degree of parallelism, time, space, power performance, efficiency of garbage collection.

Learning Outcomes and Assessment Criteria

Pass	Merit		Distinction
LO1 Examine abstract data types, concrete data structures and algorithms			
P1 Create a design specification for data structures explaining the valid operations that can be carried out on the structures.	M1 Illustrate, with an example, a concrete data structure for a First In First out (FIFO) queue.	M2 Compare the performance of two sorting algorithms.	D1 Analyse the operation, using illustrations, of two network shortest path algorithms, providing an example of each.
LO2 Specify abstract data types and algorithms in a formal notation			
P3 Using an imperative definition, specify the abstract data type for a software stack.	M3 Examine the advantages of encapsulation and information hiding when using an ADT.		D2 Discuss the view that imperative ADTs are a basis for object orientation and, with justification, state whether you agree.
LO3 Implement complex data structures and algorithms			
P4 Implement a complex ADT and algorithm in an executable programming language to solve a well-defined problem.	M4 Demonstrate how the implementation of an ADT/algorithm solves a well-defined problem.		D3 Critically evaluate the complexity of an implemented ADT/algorithm.
P5 Implement error handling and report test results.			

Pass	Merit	Distinction
<p>LO4 Assess the effectiveness of data structures and algorithms.</p> <p>P6 Discuss how asymptotic analysis can be used to assess the effectiveness of an algorithm.</p> <p>P7 Determine two ways in which the efficiency of an algorithm can be measured, illustrating your answer with an example.</p>	<p>M5 Interpret what a trade-off is when specifying an ADT using an example to support your answer.</p>	<p>D4 Evaluate three benefits of using implementation independent data structures.</p>

Recommended Resources

Textbooks

- CORMEN, T. (1990) *Introduction to Algorithms*. MIT Labs.
- CORMEN, T. (2002) *Instructors Manual: Introduction to Algorithms*. MIT Labs.
- HEINEMAN, G. (2009) *Algorithms in a Nutshell*. O'Reilly Publishing.
- LARMOUTH, J. (1999) *ASN.1 Complete*. Kaufman Publishing.
- LEISS, E. (2007) *A Programmer's Companion to Algorithm Analysis*. Chapman & Hall.
- SEGEWICK, R. (1983) *Algorithms*. Addison-Wesley.
- WIRTH, N. (2004) *Algorithms and Data Structures*. Oberon.

Links

This unit links to the following related units:

Unit 4: Programming

Unit 18: Applied Cryptography in the Cloud

Unit 21: Applied Programming and Design Principles

Unit 25: Machine Learning

Unit code	J/615/1662
Unit level	5
Credit value	15

Introduction

Machine learning is the science of getting computers with the ability to learn from data or experience to solve a given problem without being explicitly programmed. It has been around for many years, however it has become one of the hottest fields of study in the computing sector. Machine learning is in use in several areas such as predictive modelling, speech recognition, object recognition, computer vision, anomaly detection, medical diagnosis and prognosis, robot control, time series forecasting and much more.

This unit will introduce the basic theory of machine learning, the most efficient machine learning algorithms and practical implementation of these algorithms. Students will gain hands-on experience in getting these algorithms to solve real-world problems.

Topics included in this unit are: the foundations of machine learning, types of learning problems (classification, regression, clustering etc.), taxonomy of machine learning algorithms (supervised learning, unsupervised learning, reinforcement learning), machine learning algorithms (Decision Tree, Naïve Bayes, k-Nearest Neighbour, Support Vector Machine etc.).

On successful completion of this unit students will be able to understand the concept of machine learning, machine learning algorithms, gain hands-on experience in implementing algorithms using a programming language such as C/C++, C#, Java, Python, R, or a machine learning tool such as Weka, KNIME, MS AzureML etc.

As a result students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Analyse the theoretical foundation of machine learning to determine how an intelligent machine works
- 2 Investigate the most popular and efficient machine learning algorithms used in industry
- 3 Develop a machine learning application using an appropriate programming language or machine learning tool for solving a real-world problem
- 4 Evaluate the outcome or the result of the application to determine the effectiveness of the learning algorithm used in the application.

Essential Content

LO1 Analyse the theoretical foundation of machine learning to determine how an intelligent machine works

Consideration of what learning is.

Definitions of machine learning.

Core terminologies of machine learning.

Types of learning problems: classification, regression, optimisation, clustering.

How does machine learning work? Supervised learning, unsupervised learning, reinforcement learning, semi-supervised learning, deep learning.

LO2 Investigate the most popular and efficient machine learning algorithms used in industry

Machine learning algorithms and appropriate programming languages or tools:

Introduction to programming languages or tools. Introduction to the language or tool.

A quick tour of the language or tool.

Investigating the mathematical background of machine learning with the programming language or tool:

Formulas, functions, descriptive statistics and graphs, probability.

Investigate the machine learning algorithm and demonstrate using the programming language or a tool:

K-Nearest Neighbour, Support Vector Machine, Linear Regression, Decision Tree, Naïve Bayes, K-Means Clustering.

LO3 Develop a machine learning application using an appropriate programming language or machine learning tool for solving a real-world problem

Problem definition:

Investigate and characterise the problem in order to better understand the goals of the project.

Data analysis:

Understand the available data (rows, columns, classes data range and so forth).

Data preparation:

Separate the data as training sets and testing set in order to expose better the structure of the prediction to modelling algorithms.

Implement the algorithm:

Implement the algorithm with an appropriate programming language or tool, train the model using training data set, present results.

LO4 Evaluate the outcome or the result of the application to determine the effectiveness of the learning algorithm used in the application.

Improving models' accuracy.

The cause of poor performance in machine learning is either overfitting or underfitting the data.

Under-fitting situations: The cause of poor performance in machine learning is either overfitting or underfitting the data.

Over-fitting situations: Overfitting happens when a model learns the detail and noise in the training data to the extent that it negatively impacts the performance of the model on new data.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse the theoretical foundation of machine learning to determine how an intelligent machine works		
P1 Analyse the types of learning problems. P2 Demonstrate the taxonomy of machine learning algorithms.	M1 Evaluate the category of machine learning algorithms with appropriate examples.	D1 Critically evaluate why machine learning is essential to the design of intelligent machines.
LO2 Investigate the most popular and efficient machine learning algorithms used in industry		
P3 Investigate a range of machine learning algorithms and how these algorithms solve the learning problems. P4 Demonstrate the efficiency of these algorithms by implementing them using an appropriate programming language or machine learning tool.	M2 Analyse these algorithms using an appropriate example to determine their power.	

Pass	Merit	Distinction
LO3 Develop a machine learning application using an appropriate programming language or machine learning tool for solving a real-world problem		
P5 Choose an appropriate learning problem and prepare the training and test data sets in order to implement a machine learning solution. P6 Implement a machine learning solution with a suitable machine learning algorithm and demonstrate the outcome.	M3 Test the machine learning application using a range of test data and explain each stages of this activity.	D2 Critically evaluate the implemented learning solution and its effectiveness in meeting end user requirements.
LO4 Evaluate the outcome or the result of the application to determine the effectiveness of the learning algorithm used in the application.		
P7 Discuss whether the result is balanced, under-fitting or over-fitting. P8 Analyse the result of the application to determine the effectiveness of the algorithm	M4 Evaluate the effectiveness of the learning algorithm used in the application.	

Recommended Resources

Textbooks

BELL, J. (2014) *Machine Learning: Hands-On for Developers and Technical Professionals*. 1st Ed. Wiley.

FLACH, P. (2012) *Machine Learning: The Art and Science of Algorithms that Make Sense of Data*. 1st Ed. Cambridge: Cambridge University Press.

KIRK, M. (2014) *Thoughtful Machine Learning: A Test-Driven Approach*. O'Reilly Media.

Websites

archive.ics.uci.edu/ml	University of California, Irvine “Machine Learning Repository” (Data sets)
www.lfd.uci.edu	University of California, Irvine – Laboratory for Fluorescence Dynamics “Binaries for Python Extension Packages” (Development Tool)
cran.r-project.org	The R Project for Statistical Computing “R Archive Network” (Development Tool)
www.cs.waikato.ac.nz	University of Waikato – Machine Learning Group “Data Mining Software in Java” (Development Tool)
www.knime.org	Konstanz Information Miner “KNIME” (Development Tool)
www.codechef.com	CodeChef educational initiative “List of Compilers” (Wiki)
julialang.org	Julia Programming Language (Development Tool)
pkg.julialang.org	Julia Programming Language (Development Tool)
azure.microsoft.com	Microsoft Azure (Development Tool)
accord-framework.net	Accord.NET Framework (Development Tool)

Links

This unit links to the following related units:

Unit 26: Artificial Intelligence

Unit 26: Artificial Intelligence

Unit code	L/615/1663
Unit level	5
Credit value	15

Introduction

One of the dreams of the computing sector is to build an intelligent digital assistant that could serve people according to peoples' nature. Building this type of intelligent machine is a big challenge to computer scientists. An intelligent machine must have at least the following behaviours – vision, speech and voice recognition, smelling sense, learning from experience to solve new problems and coping with the unknown. The science of artificial intelligence (AI) is trying to overcome these challenges by combining the study of nature, understanding from humans' intelligent behaviour and brain function, other animal's acute senses, with mathematics, statistics, logic and traditional computer science. Some of AIs achievements include the NASA's Mars Rover, Google's Self-Driving Cars, IBM's Watson, Microsoft's Xbox 360 (the first gaming device to track human body movement) and much more.

This unit is designed to introduce the philosophy behind artificial intelligence, the most efficient techniques of AI and various intelligent systems that help us to overcome various challenges. This unit guides the student to investigate the emerging AI technologies which could solve various real-world challenges and problems.

Topics included in this unit are the philosophical background to AI, current trends and the future of AI, ethics and issues in AI ,a range of AI applications (computer vision, speech processing and so forth), top-down approach of AI techniques, fuzzy logic, knowledge-based systems, natural language processing), bottom-up approach of AI techniques (neural networks, evolutionary computing, swarm intelligence), and emerging AI technologies (Brain Computer Interfacing, Ambient AI, Smart City, GPU AI etc).

On successful completion of this unit students will be able to understand the fundamental concepts in artificial intelligence from a theoretical, practical and cognitive point of view, and also gain innovative thought processes to build intelligent systems for future needs. Furthermore, the students can gain hands-on experience in developing intelligent systems using a programming language such as C/C++, C#, Java, Prolog, Lisp, Python, R, or a tool such as Weka, KNIME, MS AzureML, Accord.NET, AForge.NET, Neuroph, tools for NLP (NLTK, AIML), tools for swarm robotics (Microsoft robotics developer studio, Orocosp, 'Player Stage Gazebo') etc.

As a result students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Analyse the theoretical foundation of artificial intelligence, current trends and issues to determine the effectiveness of AI technology
- 2 Implement an intelligent system using a technique of the top-down approach of AI
- 3 Implement an intelligent system using a technique of the bottom-up approach of AI
- 4 Investigate and discuss a range of emerging AI technologies to determine future changes in industry.

Essential Content

LO1 Analyse the theoretical foundation of artificial intelligence, current trends and issues to determine the effectiveness of AI technology

Philosophical background of AI:

What is an intelligence? How does the brain work? What is artificial intelligence? The Turing test, John Searle's 'The Chinese Room' test, Strong AI vs. Weak AI, Top-down approach of AI vs. bottom up approach of AI.

Top-down approach of AI:

Knowledge-based system, natural language processing, fuzzy logic.

Bottom up approach of AI:

Artificial neural networks, evolutionary computing, swarm intelligence.

Applications of AI:

Intelligent Robot, intelligent agent, artificial life, computer vision, speech recognition, artificial nose, data mining and other smart technologies.

Issues of AI:

Practical difficulties in building brain like machine, ethics and social issues of AI, philosophical issues of AI – will computers control the human?

LO2 Implement an intelligent system using a technique of the top-down approach of AI

Choose and develop skill on a development tool or programming language which support top-down approach:

Introduction to the language or tool; a quick tour of the language or tool; investigate and develop skill on functions, classes, libraries and/or packages which support the top-down approach.

Choose a technique from the list below, then investigate and demonstrate the technique using the programming language or a tool:

Knowledge based system: data representation, semantic net, rule-based system.

Fuzzy logic: uncertainty, fuzzy sets, fuzzy inferences, fuzzy rules.

Natural language processing: NLP techniques, parsing with generations, compositional and lexical semantics, dialogues.

LO3 Implement an intelligent system using a technique of the bottom-up approach of AI

Choose and develop skill on a development tool or programming language which support bottom-up approach:

Introduction to the language or tool; a quick tour of the language or tool; investigate and develop skill on functions, classes, libraries and/or packages which support the bottom-up approach.

Choose a technique from the list below then investigate and demonstrate the technique using the programming language or a tool:

Artificial neural network: supervised learning algorithms, single perceptron, MLP & backpropagation learning algorithms.

Evolutionary computing: problem model, fitness evaluation, selection method, crossover operator, evolution scheme, observation.

Swarm intelligence: swarm intelligent approaches, swarm robotics, team size and composition, team configurability, communication pattern and range.

LO4 Investigate and discuss a range of emerging AI technologies to determine future changes in industry.

Distributed AI; GPU AI; Ambient AI; Brain Computer Interfacing; Smart Systems, Smart Home and Smart Cities.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	<p>LO1 Analyse the theoretical foundation of artificial intelligence, current trends and issues to determine the effectiveness of AI technology</p>	
<p>P1 Investigate the top-down approach of AI and its techniques and show how these techniques have been used to build intelligent systems.</p> <p>P2 Investigate the bottom-up approach of AI and its techniques and show how these techniques have been used to build intelligent systems.</p>	<p>M1 Discuss how AI has changed the world in the last two decades and evaluate the ethical, social and philosophical issues of AI.</p>	<p>D1 Review the contribution that AI has had on a global basis to individuals and society with the use of examples.</p>
	<p>LO2 Implement an intelligent system using a technique of the top-down approach of AI</p>	
<p>P3 Develop an intelligent system using a top-down approach with a suitable programming language or tool.</p> <p>P4 Test the system and analyse the results against expected results to identify consistencies.</p>	<p>M2 Critically evaluate the effectiveness of the intelligent system and suggest methods of improvement.</p>	<p>D2 Develop an outstanding intelligent system based on a top-down approach to overcome a real-world issue.</p>
	<p>LO3 Implement an intelligent system using a technique of the bottom-up approach of AI</p>	
<p>P5 Develop an intelligent system using a bottom-up approach with a suitable programming language or tool.</p> <p>P6 Test the system and analyse the test results against expected results to identify consistencies.</p>	<p>M3 Critically evaluate the effectiveness of the intelligent system and suggest methods of improvement.</p>	<p>D3 Develop an outstanding, intelligent system based on a bottom-up approach to overcome a real-world issue.</p>

Pass	Merit	Distinction
LO4 Investigate and discuss a range of emerging AI technologies to determine future changes in industry.		
P7 Investigate and chose an emerging AI technology and demonstrate how it works. P8 Illustrate how three emerging technologies are expected to determine future changes in industry.	M4 Critically evaluate the industrial and social implications of an emerging AI technology.	D4 Discuss how emerging AI technology might change our future.

Recommended Resources

Textbooks

- ENGELBRECHT, A. (2007) *Computational Intelligence: An Introduction*. Wiley-Blackwell.
- FANKHAUSER, W. (2015) *Artificial Intelligence Applications: Natural Language Processing*. CreateSpace Independent Publishing Platform.
- FRANKISH, K. and RAMSEY, W. (2014) *The Cambridge Handbook of Artificial Intelligence*. Cambridge: Cambridge University Press.
- JAIN, A. (2011) *Introduction to Biometrics*. Springer.
- KLETTE, R. (2014) *Concise Computer Vision: An Introduction into Theory and Algorithms*. Springer.
- PICON, A. (2015) *Smart Cities: A Spatialised Intelligence. AD Primer*. John Wiley & Sons.
- VADEN, L. (2015) *Advanced Topics in Brain-Computer Interfacing*. CreateSpace Independent Publishing Platform.
- WARWICK, K. (2011) *Artificial Intelligence: The Basics*. Routledge.

Websites

archive.ics.uci.edu/ml	University of California, Irvine “Machine Learning Repository” (Data sets)
www.codechef.com	CodeChef educational initiative “List of Compilers” (Wiki)
www.lfd.uci.edu	University of California, Irvine – Laboratory for Fluorescence Dynamics “Binaries for Python Extension Packages” (Development Tool)
cran.r-project.org	The R Project for Statistical Computing “R Archive Network” (Development Tool)
julialang.org	Julia Programming Language (Development Tool)
pkg.julialang.org	Julia Programming Language (Development Tool)
www.cs.waikato.ac.nz	University of Waikato – Machine Learning Group “Data Mining Software in Java” (Development Tool)
www.knime.org	Konstanz Information Miner “KNIME” (Development Tool)
azure.microsoft.com	Microsoft Azure (Development Tool)

accord-framework.net	Accord.NET Framework (Development Tool)
www.swi-prolog.org	SWI-Prolog (Development Tool)
common-lisp.net	The Common Lisp Foundation
	“Common-Lisp.NET” (Development Tool)
www.aforgenet.com	Open source C# framework
	“AForge.NET” (Development Tool)
www.nltk.org	Natural Language Toolkit “NLTK” (Development Tool)
www.alicebot.org	ALICE A.I. Foundation
	“AIML: Artificial Intelligence Markup Language” (Development Tool)
www.orocos.org	The Orocosp Project
	“Open Robot Control Software” (Development Tool)
www.microsoft.com	Microsoft
	“Robotics Developer Studio” (Development Tool)

Links

This unit links to the following related units:

Unit 25: Machine Learning

Unit 27: Internet of Things

Unit code	T/615/1690
Unit level	5
Credit value	15

Introduction

The Internet of Things (IoT) is a network of physical objects – devices, vehicles, drones and other objects embedded with electronics, software, sensors and network connectivity that enables these objects to collect and exchange data. The objective of the IoT is to enable almost any object to become smart, accessible and data capable, thereby benefitting from advances in communications, computation and interconnectivity. IoT explores the mixture of hardware, software, data, platforms and services that can be combined to create innovative opportunities for more direct integration of the physical world and objects into computer-based systems, resulting in improved efficiency, accuracy, social and economic benefit to people.

This unit introduces students to the role, basic concepts and benefits of IoT in the design and development process of computer applications. The aim of the unit is to enhance the student's understanding of the methodology, terminology and benefits of IoT in the design and development of software applications.

Among the topics included in this unit are: classification and terminology of IoT, the hardware, software, data, platforms and services used to enable IoT, common architecture, frameworks, tools, hardware and APIs that can be utilised to design IoT-enabled objects, problems and solutions resulting from widespread deployment and adoption of IoT, software application methodology for IoT specific software application design and development, data models, network complexity, security, privacy, enabling technologies and how to simulate and test an IoT concept.

On successful completion of this unit students will be able to explain the basic concepts of IoT; design, build and simulate an IoT application using any combination of hardware, software, data, platforms and services; be able to discuss the problem IoT applications solves; the potential impact on society, business and the end user and the problems encountered when integrating into the wider IoT ecosystem.

As a result they will develop skills such as communication literacy, design thinking, team working, critical thinking, analysis, reasoning and interpretation, computer software literacy, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Analyse what aspects of IoT are necessary and appropriate when designing software applications
- 2 Outline a plan for an appropriate IoT application using common architecture, frameworks, tools, hardware and APIs
- 3 Develop an IoT application using any combination of hardware, software, data, platforms and services
- 4 Evaluate your IoT application and the problems it might encounter when integrating into the wider IoT ecosystem.

Essential Content

LO1 Analyse what aspects of IoT are necessary and appropriate when designing software applications

Identify role, formats and characteristics of IoT:

Present an overview of IoT and its appropriate use in software development.

Investigate what IoT is by researching its role, purpose, terminology and methodology.

Recognise the various forms of IoT by researching its history, current trends and use in relation to, and conjunction with, traditional computer-based systems and networks.

Define the characteristics of IoT by investigating how it can be used and how it can interact with existing computer-based networks and the physical world.

Recognise the use of appropriate IoT applications to solve specific problems.

Research specific forms of IoT functionality:

Explore various forms of IoT functionality.

Research, debate and agree current functionality, technology and trends for IoT. Investigate the advantages and disadvantages of using IoT.

Define standard architecture, frameworks, tools, hardware and APIs available for use in IoT application development:

Review architecture, frameworks, tools, hardware and APIs available to develop IoT applications.

The advantages and disadvantages of IoT architecture, frameworks, tools, hardware and APIs.

How various architecture, frameworks, tools, hardware and APIs can be used to create IoT applications.

Appropriateness of various architecture, frameworks, tools, hardware and APIs for different problem-solving requirements.

LO2 Outline a plan for an appropriate IoT application using common architecture, frameworks, tools, hardware and APIs

Identify a problem to be solved and select appropriate IoT techniques to solve this problem:

Choose a specific problem to solve using IoT.

Evaluate the benefits, features, advantages and disadvantages of IoT to solve this problem.

Review different architecture, frameworks, tools, hardware and API techniques you could apply to solve this problem.

Select the most appropriate IoT architecture, frameworks, tools, hardware and API techniques to include in an application to solve this problem.

Describe a plan for an IoT application to solve this problem:

Outline the problem you intend to solve and how IoT and your application addresses this problem.

Select an appropriate IoT application to achieve desired results.

Apply IoT architecture, frameworks, tools, hardware and API techniques to solve this problem.

Use your selected techniques to create an IoT application development plan.

LO3 Develop an IoT application using any combination of hardware, software, data, platforms and services

Utilise appropriate tools and techniques to develop an IoT application:

Employ an appropriate set of tools to develop your plan into an IoT application. Run end user experiments and examine feedback.

Reconcile and evaluate end user feedback and determine advantages and disadvantages of your chosen IoT techniques.

LO4 Evaluate your IoT application and the problems it might encounter when integrating into the wider IoT ecosystem.

Assess the success of your IoT application:

Assemble and appraise end user feedback from your IoT application.

Undertake a critical review and compare your final application with the original plan.

Evaluate the advantages, disadvantages, strengths and weaknesses of your IoT techniques.

Critique the overall success of your application. Did it solve your problem? What is the potential impact on people, business, society and the end user? What problems might it encounter when integrating into the wider IoT ecosystem?

Discusses your insight using IoT.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse what aspects of IoT are necessary and appropriate when designing software applications		
P1 Explore various forms of IoT functionality. P2 Review standard architecture, frameworks, tools, hardware and APIs available for use in IoT development.	M1 Analyse the impact of common IoT architecture, frameworks, tools, hardware and APIs in the software development life cycle. M2 Review specific forms of IoT architecture, frameworks, tools, hardware and APIs for different problem-solving requirements.	D1 Evaluate specific forms of IoT architecture and justify their use when designing software applications.
LO2 Outline a plan for an appropriate IoT application using common architecture, frameworks, tools, hardware and APIs		
P3 Investigate architecture, frameworks, tools, hardware and API techniques available to develop IoT applications. P4 Determine a specific problem to solve using IoT.	M3 Select the most appropriate IoT architecture, frameworks, tools, hardware and API techniques to include in an application to solve this problem. M4 Apply your selected techniques to create an IoT application development plan.	D2 Make multiple iterations of your IoT application and modify each iteration with enhancements gathered from user feedback and experimentation.
LO3 Develop an IoT application using any combination of hardware, software, data, platforms and services		
P5 Employ an appropriate set of tools to develop your plan into an IoT application. P6 Run end user experiments and examine feedback.	M5 Reconcile and evaluate end user feedback and determine advantages and disadvantages of your chosen IoT techniques.	

Pass	Merit	Distinction
<p>LO4 Evaluate your IoT application and the problems it might encounter when integrating into the wider IoT ecosystem.</p> <p>P7 Review your IoT application detailing the problems it solves.</p> <p>P8 Assess the potential impacts of your IoT application on people, business and society and the end user.</p> <p>P9 Investigate the potential problems your IoT application might encounter when integrating into the wider system.</p>	<p>M6 Undertake a critical review and compare your final application with the original plan.</p>	<p>D3 Critically evaluate the overall success of your application.</p>

Recommended Resources

Textbooks

ARSHDEEP, B. (2014) *Internet of Things: A Hands on Approach*. 1st Ed. VPT.

MCEWEN, A. (2013) *Designing the Internet of Things*. 1st Ed. John Wiley and Sons.

Links

This unit links to the following related units:

Unit 15: Cloud Systems Integration

Unit 20: Application Development, Testing and Debugging

Unit 28: Business Intelligence

Unit code	M/615/1641
Unit level	5
Credit value	15

Introduction

Data and information is core to any organisation and business process. The necessity of having meaningful information is the key driver for effective decision-making and problem-solving. Business intelligence has evolved from technologies such as decision support systems (DSS) to include tools and methods associated with data mining, data integration, data quality and data warehousing in conjunction with other information management systems and applications.

This unit introduces students to a range of tools, techniques and technologies for acquiring data and processing this into meaningful information that can be used to support business functions and processes.

Within this unit students will examine the concept of business processing in terms of data capture, conversion and information output. Students will also be required to define the tools and technologies associated with business intelligence functionality. The use of a business intelligence tool/s and techniques is also required to demonstrate an understanding of a given problem. Finally, students will be expected to evaluate the impact of business intelligence for effective decision-making.

On successful completion of this unit students will be able to appreciate the importance of business intelligence in terms of optimising decision-making and performance. By exploring the tools, techniques and systems that support business intelligence students will have an awareness of the role and contribution that these technologies and methodologies have and their importance to organisations.

As a result students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Discuss business processes and the mechanisms used to support business decision-making
- 2 Compare the tools and technologies associated with business intelligence functionality
- 3 Demonstrate the use of business intelligence tools and technologies
- 4 Discuss the impact of business intelligence tools and technologies for effective decision-making purposes and the legal/regulatory context in which they are used.

Essential Content

LO1 Discuss business processes and the mechanisms used to support business decision-making

Business process model:

Data input and capture, data processing/conversion and information output, security considerations; unstructured and semi-structured data.

Tactical and operational decisions, the business process model, business intelligence functionality.

Analyse and compare the systems and technologies associated with business intelligence.

Mechanisms:

Application software, databases, which are used to collect and store intelligence.

Systems that are used to manage, analyse and display business intelligence to support the decision-making process; the importance of reliable data; impacts of reliable data in businesses.

Business processes:

Management e.g. supporting decision-making, problem-solving; operational e.g. sales, purchasing and marketing; support e.g. accounting, technical supporting processes; improving the efficiency of a business process e.g. forecasting, decision-making, predictive reasoning; automating processes e.g. print runs, salary slips etc.

LO2 Compare the tools and technologies associated with business intelligence functionality

Support for business decisions:

Operational tactical and strategic. Operational examples could include product positioning or pricing. Tactical decisions could include financial outlays to gain competitive advantage. Strategic business decisions could include priorities, goals setting and forecasting for the future, global diversification etc.

Business intelligence functionality:

Analysing data, decision-making, problem-solving, designing more intuitive/innovative systems.

Systems and technologies:

Information systems at an operational, tactical and strategic level. Transaction processing, management information systems, decision support systems, expert systems.

LO3 Demonstrate the use of business intelligence tools and technologies

Tools and techniques:

Descriptive and predictive analysis, predictive modelling e.g. forecasting, use of statistical models to predict and identify trends. Data mining techniques to find anomalies, cluster patterns and/or relationships between data sets. Converting data into visual information using charts, graphs, histograms and other visual mediums.

Solutions:

Supporting a business process e.g. end user requirements, systems requirement, application to automate procedures. Designing a tool, program or package that can perform a specific task to support problem-solving or decision-making at an advanced level.

Uses:

For example, designing an application to solve a specific user need or system requirement. Create an e-commerce function for a website to support a specific business process, design a program for a specific end user that will support another application or process.

Design considerations:

Addressing a user or system requirement; designing a user-friendly and functional interface; considering user engagement and interaction with the designed solution; customisation of the solution to satisfy the user and system requirements.

LO4 Discuss the impact of business intelligence tools and technologies for effective decision-making purposes and the legal/regulatory context in which they are used.

Recognise the legal, social, ethical and professional issues involved in the exploitation of computer technology.

Cybersecurity management:

Understanding the personal, organisational and legal/regulatory context in which these tools could be used, the risks of such use and the constraints (such as time, finance and people) that may affect how cybersecurity is implemented.

Evaluation criteria:

Enhanced or improved operations e.g. more efficient, faster results, more user-friendly, higher productivity, extended target audience, more competitive, more profitable, improved customer service.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss business processes and the mechanisms used to support business decision-making		
P1 Examine, using examples, the terms 'Business Process' and 'Supporting Processes'.	M1 Differentiate between unstructured and semi-structured data within an organisation.	D1 Evaluate the benefits and drawbacks of using application software as a mechanism for business processing.
LO2 Compare the tools and technologies associated with business intelligence functionality		
P2 Compare the types of support available for business decision-making at varying levels within an organisation.	M2 Justify, with specific examples, the key features of business intelligence functionality.	D2 Compare and contrast a range of information systems and technologies that can be used to support organisations at operational, tactical and strategic levels.
LO3 Demonstrate the use of business intelligence tools and technologies		
P3 Determine, with examples, what business intelligence is and the tools and techniques associated with it. P4 Design a business intelligence tool, application or interface that can perform a specific task to support problem-solving or decision-making at an advanced level.	M3 Customise the design to ensure that it is user-friendly and has a functional interface.	D3 Provide a critical review of the design in terms of how it meets a specific user or business requirement and identify what customisation has been integrated into the design.

Pass	Merit	Distinction
LO4 Discuss the impact of business intelligence tools and technologies for effective decision-making purposes and the legal/regulatory context in which they are used.		
P5 Discuss how business intelligence tools can contribute to effective decision-making. P6 Explore the legal issues involved in the secure exploitation of business intelligence tools.	M4 Conduct research to identify specific examples of organisations that have used business intelligence tools to enhance or improve operations.	D4 Evaluate how organisations could use business intelligence to extend their target audience and make them more competitive within the market, taking security legislation into consideration.

Recommended Resources

Textbooks

BOYER, J. (2010) *Business Intelligence Strategy*. MC Press (US).

JESTON, J. and NELIS, J. (2014) *Business Process Management*. 3rd Ed. Routledge.

KOLB, J. (2013) *Business Intelligence in Plain Language: A practical guide to Data Mining and Business Analytics*. CreateSpace Independent Publishing Platform.

MARR, B. (2015) *Big Data: Using Smart Big Data, Analytics and Metrics to Make Better Decisions and Improve Performance*. 1st Ed. John Wiley & Sons, Ltd.

Journals

International Journal of Business Intelligence and Data Mining International Journal of Business Intelligence Research (IJBIR)

Websites

businessintelligence.com Business Intelligence (General Reference)

business-intelligence.ac.uk Business Intelligence Project for HE
(General Reference)

Links

This unit links to the following related units:

Unit 11: Strategic Information Systems

Unit 34: Business Information Technology Systems

Unit 29: E-Commerce & Strategy

Unit code	D/615/1683
Unit level	5
Credit value	15

Introduction

Electronic Commerce, or E-Commerce, refers to any type of commercial/business transaction where information, data, products and services are exchanged across the internet. These transactions can cover a wide diversity of business types to include: consumer-based retail sites (e.g. Amazon), sites that provide facilities such as auctions (e.g. eBay) and business exchanges between different organisations. E-Commerce allows consumers to electronically exchange goods and services 24/7 with no barriers in terms of time or geography.

Within this unit students will gain an understanding of how and why businesses and organisations develop E-Commerce strategies: to remain competitive in the global market. Students will also appreciate the elements and resources required to set up an E-Commerce site and be engaged in the design and implementation of their own strategies that would in reality form part of a secure E-Commerce site.

Students will examine the impact that E-Commerce has on society and the global market for consumers, buyers and sellers in terms of the benefits and drawbacks of online purchasing. Through investigation, students will also research the technologies involved in setting up a secure E-Commerce site in preparation for their own E-Commerce strategy.

There is an expectation that students will devise a strategy based on an element of E-Commerce such as designing a shopping cart, an ordering system, payment system or an online marketing system, for example. This design should be fully implemented and evaluated accordingly in terms of its success or failure.

Standards and levels of support, marketing, CRM, promotion and supply chain management will all be explored within the context of developing the implementation strategy.

On successful completion of this unit a student will have gained both a technical and practical insight into E-Commerce strategy, design and development. As a result they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Examine the strategies employed and the impact of E-Commerce on business organisations
- 2 Analyse the hardware, software, web-based and database technologies involved in setting up a secure E-Commerce site
- 3 Design an E-Commerce strategy based on a given end user requirement or specification
- 4 Implement an E-Commerce strategy based on a given end user requirement or specification.

Essential Content

LO1 Examine the strategies employed and the impact of E-Commerce on business organisations

Customer expectations:

Raised expectations for a quick and efficient service e.g. timely responses to customer communications, quick delivery of the product or service, accurate information, reduced pricing for the product/service, greater choice.

Benefits:

Wider market, niche target marketing, lower overheads and costs, greater flexibility and access to goods/services 27/7.

Drawbacks:

Visibility, security issues and threats, down-time, high set up and maintenance costs, need to employ a technician or web-based administrator to manage the provision.

LO2 Analyse the hardware, software, web-based and database technologies involved in setting up a secure E-Commerce site

Web architecture:

Components e.g. server-side scripting, client/server/script interaction, operation of server-side web applications, accessing data on the web server, dynamic web pages, consistent navigational menu on all pages, browser cookies, embedding animation and video content in web pages, adding interactivity with plug-ins.

Hardware and software:

Web servers, browsers, server software, web authoring tools, database system, shopping cart software, scripting software, browser and platform compatibility. Networking technology e.g. TCP/IP addresses, ports and protocols; domain names, multiple registration of domains (.com as well as .co.uk); setting up the server directory structure, deploying access configuration/security.

Database technology:

Uses and processes e.g. database-driven web pages, opening a connection to a database, storing data captured from forms, performing dynamic queries on the database, generating a web page response displaying the results of a query.

Communication technology:

Uses e.g. email support, forum; search engine optimisation; additional hardware and software components required to support communications.

Data transmission:

Features e.g. download speeds, transfer rates, bandwidth required for given applications including text, graphics, video, speech.

LO3 Design an E-Commerce strategy based on a given end user requirement or specification

Considerations:

Hardware and software, design and development, costs and resources, security, maintenance, customer online support and logistics.

Internet strategy:

Hosting e.g. internal, sub-contracted; design of the website; maintaining 24/7 access.

Marketing strategy:

Methods e.g. targeting market segments and interest groups, developing electronic 'web-communities', CRM, promotion strategies to target specific market segments, search engine optimisation, e-marketing software.

Supply chain strategy:

Methods e.g. satisfying customer demand, responsive supply chain, managed in house or sub-contracted, developing 'partnership' relationships with suppliers.

Electronic payment:

Methods e.g. online transaction processing, Commercial Off the Shelf Software (COTS), other payment systems e.g. PayPal, WorldPay.

LO4 Implement an E-Commerce strategy based on a given end user requirement or specification.

Implementation:

Demonstrate that the E-Commerce strategy devised has been implemented using suitable tools and applications. The strategy could be marketing, supply chain or payment based, for example designing an online ordering system or an online payment system.

Evaluation:

Evaluate the success of the design and implementation of the E-Commerce strategy.

Technique:

SWOT analysis to evaluate the overall strengths, weaknesses, opportunities and threats of the implemented E-Commerce strategy.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
L01 Examine the strategies employed and the impact of E-Commerce on business organisations		
P1 Discuss the importance of addressing and meeting customer expectations when employing an E-Commerce strategy.	M1 Analyse organisation case studies and examine how E-Commerce has been used to improve an element of business operations.	D1 Critically review the benefits and drawbacks of an organisation utilising E-Commerce.
L02 Analyse the hardware, software, web-based and database technologies involved in setting up a secure E-Commerce site		
P2 Discuss the technologies involved in setting up a secure E-Commerce site.	M2 Justify the importance of communications technology in E-Commerce design.	D2 Evaluate the role that database technology plays in the development and sustainability of E-Commerce.
L03 Design an E-Commerce strategy based on a given end user requirement or specification		
P3 Discuss the types of strategies that could be used to drive an E-Commerce solution.	M3 Analyse the factors and resources that should be considered when designing an E-Commerce strategy.	D3 Appraise the design and functionality of the E-Commerce solution.
P4 Design an E-Commerce solution based on a specified requirement or strategy.	M4 Differentiate between the types of payment systems that are integral to E-Commerce success.	
L04 Implement an E-Commerce strategy based on a given end user requirement or specification.		
P5 Implement an E-Commerce solution based on a specified requirement or strategy.	M5 Produce a detailed SWOT analysis to support the implemented E-Commerce design.	D4 Evaluate the success of the e-commerce implementation and identify how it fulfils a specified requirements strategy.

Recommended Resources

Textbooks

BONES, C. and HAMMERSLEY, J. (2015) *Leading Digital Strategy: Driving Business Growth Through Effective E-commerce*. 1st Ed. Kogan Page.

CHAFFEY, D. (2009) *E-Business and E-Commerce Management: Strategy, Implementation and Practice*. 4th Ed. Financial Times: Prentice Hall.

LAUDON, K. and TRAVER, C. (2015) *E-Commerce*. 11th Ed. Pearson.

PHILIPS, J. (2016) *Ecommerce Analytics: Analyse and Improve the Impact of Your Digital Strategy*. 1st Ed. Pearson FT Press.

Journals

Journal of Electronic Commerce Research

Journal of Electronic Commerce in Organisations (JECO)

Websites

www.networksolutions.com	Network Solutions Education Centre “Developing an E-Commerce Strategy” (Articles)
www.ecommercefuel.com	E-Commerce Fuel (Discussion Forum)

Links

This unit links to the following related units:

Unit 5: Database Design & Development in the Cloud

Unit 22: Financing the Cloud

Unit 28: Business Intelligence

Unit 30: Risk Analysis & Systems Testing

Unit code	F/615/1689
Unit level	5
Credit value	15

Introduction

Risk-based testing prioritises tests during the system testing phase based on the highest impact and probability of system failure.

The aim of this unit is to provide students with knowledge and skills to use risk-based testing (RBT) using a medium-sized application, developing a full and detailed RBT procedure and documenting the results. They will then be able to evaluate the effectiveness of the application and the testing procedures employed. RBT is used widely in industry to organise software testing and use test resources more efficiently.

This unit introduces students to prioritising testing software features according to risk of failure, evaluated as a function of criticality or importance and impact of failure.

Risk of software failure determines the priority of tests within a Test Plan, strategically carrying out testing over multiple test cycles.

Among the topics included in this unit are: how to classify and evaluate software risks using the risk formula, risk matrix, RBT testing and test build strategies, priority test cycles, security testing, coverage analysis and risk reduction reports.

As a result they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Examine risk-based testing and requirements
- 2 Create a customised risk-based test strategy, plans and techniques for a given specification
- 3 Demonstrate a risk-based Test Plan, producing associated outcomes
- 4 Evaluate a risk-based Test Plan and its associated outcomes.

Essential Content

LO1 Examine risk-based testing and requirements

Risk-based testing and requirements:

Stages: evaluate risk-based testing stage model (ISO/IEC 9126-1); define no risk/no test; distinguish risk classifications, business/operational, security, technical, external; apply risk formula $r(f) = P(f)*C(f)$; test risk assessment/criticality; develop risk weighted matrix; develop risk quality matrix; assess risk reduction methods; detail project risks; identify methods of reporting progress.

LO2 Create a customised risk-based test strategy, plans and techniques for a given specification

Risk-based test strategy, plan and techniques:

Test strategy: develop test risk matrix, selection of risk-based tests; develop risk test plan; build environment rollout plan development; implementation (black box or functional testing, white (or glass) box testing; sub-system, integration (use-case, whole system, interface); maintenance (following changes or reviews, after length of time, stress/overload); user evaluation (analysis of requirements, actual outcomes, acceptance, alpha, beta).

Test Plan: examine test cycles (prioritising security testing); example test data (normal, erroneous, extreme), define expected outcomes (valid, invalid, information gained), reporting of risk.

Techniques: apply black box or functional testing (e.g. control flow, data flow), white (or glass) box testing (e.g. boundary value, branch condition); validation, verification; analyse test coverage/follow up; fault density analysis.

LO3 Demonstrate a risk-based Test Plan, producing associated outcomes

Outcomes:

Review code coverage results and analysis; analyse cause defects; check fault density results; review actual results against expected results (valid information or action, invalid information or action; system-generated messages, program-generated messages).

Modifications:

Prioritisation of further test cycles; changes to specification, changes to analysis, design, amendments to code written, modifications to risk test strategy and plan; create risk reduction reports.

LO4 Evaluate a risk-based Test Plan and its associated outcomes.

Evaluation:

Develop risk heuristics evaluation criteria (probability, severity, classification); identify risk-based testing benefits/drawbacks; define fit for purpose criteria; functionality, accuracy, security effectiveness; alterations to tests carried out, possible improvements; program specification and design, self-reflection, management aspects.

Maintainability:

Perform risk testing and reporting refinement; usefulness to self, usefulness to others.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Examine risk-based testing and requirements	
P1 Investigate the testing stages involved in relation to a risk-based testing model. P2 Discuss the type of risks involved in systems testing in relation to the given specification.	M1 Determine three benefits in applying risk-based testing. M2 Present key information to be communicated post-risk-based testing.	D1 Justify selection of test cases based on quantified risk to project.
	LO2 Create a customised risk-based test strategy, plans and techniques for a given specification	
P3 Establish a risk-based test strategy for the given specification, explaining specifically how security testing will be carried out. P4 Develop a full and detailed Test Plan relating to the risk-based test strategy.	M3 Create a test risk matrix showing how the risks were evaluated. M4 Design and apply a suitable risk-based test cycle.	
	LO3 Demonstrate a risk-based Test Plan, producing associated outcomes	
P5 Perform the tests identified in the risk-based Test Plan. P6 Provide a detailed log of all test results.	M5 Discuss, with the aid of an example, how prioritisation of test cycles can improve testing. M6 Propose a strategy for designing and building a risk-based test environment.	D2 Assess the importance of a suitable build environment to support a risk-based test strategy.

Pass	Merit	Distinction
LO4 Evaluate a risk-based Test Plan and its associated outcomes.		
P7 Discuss the reasons for all modifications made at each stage of the risk-based test procedure. P8 Evaluate the effectiveness of the risk based test strategy including an assessment of security testing cycles.	M7 Compare two risk-based test strategies and explain the benefits/disadvantages.	D3 Examine how test risk heuristics are identified, evaluated and monitored in a risk based test strategy, providing justification.

Recommended Resources

Textbooks

DEMARCO, T. and LISTER, T. (2003) *Waltzing with Bears: Managing Risk on Software Projects*. Dorset House Publishing.

NETTLETON, D. (2006) *Risk-based Software Validation: Ten Easy Steps*. Parenteral Drug Association.

Journals

Mottahir, M. and Khan, A.I. (2013) *Risk-based Testing Techniques: A Perspective Study*. International Journal of Computer Applications. Article.

Websites

istqbexamcertification.com	International Software Testing Qualifications Board “What is Risk Based testing” (Article)
www.cs.tut.fi	Tampere University of Technology Faculty of Computing and Electrical Engineering “Risk based Testing” (Tutorial)

Links

This unit links to the following related units:

Unit 19: Software Development Methodologies for the Cloud

Unit 20: Application Development, Testing and Debugging

Unit 31: Critical Infrastructure Protection

Unit code	K/616/7224
Unit level	5
Credit value	15

Introduction

Contemporary life sees terror attacks on people and places become more diverse, as have natural catastrophes, which has led to a greater emphasis from public services on critical infrastructure protection. Critical infrastructure protection has become of vital importance to all countries for the protection and safety of their citizens and visitors. Critical infrastructure, such as government and civic buildings and military bases, is often seen as a 'hard' target. However, a country's critical infrastructure also includes its cyber security and energy infrastructure as well as the buildings of everyday life: schools, hospitals, sports stadiums, bars, nightclubs, shopping centres, transportation hubs.

This unit will ensure that students understand the wide-ranging nature of critical infrastructure protection and the risk of attack or natural disaster. Students will gain an understanding of the various organisations which have a role to play in this, including police, fire and government. A major part of critical infrastructure protection is the planning for, and preparedness of, the physical infrastructure and of organisations to the types of threats they face. Students will analyse the planning and preparation process by first considering the contemporary threats and risks faced.

They will also look at the responsibilities of each organisation involved, the legal requirement associated with critical infrastructure protection and how the chain of command works during the different levels of critical infrastructure protection such as operational, tactical and strategic.

Students will have the opportunity to investigate command and control procedures, which will provide a deeper understanding of the types of threats faced and the considerations and command skills required to deal with each specific threat.

Students will also consider the post-incident impact of a failure in critical infrastructure. Finally, the unit will allow students to appraise the future of critical infrastructure protection in relation to threats and risks. Related to this, students will consider society's reliance on technology and the threat to cyber security this brings in areas such as hacking, ransomware viruses and cyber terrorism.

On successful completion of this unit students will have gained a rounded view of critical infrastructure protection which will provide an excellent foundation in the workplace in areas such as civil protection and blue light services.

Learning Outcomes

By the end of this unit students will be able to:

- 1 Analyse the types of critical infrastructure and organisations involved in critical infrastructure protection
- 2 Explore the emergency planning methods for critical infrastructure protection
- 3 Investigate command and control procedures in the management of critical infrastructure scenarios
- 4 Review threats to critical infrastructure.

Essential content

LO1 Analyse the types of critical infrastructure and organisations involved in critical infrastructure protection

Critical infrastructure:

Physical or intangible assets whose destruction or disruption would seriously undermine public safety, social order and the fulfilment of key government responsibilities.

Sources of critical infrastructure risk:

Could be natural, e.g. earthquakes or floods or man-made, e.g. terrorism, sabotage.

Critical infrastructures:

Educational building, e.g. schools, colleges, universities Hospitals

Spectator venues, e.g. sporting stadiums, concert arena or theatres

Retail hubs and night-time economy, e.g. nightclubs, bars, shopping malls/centres

Transportation hubs and networks, e.g. trains, buses, ports, airports, road and motorway systems

Energy infrastructure, e.g. oil, gas, electricity or nuclear stations.

Organisations involved in critical infrastructure protection:

Police

Fire services

Maritime or coastguard agencies Ambulance Service

Intelligence agencies

Emergency services control centres National and local government Armed Forces.

LO2 Explore the emergency planning methods for critical infrastructure protection

Identification of major threats and risk assessment:

Terrorist activities Plane/rail crash Hostage situations Sabotage Espionage
Cyber-attacks, e.g. hacking, ransomware, cyber terrorism.

Role of different organisations in critical infrastructure protection:

Role and responsibilities of organisations in the event of security incident
Objective of each organisation at an incident.

Chains of command:

Command structures, e.g. inter-agency responsibilities Operational, tactical and strategic responsibilities.

Legal requirements:

National and international law, e.g. National Cyber Security and Critical Infrastructure Protection Act 2013, European Programme for Critical Infrastructure Protection.

LO3 Investigate command and control procedures in the management of critical infrastructure scenarios

How different incidents are commanded and controlled:

Terrorist activities Plane/rail crash Hostage situations Sabotage Espionage
Cyber attacks
Levels of response – command structure.

Considerations for emergency planning:

Types of incident
Location of incident (access and egress) Hazards associated with incident
Causalities
Emergency services required Rendezvous points
Inner and outer cordons and marshalled areas Environmental considerations
Inter-agency responsibilities.

Post incident:

Debriefing for all agencies Review response

Victim support and aftercare Criminal or public inquest Clearing scene or environment.

Media:

Management of information Communication of information Sources of information

Validity of information.

LO4 Review threats to critical infrastructure.

Natural/man-made:

Floods Earthquakes Terrorism Sabotage.

International consequences:

Politically motivated attacks

Military intervention, e.g. unarmed aerial vehicle (UAV), drones.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse the types of critical infrastructure and organisations involved in critical infrastructure protection		
P1 Discuss the different types of critical infrastructure at a national level. P2 Review a range of protective services involved in protecting critical infrastructure.	M1 Analyse the different methods used to protect different types of critical infrastructure.	D1 Critically evaluate the effectiveness of critical infrastructure protection provided by a protective service.
LO2 Explore the emergency planning methods for critical infrastructure protection		
P3 Review the contemporary threats facing critical infrastructure. P4 Discuss inter-agency working relationships involved in critical infrastructure protection.	M2 Analyse the effectiveness of planning systems used by protective services using a range of examples.	D2 Critically evaluate the effectiveness of emergency planning methods used by protective services in a specific protective service.
LO3 Investigate command and control procedures in the management of critical infrastructure scenarios		
P5 Discuss effective command and control in a critical infrastructure scenario.	M3 Justify emergency planning methods used in critical infrastructure protection.	D3 Critically evaluate the use of command control in critical infrastructure protection and the impact on protective services.
LO4 Review threats to critical infrastructure.		
P6 Examine emerging trends in critical infrastructure protection.	M4 Assess the impact of emerging trends on protective services.	

Recommended resources

Textbooks

ALISON, L.J. and CREGO, J. (2007) *Policing Critical Incidents: Leadership and Critical Incident Management*. Devon: Willan.

JOHNSON, T.A. (2015) *Cyber Security: Protecting Critical Infrastructures from Cyber Attack and Cyber Warfare*. Boca Raton: CRC Press.

RICHARDS, J. (2012) *A Guide to National Security: Threats, Responses, and Strategies*. Oxford: Oxford University Press.

Journals

INTERNATIONAL JOURNAL OF CRITICAL INFRASTRUCTURE PROTECTION. *Cyber Security and Cyberwar* (2014) Network Security, vol. 2014, no. 4, pp. 4.

KSHETRI, N. (2005) *Pattern of global cyber war and crime: A conceptual framework*. Journal of International Management, vol. 11, no. 4, pp. 541-562.

Websites

cipre-expo.com	Critical Infrastructure Protection and Resilience Europe (General reference)
cpni.gov.uk	Centre for the Protection of National Infrastructure (General reference)
dhs.gov	Homeland Security (USA) (General reference)
ifrc.org	International Federation of Red Cross and Red Crescent Societies (General reference)
rand.org	RAND Corporation (General reference)

Links

This unit links to the following related units:

Unit 3: Security in the Cloud

Unit 16: Information Security Management in the Cloud

Unit 17: Applied Security in the Cloud

Unit 32: Developing Individuals, Teams and Organisations

Unit code	A/508/0594
Unit level	5
Credit value	15

Introduction

The aim of this unit is to provide students with the opportunity to appreciate that developing knowledge and skills to achieve high performance is a cross-organisation activity. Students will recognise that their own professional development is just one route to improving the performance of those teams and organisations in which they work. They will also gain an awareness of the context in which learning takes place and how development needs are linked to learning interventions aimed at supporting an organisation's strategy.

On successful completion of this unit, students will have laid the foundations for their own continuing professional development which will support their future engagement in lifelong learning. They will also be able to contribute to the development of others and make a positive contribution to the sustainable growth of an organisation.

Learning Outcomes

By the end of this unit a student will be able to:

- 1 Analyse employee knowledge, skills and behaviours required by HR professionals
- 2 Analyse the factors to be considered when implementing and evaluating inclusive learning and development to drive sustainable business performance
- 3 Apply knowledge and understanding to the ways in which high-performance working (HPW) contributes to employee engagement and competitive advantage
- 4 Evaluate ways in which performance management, collaborative working and effective communication can support high-performance culture and commitment.

Essential Content

LO1 Analyse employee knowledge, skills and behaviours required by HR professionals

Continuing professional development (CPD):

What does this mean? How do we engage in CPD?

How and why should CPD be recorded and evaluated?

Frameworks for CPD:

As a means to structure CPD activities and to provide opportunities for reflection and evaluation.

Reflective learning:

Consider this as a philosophy and a concept. Using reflective learning to gain a deeper and objective insight into levels of performance in comparison to levels of expectation.

Feedback for learning:

Using feedback as part of the learning cycle where feedback informs reflection which in turn informs action.

LO2 Analyse the factors to be considered when implementing and evaluating inclusive learning and development to drive sustainable business performance

Supporting organisational and individual learning:

Learning should be focused on strategic and tactical goals and informed by, for example, GAP analysis or a skills evaluation.

Consider how learning is determined and implemented.

The learning organisation:

The use of formal and informal learning across an organisation to develop individual, team and organisational skill sets.

Training or development:

Training as a one-off event or series of activities is different to development which has a more protracted timescale and builds on the skills and knowledge gained during training. Should organisations focus on training, development or both?

The learning cycle:

Recognising that learning is continuous through the use of learning cycle theories developed by Kolb, Honey and Mumford and Lewin.

Barriers to learning:

Recognising the various environmental, physical, psychological and cognitive barriers and how to overcome them.

LO3 Apply knowledge and understanding to the ways in which high-performance working (HPW) contributes to employee engagement and competitive advantage

High-performance working (HPW):

As a concept, philosophy and approach to developing and supporting strategy development, competitive advantage and improving employee relations.

HPW organisations:

What characterises a HPW organisation (HPWO)?

How is this beneficial to employees and the employer? What barriers may exist to HPW?

High-performance HRM practice:

How are the two related? Which informs which?

What impact does the desire to achieve HPW impact of HR practices?

HPW and external stakeholders:

How will HPW be perceived and viewed by internal and external stakeholders?

Partnerships in a HPWO:

Consider who will be able to support HPW in an organisation? The use of HPW champions to act as catalysts.

How do you sell the concept of HPW to those who will be facilitating this?

LO4 Evaluate ways in which performance management, collaborative working and effective communication can support high-performance culture and commitment.

Performance management (PM):

As a concept and a process. What constitutes effective PM?

How does effective PM inform learning and development at the organisational, team and individual level?

Differences in PM systems.

Organisational culture:

How this can be both a facilitator or barrier to effective PM. The use of internal collaboration to deliver effective PM.

Transformation process:

Use PM to transform organisations. How this is achieved would depend on factors such as scale and size of the organisation, its geographic dispersal and competing challenges. The latter could be the requirement to remain strong in the market, to make a profit or to meet customer expectations during a period of transformation.

The developmental approach to PM:

Separating development from evaluation where the developmental approach considers stages in development and how these are achieved through the setting of criteria, the imposition of systems and an incremental approach to achieving developmental aims.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Analyse employee knowledge, skills and behaviours required by HR professionals	
P1 Determine appropriate and professional knowledge, skills and behaviours that are required by HR professionals. P2 Analyse a completed personal skills audit to identify appropriate knowledge, skills and behaviours and develop a professional development plan for a given job role.	M1 Provide a detailed professional skills audit and professional development plan that demonstrates evidence of personal reflection and evaluation.	D1 Produce a detailed and coherent professional development plan that appropriately sets out learning goals and training in relation to the learning cycle to achieve sustainable business performance objectives.
	LO2 Analyse the factors to be considered when implementing and evaluating inclusive learning and development to drive sustainable business performance	
P3 Analyse the differences between organisational and individual learning, training and development. P4 Analyse the need for continuous learning and professional development to drive sustainable business performance	M2 Apply learning cycle theories to critically analyse the importance of implementing continuous professional development.	

Pass	Merit	Distinction
LO3 Apply knowledge and understanding to the ways in which high-performance working (HPW) contributes to employee engagement and competitive advantage		
P5 Demonstrate understanding of how HPW contributes to employee engagement and competitive advantage within a specific organisational situation.	M3 Analyse the benefits of applying HPW with justifications to a specific organisational situation.	D2 Provide valid synthesis of knowledge and information resulting in appropriate judgements on how HPW and mechanisms used to support HPW lead to improved employee engagement, commitment and competitive advantage.
LO4 Evaluate ways in which performance management, collaborative working and effective communication can support high-performance culture and commitment.		
P6 Evaluate different approaches to performance management (e.g. collaborative working), and demonstrate with specific examples how they can support high-performance culture and commitment.	M4 Critically evaluate the different approaches and make judgements on how effective they can be to support high-performance culture and commitment.	

Recommended Resources

Textbooks

FRIEDMAN, A. L. (2012) *Continuing Professional Development: Lifelong Learning of Millions*. London: Routledge.

MEE-YAN, C-J. and HOLBECH, L. (2015) *Organizational Development: A Practitioner's Guide for OD and HR*. London: Kogan Page.

STEWART, J. and ROGERS, P. (2012) *Developing People and Organisations*. London: CIPD.

Journals

European Journal of Training and Development

International Journal of Training and Development

Organisation Development Journal

Links

This unit links to the following related units:

Unit 8: Professional Practice

Unit 33: Understanding and Leading Change

Unit 33: Understanding and Leading Change

Unit code	A/508/0529
Unit level	5
Credit value	15

Introduction

The aim of this unit is to prepare students to anticipate, plan and deliver organisational change. In addition students will be able to predetermine appropriate and timely interventions required to maximise the benefits and minimise the risk of organisational change.

On successful completion of this unit students will have developed sufficient knowledge and understanding of leadership in the context of organisational change to make an effective and immediate contribution to the way in which an organisation determines and responds to change drivers. Students will also be in a strong position to contribute to change initiatives as well as to consider the strategies required to change resistors.

Learning Outcomes

By the end of this unit a student will be able to:

- 1 Compare ways in which change impacts on an organisation's strategy and operations
- 2 Evaluate the influences that drivers of change have on organisational behaviour
- 3 Determine how barriers to change influence leadership decision-making
- 4 Apply a range of leadership approaches to a change initiative.

Essential Content

LO1 Compare ways in which change impacts on an organisation's strategy and operations

Change as a constant requirement:

What is change in a business context?

How does position and perception influence a view of change as negative or positive?

Types of organisational change:

To include structural and strategic, and people and processes.

Drivers of change:

Consideration of internal and external drivers which could be based on a PEST and/or SWOT analysis.

Dealing with change:

To include planned and emergent change, strategies for change and the Bohner and Arnold Change Impact Analysis.

LO2 Evaluate the influences that drivers of change have on organisation behaviour

Change and the impact on organisational behaviour:

Considering the psychological impact of change on people.

How change impacts on team dynamics and how people are led and managed.

Recognising drivers of change:

Using analytical tools such as PEST and SWOT. Selecting the most significant drivers in a given context.

Responding to drivers of change:

Using systems theory and continuous improvement models to predict and proactively plan for change.

Using the Burke-Litwen model to make the change process efficient and effective.

LO3 Determine how barriers to change influence leadership decision-making

Initiated or imposed change:

Deciding to be pre-emptive and proactive or responsive and reactive will be based on the situation and the nature/scope of the change.

Adaptive and constructive change.

Barriers and resistance to change:

Using a force field analysis to understand likely opposition and support for change in a contemporary context.

Schein's organisational culture model, self-efficacy perceptions and situational resistance when determining barriers.

Leadership and decision-making:

Doing the right thing is important when dealing with change as change mostly affects people. Decisions should be considered with this in mind.

LO4 Apply a range of leadership approaches to a change initiative.

Situational leadership:

The context of a task/activity/challenge determines the appropriate leadership style/approach.

Initiating change:

Where change is initiated then leaders have more control, more time and, therefore, more opportunity to select the best approach to apply.

When change is imposed then these opportunities are reduced or even negated.

Change theories, concepts and models:

The key theories, concepts and models, including Kotter's 8-step Change model, Lewin's change management model, change through strategic communication, change and movement through leadership, the principles of change leadership.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Compare ways in which change impacts on an organisation's strategy and operations		
P1 Compare different organisational examples where there has been an impact of change on an organisation's strategy and operations.	M1 Assess the different drivers for change in each of the given examples and the types of organisational change they have affected.	D1 Draw conclusions and recommendations with valid justifications for planning effectively for change and applying change impact analysis.
LO2 Evaluate the influences that drivers of change have on organisational behaviour		
P2 Evaluate the ways in which internal and external drivers of change affect leadership, team and individual behaviours within an organisation. P3 Evaluate measures that can be taken to minimise negative impacts of change on organisational behaviour.	M2 Critically evaluate the long term implications of internal and external drivers of change within an organisation.	
LO3 Determine how barriers to change influence leadership decision-making		
P4 Explain different barriers to change and determine how they influence leadership decision-making in a given organisational context.	M3 Use force field analysis to analyse both driving and resisting forces to show how they influence decision-making in a given organisational context.	D2 Make valid decisions and outcomes based on force field analysis in the context of meeting organisational objectives.
LO4 Apply a range of leadership approaches to a change initiative.		
P5 Apply different leadership approaches to dealing with change in a range of organisational contexts.	M4 Evaluate the extent to which leadership approaches can deliver organisational change effectively applying appropriate models and frameworks.	D3 Critically evaluate the effectiveness of leadership approaches and models of change management.

Recommended Resources

Textbooks

- LEWIS, L. K. (2011) *Organizational Change: Creating Change Through Strategic Communication*. Chichester: Wiley-Blackwell.
- MEE-YAN, C-J. and HOLBECH, L. (2015) *Organizational Development: a Practitioner's Guide for OD and HR*. London: Kogan Page.
- NORTHOUSE, P. G. (2010) *Leadership Theory and Practice*. 5th Ed. London: SAGE.
- PENDLETON, D. and FURNHAM, A. (2012) *Leadership: All You Need to Know*. London: Palgrave Macmillan.
- STANFORD, N. (2013) *Organization Design: Engaging with Change*. 2nd Ed. London: Routledge.

Journals

Journal of Change Management

Journal of Organisational Change Management Leadership

Links

This unit links to the following related units:

Unit 32: Developing Individuals, Teams and Organisations

Unit 34: Business Information Technology Systems

Unit code	A/618/4934
Unit level	5
Credit value	15

Introduction

Information is the most valuable resource that an organisation possesses. The effective gathering, protection, analysis, processing and dissemination of information is vital to the success of any organisation. As globalisation and the 24-hour economy develop and increase, organisations must ensure that their information systems are reliable, efficient and able to cope with rapid change. This unit introduces students to the importance of information to organisations. It will examine how systems can be used to support core business functions and enable organisations to be more productive and competitive within the global marketplace.

The aim of this unit is to enhance students' understanding of contemporary business information technology (IT) systems and how organisations develop and continuously review their IT strategy in order to gain and maintain competitive advantage. Students will explore the areas of business that benefit from the support of IT systems and how organisations are using IT as a driver for business improvement.

By the end of this unit students will be able to critically analyse the application of current and future technologies and suggest best solutions for an organisation.

Learning Outcomes

By the end of this unit a student will be able to:

- 1 Analyse the role of different IT systems in support of organisational objectives
- 2 Compare flexible and reliable IT systems that respond to organisational requirements within an organisational context
- 3 Evaluate IT systems that support value-added change within organisations
- 4 Recommend practical IT systems solutions to given organisational scenarios.

Essential Content

LO1 Analyse the role of different IT systems in support of organisational objectives

IT systems:

Definition of IT systems and categories of information systems e.g. operational, tactical and strategic information systems.

Definition of information and data, sources of information, information requirements and the needs for information at different levels within an organisation.

Hardware and software for IT systems e.g. operating systems, computer communications and networks, distributed computing.

Emerging digital technologies and use of digital devices including cloud computing for data storage, retrieval and transmission.

Mobile devices for database management, stock management, goods tracking and customer service.

Distributed ledger technology (DLT) e.g. blockchain for recording transactions, record keeping and streamlining the supply chain

The transformational impact of 5G networks on IT systems for faster and efficient decision making.

The role of IT systems:

The role of IT in knowledge management, data management and customer service management.

Storing information and its importance with regard to security, accuracy and relevance.

The impact of IT systems and their contribution to decision making and solving business problems.

Capabilities and limitations of IT solutions.

The impact of IT systems on the functions and structure of organisations to support meeting organisational objectives.

LO2 Compare flexible and reliable IT systems that respond to organisational requirements within an organisational context.

Types of IT systems:

Use of different types of IT systems and their roles in relation to meeting business objectives and improving operational efficiency:

EOPS (End of Point Sales) for transaction processing.

CRM systems for customer relationship management e.g. Salesforce.

Database management systems, use of data dashboards, data warehouses and data discovery tools for business intelligence. e.g. Datapine, Clear analytics and Tableau Online

Knowledge management systems (KMS) e.g. Microsoft Teams, Alfresco, Google for streamlining employee workflows, collaboration, sharing and disseminating data and information.

Enterprise Resource Planning (ERP) cloud solutions e.g. Oracle for integrating different technologies and systems across the business.

Types of information and data:

Layers of information systems e.g. services, integration, security and analytics.

Corporate database management systems, data management and characteristics of data within organisations.

Processing Big Data, data warehousing and online databases.

Types and flow of data and information within an organisation.

Cybersecurity measures for data protection and confidentiality.

Reliability of IT systems and data quality:

The importance of ensuring accurate and appropriate data collection.

Quality assurance and control measures used to ensure data quality on entry and after data collection.

LO3 Evaluate IT systems that support value-added change within organisations

Project management methodologies and strategies to create value and competitive advantage:

Project management methodology for achieving specific goals.

Value creation strategy, competitive advantage, make or buy decisions.

Cost and benefit analysis.

IT support for value-added change:

IT for improving knowledge in activities within the value chain, increasing quality, reducing costs.

New and existing approaches to improving IT position and impact on other business areas providing value-added services e.g. solutions for providing real time performance data, maintenance histories, organic systems for effective data management and cybersecurity solutions.

System development tools and techniques e.g. Agile, RAD, Scrum, Waterfall

LO4 Recommend practical IT systems solutions to given organisational scenarios.

IT systems support for problem-solving:

Problem-solving using decision-making models e.g. decision support, group decision, artificial intelligence and IT systems application.

The use of IT systems to support the storing and managing of data, information sharing, communication, security and gaining a competitive edge.

The use of IT systems for a seamless customer experience management, streamlining and integrating business operations across teams, speeding up processes and increasing efficiency.

Monitoring and evaluating IT systems:

Effective monitoring and evaluation of IT systems and their impact on organisations.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
	LO1 Analyse the role of different IT systems in support of organisational objectives	
P1 Analyse the use of IT systems within different functions of an organisation. P2 Examine how IT systems contribute to the achievement of objectives in a specific organisational context.	M1 Critically analyse how IT systems are applied in the different functions of an organisation and how they work together to achieve high performance.	D1 Justify the role and purpose of IT systems in different functions of an organisation, and their contribution to achieving organisational objectives.
	LO2 Compare different flexible and reliable IT systems that respond to organisational requirements within an organisational context	
P3 Compare different ways IT systems store and process data for knowledge management, customer relationship management, data management and communication management, within an organisational context.	M2 Evaluate the different ways IT systems store and process data to meet organisational objectives providing specific organisational examples.	D2 Critically evaluate the choices that have been made in specific organisational examples to make recommendations.
	LO3 Evaluate IT systems that support value-added change within organisations	
P4 Evaluate how IT systems can be used to support value-added change for improving business operations, performance and sustainability.	M3 Critically evaluate advantages and disadvantages of different IT systems that support value-added change in an organisational context.	D3 Provide justified recommendations for improving IT systems in the support of value-added change in an organisational context.

Pass	Merit	Distinction
<p>LO4 Recommend practical IT systems solutions to given organisational scenarios.</p> <p>P5 Recommend practical IT solutions for organisational scenarios that cover a range of common business problems experienced in the workplace.</p>	<p>M4 Recommend IT practical solutions with potential consequences and benefits of their implementation.</p>	<p>D4 Evaluate how IT systems solutions support added future value and improve the workplace.</p>

Recommended Resources

Textbooks

BENYON-DAVIES, P. (2019) *Business Information Systems*. 3rd Ed. London: Palgrave Macmillan.

BOCIJ, P. (2018) *Business Information Systems: Technology, Development and Management for the E-Business*. 6th Ed. London: Prentice Hall.

LAUDON, K. C. and LAUDON J. P. (2019) *Management Information Systems*. 16th Ed. Harlow: Pearson.

TURBAN, E. et al (2018) *Information Technology for Management: Advancing Sustainable, Profitable Growth*. 11th Ed. Oxford: Wiley.

Links

This unit links to the following related units:

Unit 11: Strategic Information Systems

Unit 28: Business Intelligence

Unit 29: Ecommerce and Strategy

11 Appendices

Appendix 1: Skills Framework for the Information Age (SFIA)

SFIA LEVEL 3 SKILLS

Skill	Description	
Information security	<p>The selection, design, justification, implementation and operation of controls and management strategies to maintain the security, confidentiality, integrity, availability, accountability and relevant compliance of information systems with legislation, regulation and relevant standards.</p>	<p>Communicates information security risks and issues to business managers and others. Performs basic risk assessments for small information systems. Contributes to vulnerability assessments. Applies and maintains specific security controls as required by organisational policy and local risk assessments. Takes action to respond to security breaches in line with security policy and records the incidents and action taken.</p>
Analytics	<p>The validation and analysis of significant volumes of data, including the ability to discover and quantify patterns and trends in numbers, symbols, text, sound and image. Relevant techniques may include statistical and data mining algorithms and machine learning methods such as rule induction, artificial neural networks, genetic algorithms and automated indexing systems.</p>	<p>Undertakes analytical activities and delivers analysis outputs, in accordance with customer needs and conforming to agreed standards.</p>

Skill	Description
Information content publishing	<p>The evaluation and application of different publishing methods and options, recognising key features, including open source and proprietary options. The management and tuning of the processes that collect, assemble and publish information, including in unstructured and semi-structured forms, for delivery to the user at the point at which it is needed. The management of copyright, data protection and other legal issues associated with publishing and re-use of published information and data.</p>
Research	<p>The advancement of knowledge by data gathering, innovation, experimentation, evaluation and dissemination, carried out in pursuit of a predetermined set of research goals.</p>
Data management	<p>The management of practices and processes to ensure the security, integrity, safety and availability of all forms of data and data structures that make up the organisation's information. The management of data and information in all its forms and the analysis of information structure (including logical analysis of taxonomies, data and metadata). The development of innovative ways of managing the information assets of the organisation.</p>

Skill	Description	
Portfolio, programme and project support	<p>The provision of support and guidance on portfolio, programme and project management processes, procedures, tools and techniques. Support includes definition of portfolios, programmes, and projects; advice on the development, production and maintenance of business cases; time, resource, cost and exception plans, and the use of related software tools. Tracking and reporting of programme/project progress and performance are also covered, as is the capability to facilitate all aspects of portfolio/programme/project meetings, workshops and documentation.</p>	<p>Uses recommended portfolio, programme and project control solutions for planning, scheduling and tracking. Sets up project files, compiles and distributes reports. Provides administrative services to project boards, project assurance teams and quality review meetings. Provides guidance on project management software, procedures, processes, tools and techniques.</p>
Business analysis	<p>The methodical investigation, analysis, review and documentation of all or part of a business in terms of business functions and processes, the information used and the data on which the information is based. The definition of requirements for improving processes and systems, reducing their costs, enhancing their sustainability, and the quantification of potential business benefits. The collaborative creation and iteration of viable specifications and acceptance criteria in preparation for the deployment of information and communication systems.</p>	<p>Investigates operational needs and problems, and opportunities, contributing to the recommendation of improvements in automated and non-automated components of new or changed processes and organisation. Assists in defining acceptance tests for these recommendations.</p>

Skill	Description	
Requirements definition and management	<p>The definition and management of the business goals and scope of change initiatives. The specification of business requirements to a level that enables effective delivery of agreed changes.</p>	<p>Defines scope and business priorities for small-scale changes and may assist in larger-scale scoping exercises. Elicits and discovers requirements from operational management and other stakeholders. Selects appropriate techniques for the elicitation of detailed requirements, taking into account the nature of the required changes, established practice and the characteristics and culture of those providing the requirements. Specifies and documents business requirements as directed, ensuring traceability back to source. Analyses them for adherence to business objectives and for consistency, challenging positively as appropriate. Works with stakeholders to prioritise requirements.</p>
Business modelling	<p>The production of abstract or distilled representations of real-world, business or gaming situations in traditional or trans-media applications, to aid the communication and understanding of existing, conceptual or proposed scenarios. Predominantly focused on the representation of processes, roles, data, organisation and time. Models may be used to represent a subject at varying levels of detail and decomposition.</p>	<p>Conversant with techniques covering full range of modelling situations. Models current and desired scenarios as directed. Selects appropriate modelling techniques for meeting assigned objectives. Gains agreement from subject matter experts to models produced. Reviews resulting models with stakeholders and gains resolution to resultant issues.</p>

Skill	Description	
Data analysis	<p>The investigation, evaluation, interpretation and classification of data, in order to define and clarify information structures that describe the relationships between real-world entities. Such structures facilitate the development of software systems, links between systems or retrieval activities.</p>	<p>Applies data analysis, data modelling, and quality assurance techniques, based on a detailed understanding of business processes, to establish, modify or maintain data structures and associated components (entity descriptions, relationship descriptions, attribute definitions). Advises database designers and other application development team members on the details of data structures and associated components.</p>
Systems design	<p>The specification and design of information systems to meet defined business needs in any public or private context, including commercial, industrial, scientific, gaming and entertainment. The identification of concepts and their translation into implementable design. The design or selection of components. The retention of compatibility with enterprise and solution architectures, and the adherence to corporate standards within constraints of cost, security and sustainability.</p>	<p>Specifies user/system interfaces and translates logical designs into physical designs, taking account of target environment, performance security requirements and existing systems. Produces detailed designs and documents that all work using required standards, methods and tools, including prototyping tools where appropriate.</p>
Database design	<p>The specification, design and maintenance of mechanisms for storage and access to both structured and unstructured information, in support of business information needs.</p>	<p>Develops specialist knowledge of database concepts, object and data modelling techniques and design principles. Translates object and data models into appropriate database schemas within design constraints. Interprets installation standards to meet project needs and produces database components as required. Evaluates potential solutions, demonstrating, installing and commissioning selected products.</p>

Skill	Description	
Programming/software development	<p>The design, creation, testing and documenting of new and amended software components from supplied specifications in accordance with agreed development and security standards and processes.</p>	<p>Designs, codes, tests, corrects, and documents moderately complex programs and scripts from agreed specifications and subsequent iterations, using agreed standards and tools. Collaborates in reviews of specifications, with others as appropriate.</p>
Safety engineering	<p>The application of appropriate methods to assure safety during all lifecycle phases of safety-related systems developments, including maintenance and re-use. These include safety hazard and risk analysis, safety requirements specification, safety-related system architectural design, formal method design, safety validation and verification, and safety case preparation.</p>	<p>Assists with the collection of safety assurance evidence, undertaking all work in accordance with agreed safety, technical and quality standards, using appropriate methods and tools. Documents the results of hazard and risk analysis activities.</p>
Information content authoring	<p>The management and application of the principles and practices of designing, creation and presentation of textual information, supported where necessary by graphical content for interactive and digital uses. The adoption of workflow principles and definition of user roles and engagement and training of content providers. This material may be delivered electronically (for example as collections of web pages) or otherwise. This skill includes managing the quality assurance and authoring processes for the material being produced.</p>	<p>Liaises with clients/users to clarify details of requirements. Designs, creates and tests moderately complex subject matter, using easily understood language. Designs content for search engine optimisation, making informed decisions about the best way to present information to users. Ensures that content is accurate, relevant and current and takes into account user needs.</p>

Skill	Description	
Testing	<p>The planning, design, management, execution and reporting of tests, using appropriate testing tools and techniques, and conforming to agreed process standards and industry specific regulations. The purpose of testing is to ensure that new and amended systems, configurations, packages, or services, together with any interfaces, perform as specified (including security requirements) and that the risks associated with deployment are adequately understood and documented.</p> <p>Testing includes the process of engineering, using and maintaining testware (test cases, test scripts, test reports, test plans, etc.) to measure and improve the quality of the software being tested.</p>	<p>Reviews requirements and specifications, and defines test conditions. Designs test cases and test scripts under own direction, mapping back to pre-determined criteria, recording and reporting outcomes.</p> <p>Analyses and reports test activities and results. Identifies and reports issues and risks associated with own work.</p>
User experience analysis	<p>The identification, analysis, clarification and communication of the context of use in which applications will operate, and of the goals of products, systems or services. Analysis and prioritisation of stakeholders' 'user experience' needs and definition of required system behaviour and performance. Resolution of potential conflicts between user requirements and determination of usability objectives.</p>	<p>Identifies and engages with users/stakeholders, defines relevant characteristics (for example 'personas') and describes users goals and tasks (for example as 'user stories'). Describes the environment within which the system will be used. Identifies and describes requirements of users with special needs (for example resulting from physical disabilities).</p>

Skill	Description	
User experience design	<p>The iterative development of user tasks, interaction and interfaces to meet user requirements, considering the whole user experience. Refinement of design solutions in response to user-centred evaluation and feedback, and communication of the design to those responsible for implementation.</p>	<p>Develops visual user experiences across digital assets (web and other digital channels). Works as part of a team to translate digital concepts into consistent graphical representations under creative direction. Supports the capture of business requirements from clients and users, and translates requirements into design briefs. Produces accessible user experiences, prototypes and final assets. Defines cost effective and efficient digital solutions, proactively resolves technical problems and ensures that technical solutions continue to meet business requirements.</p>
User experience evaluation	<p>Evaluation of systems, products or services, to assure that the stakeholder and organisational requirements have been met, required practice has been followed, and systems in use continue to meet organisational and user needs. Iterative assessment (from early prototypes to final live implementation) of effectiveness, efficiency, user satisfaction, health and safety, and accessibility to measure or improve the usability of new or existing processes, with the intention of achieving optimum levels of product or service usability.</p>	<p>Evaluate prototypes to obtain user feedback on requirements of developing systems. Tests the usability of component systems, and alternative designs, administering formative and summative usability tests, logging and analysing data. Check systems for adherence to applicable human science knowledge, style guides, guidelines, standards and legislation. Evaluates the usability of existing or competitor systems to provide benchmark values and as input to design.</p>

Skill	Description
Systems integration	<p>The incremental and logical integration and testing of components and/or subsystems and their interfaces in order to create operational services.</p> <p>Defines the integration build and produces a build definition for generation of the software. Accepts software modules from software developers and produces software builds for loading onto the target hardware from software source code. Configures the hardware environment, produces integration test specifications, conducts tests and records the details of any failures. Carries out and reports fault diagnosis relating to moderately complex problems.</p>
Porting/software configuration	<p>The configuration of software products into new or existing software environments/platforms.</p> <p>Assists in the configuration of software and equipment and the systems testing of platform-specific versions of one or more software products. Documents faults, implements resolutions and retests to agreed standards.</p>
Systems installation/decommissioning	<p>The installation, testing, implementation or decommissioning and removal of cabling, wiring, equipment, hardware and associated software, following plans and instructions and in accordance with agreed standards. The testing of hardware and software components, resolution of malfunctions, and recording of results. The reporting of details of hardware and software installed so that configuration management records can be updated.</p> <p>Installs or removes hardware and/or software, using supplied installation instructions and tools including, where appropriate, handover to the client. Conducts tests, corrects malfunctions, and documents results in accordance with agreed procedures. Reports details of all hardware/software items that have been installed and removed so that configuration management records can be updated. Provides assistance to users in a professional manner following agreed procedures for further help or escalation.</p>

Skill	Description
	<p>Reviews change requests. Maintains accurate records of user requests, contact details and outcomes. Contributes to the development of installation procedures and standards.</p>
Service level management	<p>The planning, implementation, control, review and audit of service provision, to meet customer business requirements. This includes negotiation, implementation and monitoring of service level agreements and the ongoing management of operational facilities to provide the agreed levels of service, seeking continually and proactively to improve service delivery and sustainability targets.</p>
Configuration management	<p>The lifecycle planning, control and management of the assets of an organisation (such as documentation, software and service assets, including information relating to those assets and their relationships). This involves identification, classification and specification of all configuration items (CIs) and the interfaces to other processes and data. Required information relates to storage, access, service relationships, versions, problem reporting and change control of CIs. The application of status accounting and auditing, often in line with acknowledged external criteria such as ISO 9000, ISO/IEC 20000, ISO/IEC 27000 and security throughout all stages of the CI lifecycle, including the early stages of system development.</p>

Skill	Description	
Change management	<p>The management of change to the service infrastructure, including service assets, configuration items and associated documentation.</p> <p>Change management uses requests for change (RFC) for standard or emergency changes and changes due to incidents or problems, to provide effective control and reduction of risk to the availability, performance, security and compliance of the business services impacted by the change.</p>	Develops, documents and implements changes based on requests for change. Applies change control procedures.
Release and deployment	<p>The management of the processes, systems and functions to package, build, test and deploy changes and updates (which are bounded as 'releases') into a live environment, establishing or continuing the specified service, to enable controlled and effective handover to Operations and the user community.</p>	<p>Uses the tools and techniques for specific areas of release and deployment activities.</p> <p>Administers the recording of activities, logging of results and documents technical activity undertaken. May carry out early life support activities such as providing support advice to initial users.</p>
System software	<p>The provision of specialist expertise to facilitate and execute the installation and maintenance of system software such as operating systems, data management products, office automation products and other utility software.</p>	<p>Uses system management software and tools to collect agreed performance statistics.</p> <p>Carries out agreed system software maintenance tasks.</p>
Security administration	<p>The provision of operational security management and administrative services. Typically includes the authorisation and monitoring of access to IT facilities or infrastructure, the investigation of unauthorised access and compliance with relevant legislation.</p>	<p>Investigates minor security breaches in accordance with established procedures. Assists users in defining their access rights and privileges. Performs non-standard security administration tasks and resolves security administration issues.</p>

Skill	Description
Application support	<p>The provision of application maintenance and support services, either directly to users of the systems or to service delivery functions. Support typically includes investigation and resolution of issues and may also include performance monitoring. Issues may be resolved by providing advice or training to users, by devising corrections (permanent or temporary) for faults, making general or site-specific modifications, updating documentation, manipulating data, or defining enhancements support often involves close collaboration with the system's developers and/or with colleagues specialising in different areas, such as database administration or network support.</p>
IT infrastructure	<p>The operation and control of the IT infrastructure (typically hardware, software, data stored on various media, and all equipment within wide and local area networks) required to deliver and support IT services and products to meet the needs of a business. Includes preparation for new or changed services, operation of the change process, the maintenance of regulatory, legal and professional standards, the building and management of systems and components in virtualised computing environments and the monitoring of performance of systems and services in relation to their contribution to business performance, their security and their sustainability.</p>

Skill	Description	
Database administration	The installation, configuration, upgrade, administration, monitoring and maintenance of databases.	Uses database management system software and tools to collect agreed performance statistics. Carries out agreed database maintenance and administration tasks.
Storage management	The planning, implementation, configuration and tuning of storage hardware and software covering online, offline, remote and offsite data storage (backup, archiving and recovery) and ensuring compliance with regulatory and security requirements.	Performs regular high-performance, scalable backups and restores on a schedule and tracks offsite storage. Carries out documented configuration for allocation of storage, installation and maintenance of secure storage systems as per the agreed operational procedure (for example using replication software to allow resilience). Identifies operational problems and contributes to their resolution (for example monitoring SAN for disk failures and replacing). Uses standard management and reporting tools to collect and report on storage utilisation, performance and backup statistics.
Network support	The provision of network maintenance and support services. Support may be provided both to users of the systems and to service delivery functions. Support typically takes the form of investigating and resolving problems and providing information about the systems. It may also include monitoring their performance. Problems may be resolved by providing advice or training to users about the network's functionality, correct operation or constraints, by devising work-arounds, correcting faults, or making general or site-specific modifications.	Identifies and resolves network problems following agreed procedures. Uses network management software and tools to collect agreed performance statistics. Carries out agreed network maintenance tasks.

Skill	Description	
Problem management	The resolution (both reactive and proactive) of problems throughout the information system lifecycle, including classification, prioritisation and initiation of action, documentation of root causes and implementation of remedies to prevent future incidents.	Investigates problems in systems, processes and services. Assists with the implementation of agreed remedies and preventative measures.
Incident management	The processing and coordination of appropriate and timely responses to incident reports, including channelling requests for help to appropriate functions for resolution, monitoring resolution activity, and keeping clients appraised of progress towards service restoration.	Following agreed procedures, identifies, registers and categorises incidents. Gathers information to enable incident resolution and promptly allocates incidents as appropriate. Maintains records and advises relevant persons of actions taken.
Facilities management	The planning, control and management of all the facilities which, collectively, make up the IT estate. This involves provision and management of the physical environment, including space and power allocation, and environmental monitoring to provide statistics on energy usage. Encompasses physical access control, and adherence to all mandatory policies and regulations concerning health and safety at work.	Monitors compliance against agreed processes and investigates, assesses and resolves incidents of non-compliance, escalating where necessary. Grants users required physical accesses and monitors and reports on overall access control.
Learning and development management	The provision of learning and development processes (including learning management systems) in order to develop the professional, business and/or technical skills required by the organisation.	Contributes to the maintenance and updates of training records and training catalogue.

Skill	Description	
Learning assessment and evaluation	<p>The assessment of knowledge, skills and behaviour by any means, whether formal or informal, against capability and qualification frameworks such as SFIA. The evaluation of learning or education programmes against defined outcomes.</p>	<p>Performs routine assessments of knowledge and experience using specified methods and according to specified standards.</p>
Learning delivery	<p>The transfer of business and/or technical skills and knowledge and the promotion of professional attitudes in order to facilitate learning and development. Uses a range of techniques, resources and media (which might include eLearning, online virtual environments, self-assessment, peer-assisted learning, simulation, and other current methods).</p>	<p>Delivers learning activities to a variety of audiences.</p>
Quality assurance	<p>The process of ensuring that the agreed quality standards in an organisation are adhered to and that best practice is promulgated throughout the organisation.</p>	<p>Uses appropriate methods and tools in the development, maintenance, control and distribution of quality and environmental standards. Makes technical changes to quality and environmental standards according to documented procedures. Distributes new and revised standards.</p>
Quality standards	<p>The development, maintenance, control and distribution of quality standards.</p>	<p>Controls, updates and distributes new and revised quality standards.</p>
Conformance review	<p>The independent assessment of the conformity of any activity, process, deliverable, product or service to the criteria of specified standards, best practice, or other documented requirements. May relate to, for example, asset management, network security tools, firewalls and internet security, sustainability, real-time systems, application design and specific certifications.</p>	<p>Collects and collates evidence as part of a formally conducted and planned review of activities, processes, products or services. Examines records as part of specified testing strategies for evidence of compliance with management directives, or the identification of abnormal occurrences.</p>

Skill	Description	
Sourcing	<p>The provision of policy, internal standards and advice on the procurement or commissioning of externally supplied and internally developed products and services.</p> <p>The provision of commercial governance, conformance to legislation and assurance of information security. The implementation of compliant procurement processes, taking full account of the issues and imperatives of both the commissioning and supplier sides.</p> <p>The identification and management of suppliers to ensure successful delivery of products and services required by the business.</p>	<p>Prepares pre-qualification questionnaires and tender invitations in response to business cases. Recognises the difference between open source and proprietary systems options.</p> <p>Produces detailed evaluation criteria for more complex tenders and assists in evaluation of tenders. Acts as the routine contact point between organisation and supplier.</p> <p>Collects and reports on supplier performance data.</p>
Customer service support	<p>The management and operation of one or more customer service or service desk functions. Acting as a point of contact to support service users and customers reporting issues, requesting information, access, or other services.</p>	<p>Acts as the routine contact point, receiving and handling requests for support. Responds to a broad range of service requests for support by providing information to fulfil requests or enable resolution. Provides first line investigation and diagnosis, and promptly allocates unresolved issues as appropriate. Assists with the development standards, and applies these to track, monitor, report, resolve or escalate issues. Contributes to creation of support documentation.</p>

Skill	Description	
Sales support	<p>The provision of technical advice and assistance to the sales force, sales agents, reseller/distributor staff and existing or prospective customers, either in support of customer development or sales activity or in fulfilment of sales obligations.</p>	<p>Provides customer service, including technical advice and guidance on all matters bearing on the successful use of complex products and services. Helps customers to clarify their requirements; documents the conclusions reached and contributes to preparing and supporting bids and sales proposals.</p>
Product management	<p>The active management of a product or service throughout its lifecycle (inception through to retirement) in order to address a market opportunity/customer need and generate the greatest possible value for the business.</p>	<p>Carries out research and performance monitoring activities for specified products. Develops marketing collateral content and evaluates results and feedback from marketing campaigns.</p>

SFIA LEVEL 4 SKILLS

Skill	Description	
Information management	<p>The overall governance of how all types of information, structured and unstructured, whether produced internally or externally, are used to support decision making, business processes and digital services. Encompasses development and promotion of the strategy and policies covering the design of information structures and taxonomies, the setting of policies for the sourcing and maintenance of the data content, and the development of policies, procedures, working practices and training to promote compliance with legislation regulating all aspects of holding, use and disclosure of data.</p>	<p>Understands and complies with relevant organisational policies and procedures, taking responsibility for assessing and managing risks around the use of information. Ensures that information is presented effectively. Ensures that effective controls are in place for internal delegation, audit and control, and that the board receives timely reports and advice that will inform their decisions.</p>
Information security	<p>The selection, design, justification, implementation and operation of controls and management strategies to maintain the security, confidentiality, integrity, availability, accountability and relevant compliance of information systems with legislation, regulation and relevant standards.</p>	<p>Explains the purpose of and provides advice and guidance on the application and operation of elementary physical, procedural and technical security controls. Performs security risk, vulnerability assessments, and business impact analysis for medium complexity information systems. Investigates suspected attacks and manages security incidents. Uses forensics where appropriate.</p>

Skill	Description	
Analytics	<p>The validation and analysis of significant volumes of data, including the ability to discover and quantify patterns and trends in numbers, symbols, text, sound and image. Relevant techniques may include statistical and data mining algorithms and machine learning methods such as rule induction, artificial neural networks, genetic algorithms and automated indexing systems.</p>	<p>Applies a variety of analytical and visualisation techniques, in consultation with experts if appropriate, and with sensitivity to the limitations of the techniques.</p>
Information content publishing	<p>The evaluation and application of different publishing methods and options, recognising key features, including open source and proprietary options. The management and tuning of the processes that collect, assemble and publish information, including in unstructured and semi-structured forms, for delivery to the user at the point at which it is needed. The management of copyright, data protection and other legal issues associated with publishing and re-use of published information and data.</p>	<p>Defines and manages content management processes to meet the needs of users. Select appropriate channels through which content should be published. Uses appropriate tools and techniques to provide moderately complex interfaces to new or existing platforms and applications. Applies propriety guidelines. Identifies the implications of copyright, data protection and other legal issues associated with publishing. Applies search engine optimisation techniques and facilitates ease of use in delivered digital services.</p>
Technical specialism	<p>The development and exploitation of expertise in any specific area of information or communications technology, technique, method, product or application area.</p>	<p>Maintains knowledge of specific specialisms, provides detailed advice regarding their application and executes specialised tasks. The specialism can be any area of information or communication technology, technique, method, product or application area.</p>

Skill	Description	
Research	<p>The advancement of knowledge by data gathering, innovation, experimentation, evaluation and dissemination, carried out in pursuit of a predetermined set of research goals.</p>	<p>Contributes to research goals and builds on and refines appropriate outline ideas for the evaluation, development, demonstration and implementation of research. Reports on work carried out and may contribute significant sections of material of publication quality. Contributes to research plans and identifies appropriate opportunities for publication and dissemination of research findings.</p>
Financial management	<p>The overall financial management, control and stewardship of the IT assets and resources used in the provision of IT services, including the identification of materials and energy costs, ensuring compliance with all governance, legal and regulatory requirements.</p>	<p>Monitors and maintains all required financial records for compliance and audit to all agreed requirements. Assists all other areas of IT with their financial tasks, especially in the areas of identification of process, service, project and component costs and the calculation and subsequent reduction of all IT service, project, component and process failures. Contributes to financial planning and budgeting. Collates required financial data and reports for analysis and to facilitate decision making.</p>
Business risk management	<p>The planning and implementation of organisation-wide processes and procedures for the management of risk to the success or integrity of the business, especially those arising from the use of information technology, reduction or non-availability of energy supply or inappropriate disposal of materials, hardware or data.</p>	<p>Investigates and reports on hazards and potential risk events within a specific function or business area.</p>

Skill	Description	
Sustainability strategy	<p>The preparation of a sustainability strategy, taking into account any established corporate strategy, to be used as a basis for policies and planning, and covering both consumption and sources of supply of energy and materials.</p> <p>Evaluation and inclusion, as appropriate, of political, legislative, economic, social and technological factors. Identification of major external standards, practices or schemes to be adopted.</p> <p>Consultation with identified relevant parties, either internal or external. Obtaining agreement to the strategy and the commitment to act upon it.</p>	<p>Assesses and reports on how different tactical decisions affect organisational sustainability.</p> <p>Evaluates factors and risks (political, legislative, technological, economic, and social) that impact on operational processes and strategic direction.</p>
Emerging technology monitoring	<p>The identification of new and emerging hardware, software and communication technologies and products, services, methods and techniques and the assessment of their relevance and potential value as business enablers, improvements in cost/performance or sustainability.</p> <p>The promotion of emerging technology awareness among staff and business management.</p>	<p>Maintains awareness of opportunities provided by new technology to address challenges or to enable new ways of working. Within own sphere of influence, works to further organisational goals, by the study and use of emerging technologies and products.</p> <p>Contributes to briefings and presentations about their relevance and potential value to the organisation.</p>

Skill	Description	
Continuity management	<p>The provision of service continuity planning and support. This includes the identification of information systems that support critical business processes, the assessment of risks to those systems' availability, integrity and confidentiality and the co-ordination of planning, designing, testing and maintenance procedures and contingency plans to address exposures and maintain agreed levels of continuity. This function should be performed as part of, or in close cooperation with, the function which plans business continuity for the whole organisation.</p>	<p>Provides input to the service continuity planning process and implements resulting plans.</p>
Data management	<p>The management of practices and processes to ensure the security, integrity, safety and availability of all forms of data and data structures that make up the organisation's information. The management of data and information in all its forms and the analysis of information structure (including logical analysis of taxonomies, data and metadata). The development of innovative ways of managing the information assets of the organisation.</p>	<p>Takes responsibility for the accessibility, retrievability and security of specific subsets of data. Assesses the integrity of data from multiple sources (including, for example, from sensors' measurement systems). Provides advice on the transformation of data/information from one format/medium to another, where appropriate. Maintains and implements information handling procedures. Enables the availability, integrity and searchability of information through the application of formal data structures and protection measures. Manipulates specific data from information services, to satisfy local or specific information needs.</p>

Skill	Description	
Methods and tools	Ensuring that appropriate methods and tools for the planning, development, testing, operation, management and maintenance of systems are adopted and used effectively throughout the organisation.	Provides expertise and support on use of methods and tools.
Project management	The management of projects, typically (but not exclusively) involving the development and implementation of business processes to meet identified business needs, acquiring and utilising the necessary resources and skills, within agreed parameters of cost, timescales, and quality.	Defines, documents and carries out small projects or sub-projects (typically less than six months, with limited budget, limited interdependency with other projects and no significant strategic impact), alone or with a small team, actively participating in all phases. Identifies, assesses and manages risks to the success of the project. Agrees project approach with stakeholders, and prepares realistic plans (including quality, risk and communications plans) and tracks activities against the project schedule, managing stakeholder involvement as appropriate. Monitors costs, timescales and resources used, and takes action where these deviate from agreed tolerances. Ensures that own projects are formally closed and, where appropriate, subsequently reviewed, and that lessons learned are recorded.

Skill	Description	
Portfolio, programme and project support	<p>The provision of support and guidance on portfolio, programme and project management processes, procedures, tools and techniques. Support includes definition of portfolios, programmes, and projects; advice on the development, production and maintenance of business cases; time, resource, cost and exception plans, and the use of related software tools. Tracking and reporting of programme/project progress and performance are also covered, as is the capability to facilitate all aspects of portfolio/programme/project meetings, workshops and documentation.</p>	<p>Takes responsibility for the provision of support services to projects. Uses and recommends project control solutions for planning, scheduling and tracking projects. Sets up and provides detailed guidance on project management software, procedures, processes, tools and techniques. Supports programme or project control boards, project assurance teams and quality review meetings. Provides basic guidance on individual project proposals. May be involved in aspects of supporting a programme by providing a cross-programme view on risk, change, quality, finance or configuration management.</p>
Business analysis	<p>The methodical investigation, analysis, review and documentation of all or part of a business in terms of business functions and processes, the information used and the data on which the information is based. The definition of requirements for improving processes and systems, reducing their costs, enhancing their sustainability, and the quantification of potential business benefits. The collaborative creation and iteration of viable specifications and acceptance criteria in preparation for the deployment of information and communication systems.</p>	<p>Investigates operational requirements, problems, and opportunities, seeking effective business solutions through improvements in automated and non-automated components of new or changed processes. Assists in the analysis of stakeholder objectives and the underlying issues arising from investigations into business requirements and problems, and identifies options for consideration. Works iteratively with stakeholders, to identify potential benefits and available options for consideration and in defining acceptance tests.</p>

Skill	Description	
Requirements definition and management	<p>The definition and management of the business goals and scope of change initiatives. The specification of business requirements to a level that enables effective delivery of agreed changes.</p>	<p>Facilitates scoping and business priority setting for change initiatives of medium size and complexity. Contributes to selection of the most appropriate means of representing business requirements in the context of a specific change initiative, ensuring traceability back to source. Discovers and analyses requirements for fitness for purpose as well as adherence to business objectives and consistency, challenging positively as appropriate. Obtains formal agreement by stakeholders and recipients to scope and requirements and establishes a baseline on which delivery of a solution can commence. Manages requests for and the application of changes to baselined requirements. Identifies the impact on business requirements of interim (for example migration) scenarios as well as the required end position.</p>

Skill	Description	
Business process testing	<p>The planning, design, management, execution and reporting of business process tests and usability evaluations. The application of evaluation skills to the assessment of the ergonomics, usability and fitness for purpose of defined processes. This includes the synthesis of test tasks to be performed (from statement of user needs and user interface specification), the design of an evaluation programme, the selection of user samples, the analysis of performance, and inputting results to the development team.</p>	<p>Specifies and develops test scenarios to test that new/updated processes deliver improved ways of working for the end user at the same time as delivering efficiencies and planned business benefits. Records and analyses test results and reports any unexpected or unsatisfactory outcomes. Uses test plans and outcomes to specify user instructions.</p>
Business modelling	<p>The production of abstract or distilled representations of real world, business or gaming situations in traditional or trans-media applications, to aid the communication and understanding of existing, conceptual or proposed scenarios. Predominantly focused on the representation of processes, roles, data, organisation and time. Models may be used to represent a subject at varying levels of detail and decomposition.</p>	<p>Conducts advanced modelling activities for significant change programmes and across multiple business functions. Has an in-depth knowledge of organisation-standard techniques. Plans own modelling activities, selecting appropriate techniques and the correct level of detail for meeting assigned objectives. May contribute to discussions about the choice of the modelling approach to be used. Obtains input from and communicates modelling results to senior managers for agreement.</p>

Skill	Description	
Sustainability assessment	<p>The evaluation of the sustainability of operational or planned services, devices and day-to-day operations such as travel. The establishment of a model or scheme to track changes in consumption over time and to generate feedback to enable improvements in energy or resource efficiency. The identification of areas requiring attention and the initiation of actions to change or control the procurement of energy or other resources so as to improve sustainability.</p>	<p>Assesses, records and reports on utilisation of energy and other resources, showing expertise in a given area such as a class of computing devices, or business travel. Provides advice on the improvement of sustainability in that area of expertise.</p>
Data analysis	<p>The investigation, evaluation, interpretation and classification of data, in order to define and clarify information structures that describe the relationships between real-world entities. Such structures facilitate the development of software systems, links between systems or retrieval activities.</p>	<p>Investigates corporate data requirements and applies data analysis, data modelling and quality assurance techniques, to establish, modify or maintain data structures and their associated components (entity descriptions, relationship descriptions, attribute definitions). Provides advice and guidance to database designers and others using the data structures and associated components.</p>

Skill	Description	
Systems design	<p>The specification and design of information systems to meet defined business needs in any public or private context, including commercial, industrial, scientific, gaming and entertainment. The identification of concepts and their translation into implementable design. The design or selection of components. The retention of compatibility with enterprise and solution architectures, and the adherence to corporate standards within constraints of cost, security and sustainability.</p>	<p>Recommends/designs structures and tools for systems that meet business needs and takes into account target environment, performance security requirements and existing systems. Delivers technical visualisation of proposed applications for approval by customer and execution by system developers. Translates logical designs into physical designs and produces detailed design documentation. Maps work to user specification and removes errors and deviations from specification to achieve user-friendly processes.</p>
Database design	<p>The specification, design and maintenance of mechanisms for storage and access to both structured and unstructured information, in support of business information needs.</p>	<p>Develops and maintains specialist knowledge of database concepts, object and data modelling techniques and design principles, and a detailed knowledge of database architectures, software and facilities. Analyses data requirements to establish, modify or maintain object/data models. Evaluates potential solutions, demonstrating, installing and commissioning selected products.</p>
Programming/software development	<p>The design, creation, testing and documenting of new and amended software components from supplied specifications in accordance with agreed development and security standards and processes.</p>	<p>Designs, codes, tests, corrects and documents complex programs and scripts from agreed specifications, and subsequent iterations, using agreed standards and tools, to achieve a well-engineered result. Takes part in reviews of own work and leads reviews of colleagues' work.</p>

Skill	Description	
Safety engineering	<p>The application of appropriate methods to assure safety during all lifecycle phases of safety-related systems developments, including maintenance and re-use. These include safety hazard and risk analysis, safety requirements specification, safety-related system architectural design, formal method design, safety validation and verification, and safety case preparation.</p>	<p>Contributes to the identification, analysis and documentation of hazards, and to the capture, evaluation and specification of safety requirements. Analyses and documents safety validation results. Contributes to the development and maintenance of project safety assurance plans and gathers safety assurance evidence for safety case preparation.</p>
Sustainability engineering	<p>The development and application of appropriate knowledge and methods to assure sustainability in all phases of the life cycle of energy- or materials-consuming systems and services, including maintenance and re-use. These include such things as energy supply risk analysis, specification of guidelines for sustainable procurement of assets and materials, energy efficiency and sustainability factors influencing system design, system design for sustainable operation and use, efficient coding design and adoption of re-use/sharing principles, achieving behaviour change to more sustainable ways of working, and the verification of energy and resource efficiency in operation.</p>	<p>Investigates and recommends components and subsystems that meet sustainability criteria and levels.</p>

Skill	Description	
Information content authoring	<p>The management and application of the principles and practices of designing, creation and presentation of textual information, supported where necessary by graphical content for interactive and digital uses. The adoption of workflow principles and definition of user roles and engagement and training of content providers. This material may be delivered electronically (for example as collections of web pages) or otherwise. This skill includes managing the quality assurance and authoring processes for the material being produced.</p>	<p>Engages with senior content owners, using objective evidence to determine the content needs of users. Controls, monitors and evaluates web content to ensure quality, consistency and accessibility of messages. Designs the content and appearance of complex information deliverables (for example web pages) in collaboration with clients/users. Moderates content and ensures it can be reused. Creates and tests complex, well-engineered deliverables to support simple, clear, fast services. Interprets analytics data to optimise content so that it meets user needs and is optimised for search engines. Reviews work of other content designers for consistency and accuracy, and takes responsibility for its publication. Understand the implications of publishing content and manages the risks of doing so.</p>
Testing	<p>The planning, design, management, execution and reporting of tests, using appropriate testing tools and techniques, and conforming to agreed process standards and industry specific regulations. The purpose of testing is to ensure that new and amended systems, configurations, packages, or services, together with any interfaces, perform as specified (including security requirements) and that the risks associated with deployment are adequately understood and documented.</p>	<p>Accepts responsibility for creation of test cases using own in-depth technical analysis of both functional and non-functional specifications (such as reliability, efficiency, usability, maintainability and portability). Creates traceability records, from test cases back to requirements.</p>

Skill	Description	
	<p>Testing includes the process of engineering, using and maintaining testware (test cases, test scripts, test reports, test plans, etc.) to measure and improve the quality of the software being tested.</p>	<p>Produces test scripts, materials and regression test packs to test new and amended software or services. Specifies requirements for environment, data, resources and tools. Interprets, executes and documents complex test scripts using agreed methods and standards. Records and analyses actions and results and maintains a defect register. Reviews test results and modifies tests if necessary. Provides reports on progress, anomalies, risks and issues associated with the overall project. Reports on system quality and collects metrics on test cases. Provides specialist advice to support others.</p>
User experience analysis	<p>The identification, analysis, clarification and communication of the context of use in which applications will operate, and of the goals of products, systems or services. Analysis and prioritisation of stakeholders' 'user experience' needs and definition of required system behaviour and performance. Resolution of potential conflicts between user requirements and determination of usability objectives</p>	<p>Analyses qualitative data (for example from site visits) and presents the data in ways that can be used to drive design (for example, personas, red routes, user journey maps). Describes the user/stakeholder objectives for the system and identifies the roles of affected stakeholder groups. Defines the required behaviour and performance of the system in terms of the total user experience (for example in the form of scenarios of use), resolving potential conflicts between user requirements, (for example between accuracy and speed). Specifies measurable criteria for the required usability of the system.</p>

Skill	Description	
User experience design	<p>The iterative development of user tasks, interaction and interfaces to meet user requirements, considering the whole user experience. Refinement of design solutions in response to user-centred evaluation and feedback, and communication of the design to those responsible for implementation.</p>	<p>Collaborates with colleagues from other disciplines to define technology objectives, assess solution options and devise architectural solutions that both achieve strategic business goals and meet operational requirements. Creates design briefs for new web and digital projects or refreshes of existing projects. Develops visual user experiences across digital assets, working with project teams to present propositions and strategies. Rapidly translates digital concepts into hi-fidelity visual outputs and interactive prototypes. Captures multi-disciplinary requirements, and translates those requirements into user experiences, prototypes and final assets. Plans and costs UX activities, building in time for iteration, user feedback and design changes, and articulating the costs and benefits of different design approaches.</p>
User experience evaluation	<p>Evaluation of systems, products or services, to assure that the stakeholder and organisational requirements have been met, required practice has been followed, and systems in use continue to meet organisational and user needs. Iterative assessment (from early prototypes to final live implementation) of effectiveness, efficiency, user satisfaction, health and safety, and accessibility to measure or improve the usability of new or existing processes, with the intention of achieving optimum levels of product or service usability.</p>	<p>Plans and performs all types of evaluation in order to check that stakeholder and organisational requirements have been met, choosing between formative and summative usability tests. Selects and administers moderated or unmoderated usability tests. Tests developing systems to ensure compatibility with user requirements, tasks and environment, as defined in agreed specifications. Checks systems in use for changes in organisational, user, other stakeholder, and usability needs and to ensure that these needs continue to be met.</p>

Skill	Description
	Assesses the stability of requirements against changes in context of use. Interprets and presents results of evaluations to design team(s), prioritising usability issues.
Systems integration	The incremental and logical integration and testing of components and/or subsystems and their interfaces in order to create operational services.
Porting/software configuration	The configuration of software products into new or existing software environments/platforms.
Hardware design	The specification and design of computing and communications equipment (such as semiconductor processors, HPC architectures and DSP and graphics processor chips), typically for integration into, or connection to an IT infrastructure or network. The identification of concepts and their translation into implementable design. The selection and integration, or design and prototyping of components. The adherence to industry standards including compatibility, security and sustainability.
	Defines the integration build, accepts software modules from software developers, and produces software builds for loading onto the target environment. Configures the hardware environment, produces integration test specifications, and conducts tests, recording details of any failures and carrying out fault diagnosis.
	Configures software and equipment and tests platform-specific versions of one or more software products. Reports the outcome of testing and identifies potential improvements to the process and to the software products according to agreed designs and standards.
	Designs computing and communications equipment, taking account of target environment, performance, security and sustainability requirements. Translates logical designs into physical designs and delivers technical prototypes of proposed components for approval by customer and execution by technicians. Designs tests to measure performance of prototypes and production output against specification and inform iterative development.

Skill	Description	
Systems installation/decommissioning	<p>The installation, testing, implementation or decommissioning and removal of cabling, wiring, equipment, hardware and associated software, following plans and instructions and in accordance with agreed standards. The testing of hardware and software components, resolution of malfunctions, and recording of results. The reporting of details of hardware and software installed so that configuration management records can be updated.</p>	<p>Undertakes routine installations and de-installations of items of hardware and/or software. Takes action to ensure targets are met within established safety and quality procedures, including, where appropriate, handover to the client. Conducts tests of hardware and/or software using supplied test procedures and diagnostic tools. Corrects malfunctions, calling on other experienced colleagues and external resources if required. Documents details of all hardware/software items that have been installed and removed so that configuration management records can be updated. Develops installation procedures and standards, and schedules installation work. Provides specialist guidance and advice to less experienced colleagues to ensure best use is made of available assets, and to maintain or improve the installation service.</p>
Availability management	<p>The definition, analysis, planning, measurement, maintenance and improvement of all aspects of the availability of services, including the availability of power. The overall control and management of service availability to ensure that the level of service delivered in all services is matched to or exceeds the current and future agreed needs of the business, in a cost-effective manner.</p>	<p>Contributes to the availability management process and its operation and performs defined availability management tasks. Analyses service and component availability, reliability, maintainability and serviceability. Ensures that services and components meet and continue to meet all of their agreed performance targets and service levels. Implements arrangements for disaster recovery and documents recovery procedures. Conducts testing of recovery procedures.</p>

Skill	Description	
Service level management	<p>The planning, implementation, control, review and audit of service provision, to meet customer business requirements. This includes negotiation, implementation and monitoring of service level agreements and the ongoing management of operational facilities to provide the agreed levels of service, seeking continually and proactively to improve service delivery and sustainability targets.</p>	<p>Performs defined tasks to monitor service delivery against service level agreements and maintains records of relevant information. Analyses service records against agreed service levels regularly to identify actions required to maintain or improve levels of service, and initiates or reports these actions.</p>
Service acceptance	<p>The achievement of formal confirmation that service acceptance criteria have been met and that the service provider is ready to operate the new service when it has been deployed. (Service acceptance criteria are used to ensure that a service meets the defined service requirements, including functionality, operational support, performance and quality requirements.)</p>	<p>Engages with project management to confirm that products developed meet the service acceptance criteria and are to the required standard. Feeds into change management processes.</p>

Skill	Description	
Configuration management	<p>The lifecycle planning, control and management of the assets of an organisation (such as documentation, software and service assets, including information relating to those assets and their relationships). This involves identification, classification and specification of all configuration items (CIs) and the interfaces to other processes and data. Required information relates to storage, access, service relationships, versions, problem reporting and change control of CIs. The application of status accounting and auditing, often in line with acknowledged external criteria such as ISO 9000, ISO/IEC 20000, ISO/IEC 27000 and security throughout all stages of the CI lifecycle, including the early stages of system development.</p>	<p>Maintains secure configuration, applying and maintaining tools, techniques and processes to identify, track, log and maintain accurate, complete and current information.</p>
Asset management	<p>The management of the lifecycle for all managed assets (hardware, software, intellectual property, licences, warranties etc.), including security, inventory, compliance, usage and disposal, aiming to protect and secure the corporate assets portfolio, optimise the total cost of ownership and sustainability by minimising operating costs, improving investment decisions and capitalising on potential opportunities. Knowledge and use of international standards for asset management and close integration with security, change, and configuration management are examples of enhanced asset management development.</p>	<p>Controls IT assets in one or more significant areas, ensuring that administration of the acquisition, storage, distribution, movement and disposal of assets is carried out. Produces and analyses registers and histories of authorised assets (including secure master copies of software, documentation, data, licenses and agreements for supply, warranty and maintenance) and verifies that all these assets are in a known state and location. Acts to highlight and resolve potential instances of unauthorised assets such as unlicensed copies of software.</p>

Skill	Description	
Change management	<p>The management of change to the service infrastructure, including service assets, configuration items and associated documentation.</p> <p>Change management uses requests for change (RFC) for standard or emergency changes, and changes due to incidents or problems to provide effective control and reduction of risk to the availability, performance, security and compliance of the business services impacted by the change.</p>	<p>Assesses, analyses, develops, documents and implements changes based on requests for change.</p>
Release and deployment	<p>The management of the processes, systems and functions to package, build, test and deploy changes and updates (which are bounded as 'releases') into a live environment, establishing or continuing the specified service, to enable controlled and effective handover to Operations and the user community.</p>	<p>Assesses and analyses release components. Provides input to scheduling. Carries out the builds and tests in coordination with testers and component specialists maintaining and administering the tools and methods – manual or automatic – and ensuring, where possible, information exchange with configuration management.</p> <p>Ensures release processes and procedures are maintained.</p>
System software	<p>The provision of specialist expertise to facilitate and execute the installation and maintenance of system software such as operating systems, data management products, office automation products and other utility software.</p>	<p>Reviews system software updates and identifies those that merit action. Tailors system software to maximise hardware functionality. Installs and tests new versions of system software. Investigates and coordinates the resolution of potential and actual service problems. Prepares and maintains operational documentation for system software. Advises on the correct and effective use of system software.</p>

Skill	Description	
Capacity management	<p>The management of the capability, functionality and sustainability of service components (including hardware, software, network resources and software/infrastructure as a service) to meet current and forecast needs in a cost-efficient manner aligned to the business. This includes predicting both long-term changes and short-term variations in the level of capacity required to execute the service, and deployment, where appropriate, of techniques to control the demand for a particular resource or service.</p>	<p>Monitors service component capacity and initiates actions to resolve any shortfalls according to agreed procedures. Applies techniques to control the demand on a particular resource or service.</p>
Security administration	<p>The provision of operational security management and administrative services. Typically includes the authorisation and monitoring of access to IT facilities or infrastructure, the investigation of unauthorised access and compliance with relevant legislation.</p>	<p>Maintains security administration processes and checks that all requests for support are dealt with according to agreed procedures. Provides guidance in defining access rights and privileges. Investigates security breaches in accordance with established procedures and recommends required actions and supports/follows up to ensure these are implemented.</p>

Skill	Description	
Penetration testing	<p>The assessment of organisational vulnerabilities through the design and execution of penetration tests that demonstrate how an adversary can either subvert the organisation's security goals (for example the protection of specific Intellectual Property) or achieve specific adversarial objectives (for example establishment of a covert Command and Control infrastructure). Pen Test results provide deeper insight into the business risks of various vulnerabilities.</p>	<p>Maintains current knowledge of malware attacks, and other cyber security threats. Creates test cases using in-depth technical analysis of risks and typical vulnerabilities. Produces test scripts, materials and test packs to test new and existing software or services. Specifies requirements for environment, data, resources and tools. Interprets, executes and documents complex test scripts using agreed methods and standards. Records and analyses actions and results. Reviews test results and modifies tests if necessary. Provides reports on progress, anomalies, risks and issues associated with the overall project. Reports on system quality and collects metrics on test cases. Provides specialist advice to support others.</p>

Skill	Description	
Application support	<p>The provision of application maintenance and support services, either directly to users of the systems or to service delivery functions. Support typically includes investigation and resolution of issues and may also include performance monitoring. Issues may be resolved by providing advice or training to users, by devising corrections (permanent or temporary) for faults, making general or site-specific modifications, updating documentation, manipulating data, or defining enhancements support often involves close collaboration with the system's developers and/or with colleagues specialising in different areas, such as database administration or network support.</p>	<p>Maintains application support processes and checks that all requests for support are dealt with according to agreed procedures. Uses application management software and tools to investigate issues, collect performance statistics and create reports.</p>
IT infrastructure	<p>The operation and control of the IT infrastructure (typically hardware, software, data stored on various media, and all equipment within wide and local area networks) required to deliver and support IT services and products to meet the needs of a business. Includes preparation for new or changed services, operation of the change process, the maintenance of regulatory, legal and professional standards, the building and management of systems and components in virtualised computing environments and the monitoring of performance of systems and services in relation to their contribution to business performance, their security and their sustainability.</p>	<p>Provides technical expertise to enable the correct application of operational procedures. Uses network management tools to determine network load and performance statistics. Contributes to the planning and implementation of maintenance and installation work, including building and management of systems and components in virtualised computing environments. Implements agreed network changes and maintenance routines. Identifies operational problems and contributes to their resolution, checking that they are managed in accordance with agreed standards and procedures. Provides reports and proposals for improvement, to specialists, users and managers.</p>

Skill	Description	
Database administration	The installation, configuration, upgrade, administration, monitoring and maintenance of databases.	Uses database management system software and tools, and knowledge of logical database schemata, to investigate problems and collect performance statistics and create reports. Carries out routine configuration/installation and reconfiguration of database and related products.
Storage management	The planning, implementation, configuration and tuning of storage hardware and software covering online, offline, remote and offsite data storage (backup, archiving and recovery) and ensuring compliance with regulatory and security requirements.	Reviews capacity, performance, availability and other operational metrics and take appropriate action to ensure corrective and proactive maintenance of storage and backup systems to support the requirement to protect and secure business information. Creates reports and proposals for improvement and contributes to the planning and implementation of new installations and scheduled maintenance and changes within the system. Prepares and maintains operational procedures and provides technical expertise and appropriate information to the management.

Skill	Description	
Network support	<p>The provision of network maintenance and support services. Support may be provided both to users of the systems and to service delivery functions. Support typically takes the form of investigating and resolving problems and providing information about the systems. It may also include monitoring their performance. Problems may be resolved by providing advice or training to users about the network's functionality, correct operation or constraints, by devising work-arounds, correcting faults, or making general or site-specific modifications.</p>	<p>Maintains the network support process and checks that all requests for support are dealt with according to agreed procedures. Uses network management software and tools to investigate and diagnose network problems, collect performance statistics and create reports, working with users, other staff and suppliers as appropriate.</p>
Problem management	<p>The resolution (both reactive and proactive) of problems throughout the information system lifecycle, including classification, prioritisation and initiation of action, documentation of root causes and implementation of remedies to prevent future incidents.</p>	<p>Initiates and monitors actions to investigate and resolve problems in systems, processes and services. Determines problem fixes/remedies. Assists with the implementation of agreed remedies and preventative measures.</p>
Incident management	<p>The processing and coordination of appropriate and timely responses to incident reports, including channelling requests for help to appropriate functions for resolution, monitoring resolution activity, and keeping clients appraised of progress towards service restoration.</p>	<p>Prioritises and diagnoses incidents according to agreed procedures. Investigates causes of incidents and seeks resolution. Escalates unresolved incidents. Facilitates recovery, following resolution of incidents. Documents and closes resolved incidents according to agreed procedures.</p>

Skill	Description	
Facilities management	<p>The planning, control and management of all the facilities which, collectively, make up the IT estate. This involves provision and management of the physical environment, including space and power allocation, and environmental monitoring to provide statistics on energy usage. Encompasses physical access control and adherence to all mandatory policies and regulations concerning health and safety at work.</p>	<p>Uses data centre management tools to produce management information on power, cooling and space and investigate issues where necessary. Carries out routine audit and checks to ensure adherence to policies and procedures. Facilitates the implementation of mandatory electrical safety testing.</p>
Learning and development management	<p>The provision of learning and development processes (including learning management systems) in order to develop the professional, business and/or technical skills required by the organisation.</p>	<p>Contributes to the development and maintenance of a catalogue of learning and development resources. Books and organises learning events. Updates and controls training records, including attainment of certificates and accreditations.</p>
Learning assessment and evaluation	<p>The assessment of knowledge, skills and behaviour by any means whether formal or informal against capability and qualification frameworks such as SFIA. The evaluation of learning or education programmes against defined outcomes.</p>	<p>Performs routine and non-routine assessments of knowledge, skills and behaviour using specified methods and according to specified standards. Gathers inputs for the analysis and evaluation of learning programmes.</p>

Skill	Description	
Learning design and development	<p>The specification, design, creation, packaging and maintenance of materials and resources for use in learning and development in the workplace or in compulsory, further or higher education.</p> <p>Typically involves the assimilation of information from existing sources, selection and representation in a form suitable to the intended purpose and audience. Includes instructional design, content development, configuration and testing of learning environments, and use of appropriate current technologies such as audio, video, simulation and assessment. May include third party accreditation.</p>	<p>Designs, creates, develops, customises and maintains learning materials and resources to deliver agreed outcomes, and meet accreditation requirements if appropriate. Assists with design, configuration and testing of learning environments, including creation of simulated data, and replication of external systems, interfaces and assessment systems.</p>
Learning delivery	<p>The transfer of business and/or technical skills and knowledge and the promotion of professional attitudes in order to facilitate learning and development. Uses a range of techniques, resources and media (which might include e-learning, online virtual environments, self-assessment, peer-assisted learning, simulation, and other current methods).</p>	<p>Prepares or customises and delivers learning activities to a variety of audiences.</p>
Performance management	<p>The optimisation of performance of people, including determination of capabilities, integration into teams, allocation of tasks, direction, support, guidance, motivation, and management of performance.</p>	<p>Supervises individuals and teams. Allocates routine tasks and/or project work. Provides direction, support and guidance as necessary, in line with individuals' skills and abilities. Monitors progress against agreed quality and performance criteria. Acts to facilitate effective working relationships between team members.</p>

Skill	Description	
Resourcing	<p>The overall resource management of the workforce to enable effective operation of the organisation. Provision of advice on any aspect of acquiring resources, including employees, consultants and contractors.</p>	<p>Implements resource plans, including conducting recruitment interviews. Facilitates selection, assessment and on-boarding processes, and internal resource allocation. Contributes to transitioning of resources, complying with relevant statutory or external regulations and codes of good practice.</p>
Professional development	<p>The facilitation of the professional development of individuals, including initiation, monitoring, review and validation of learning and development plans in line with organisational or business requirements. The counselling of participants in all relevant aspects of their continual professional development. The identification of appropriate learning/development resources. Liaison with internal and external training providers. The evaluation of the benefits of continual professional development activities.</p>	<p>Maintains skills framework, or information about access to standard frameworks. Advises on required outcomes for learning or development, from knowledge of skills frameworks and organisational development needs. Assists practitioners with the process of creating development plans based on outcome statements. Monitors practitioners' continuing professional development records, ensuring that achievements and enhanced capabilities are recorded and referenced to the outcome statements.</p>
Quality management	<p>The application of techniques for monitoring and improvement of quality to any aspect of a function or process. The achievement of, and maintenance of compliance to, national and international standards, as appropriate, and to internal policies, including those relating to sustainability and security.</p>	<p>Uses quality management models and techniques to identify areas for improvement. Determines corrective action to reduce errors and improve the quality of the system and services.</p>
Quality assurance	<p>The process of ensuring that the agreed quality standards within an organisation are adhered to and that best practice is promulgated throughout the organisation.</p>	<p>Investigates and documents the internal control of specified aspects of automated or partly automated processes and assesses compliance with the relevant standard.</p>

Skill	Description	
Quality standards	The development, maintenance, control and distribution of quality standards.	Controls, updates and distributes new and revised quality standards, including technical changes.
Conformance review	The independent assessment of the conformity of any activity, process, deliverable, product or service to the criteria of specified standards, best practice, or other documented requirements. May relate to, for example, asset management, network security tools, firewalls and internet security, sustainability, real-time systems, application design and specific certifications.	Conducts formal reviews of activities, processes, products or services. Collects, collates and examines records as part of specified testing strategies for evidence of compliance with management directives, or the identification of abnormal occurrences. Analyses evidence collated and drafts part or all of formal reports, commenting on the conformance found to exist in the reviewed part of an information systems environment.
Digital forensics	The collection, processing, preserving, analysing, and presenting of computer-related evidence in support of security vulnerability mitigation and/or criminal, fraud, counterintelligence, or law enforcement investigations.	Contributes to digital forensic investigations. Processes and analyses computer evidence in line with policy, standards and guideline and supports production of forensics findings and reports.

Skill	Description	
Sourcing	<p>The provision of policy, internal standards and advice on the procurement or commissioning of externally supplied and internally developed products and services.</p> <p>The provision of commercial governance, conformance to legislation and assurance of information security. The implementation of compliant procurement processes, taking full account of the issues and imperatives of both the commissioning and supplier sides.</p> <p>The identification and management of suppliers to ensure successful delivery of products and services required by the business.</p>	<p>Reviews business cases (requirements, potential benefits and options) and determines appropriate procurement routes, for example open market or collaborative framework. Using market knowledge to inform specifications, ensures detailed pre-qualification questionnaires and tender invitations are prepared. Collects and collates data to support collaboration and negotiates terms and conditions to reflect the scale of requirements and encourage good performance.</p>
		<p>Evaluates tenders based on specification and evaluation criteria, prepares acceptance documentation and advises on contracts and service level agreements. Monitors and reports on supplier performance, information security, customer satisfaction, and market intelligence.</p> <p>Investigates, resolves or escalates problems. Implements supplier service improvement actions and programmes.</p>

Skill	Description	
Contract management	The overall management and control of the operation of formal contracts for supply of products and services.	Sources and collects contract performance data (such as pricing and supply chain costs) and monitors performance against KPIs. Identifies and reports under-performance and develops opportunities for improvement. Monitors compliance with terms and conditions, and takes appropriate steps to address non-compliance. Proactively manages risk and reward mechanisms in the contract. Monitors progress against business objectives specified in the business case. Identifies where change is required and plans for variations. In consultation with stakeholders, ensures that change management protocols are implemented.
Relationship management	The identification, analysis, management and monitoring of relationships with and between stakeholders. (Stakeholders are individuals, groups, or organisations who may affect, be affected by, or perceive themselves to be affected by decisions, activities and outcomes related to products, services or changes to products and services.) The clarification of mutual needs and commitments through consultation and consideration of impacts. For example, the coordination of all promotional activities to one or more clients to achieve satisfaction for the client and an acceptable return for the supplier; assistance to the client to ensure that maximum benefit is gained from products and services supplied.	Implements stakeholder engagement/communications plans, including, for example: handling of complaints; problems and issues; managing resolutions; corrective actions and lessons learned; collection and dissemination of relevant information. Uses feedback from customers and stakeholders to help measure effectiveness of stakeholder management. Helps develop and enhance customer and stakeholder relationships.

Skill	Description	
Customer service support	<p>The management and operation of one or more customer service or service desk functions. Acting as a point of contact to support service users and customers reporting issues, requesting information, access, or other services.</p>	<p>Monitors customer service or service desk functions and collects performance data. Assists with the specification, development, research and evaluation of services standards. Applies these standards to resolve or escalate issues and gives technical briefings to staff members.</p>
Digital marketing	<p>Integration of digital marketing with traditional print/broadcast methods, to support the research, analysis and stimulation of potential or existing markets for products and services, both to provide a sound basis for business development and to generate a satisfactory flow of sales enquiries. The management and development of strategies, campaigns and day-to-day marketing activity delivered through web and other appropriate digital channels and technologies.</p>	<p>Appraises factors that influence online marketing activity, carries out market research, and identifies unique selling points and key messages. Investigates and analyses customer and competitor dynamics and uses appropriate channels and technologies for target marketing and engagement.</p>
		<p>Recognises and uses the similarities and differences between online and traditional marketing concepts and applications, providing advice on channel methodology, effectiveness and implementation. Makes creative use of elements relevant to both digital and traditional environments, and drafts appropriate support materials. Analyses the effectiveness of campaigns and services and their impact on audience behaviour and business outcomes. Organises and participates actively in marketing events.</p>

Skill	Description	
Selling	<p>The identification of sales prospects and their qualification, the development of customer interest and the preparation (including managing the bid process), execution and monitoring of the sale of any product or service into an external or internal market.</p>	<p>Collects and uses information in order to achieve sales objectives. Responds to existing sales leads and identifies and qualifies new leads and prospects with a view to developing a pipeline of potential opportunities. Understands customer and needs, and develops and enhances customer relationships, before, during and after the conclusion of agreements/contracts. Key tasks may also include bid management, value analysis, negotiation, presentation and preparation of contracts. Monitors and reports on quota, performance, customer satisfaction, market intelligence and competitors.</p>
Sales support	<p>The provision of technical advice and assistance to the sales force, sales agents, reseller/distributor staff and existing or prospective customers, either in support of customer development or sales activity or in fulfilment of sales obligations.</p>	<p>Works closely with the sales team to help prospects to clarify their needs and requirements; devises solutions and assesses their feasibility and practicality. Demonstrates technical feasibility using physical or simulation models. Produces estimates of cost and risk and initial project plans to inform sales proposals. Resolves technical problems.</p>

Skill	Description	
Product management	<p>The active management of a product or service throughout its lifecycle (inception through to retirement) in order to address a market opportunity/customer need and generate the greatest possible value for the business.</p>	<p>Manages aspects of the product lifecycle, working with colleagues in other disciplines to enable effective marketing and customer support. May act as product owner for one or more lower value products or services. Facilitates product sales by planning development of marketing collateral content, supporting and evaluating campaigns, and monitoring product performance.</p>

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	<p>Present the outcome of methodical and detailed examination, either:</p> <ul style="list-style-type: none">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. <p>Analysis can be through activity, practice, written or verbal presentation.</p>
Apply	<p>Put into operation or use.</p> <p>Use relevant skills/knowledge/understanding appropriate to context.</p>
Arrange	Organise or make plans.
Assess	Offer a reasoned judgement of the standard/quality of a situation or a skill informed by relevant facts.
Calculate	Generate a numerical answer with workings shown.
Compare	<p>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.</p> <p>This is used to show depth of knowledge through selection of characteristics.</p>
Compose	Create or make up or form.
Communicate	<p>Convey ideas or information to others.</p> <p>Create/construct skills to make or do something, for example a display or set of accounts.</p>
Create/construct	Skills to make or do something, for example a display or set of accounts.
Critically analyse	Separate information into components and identify characteristics with depth to the justification.

Term	Definition
Critically evaluate	Make a judgement, taking into account different factors and using available knowledge/experience/evidence where the judgement is supported in depth.
Define	State the nature, scope or meaning.
Describe	Give an account, including all the relevant characteristics, qualities and events.
Discuss	<p>Consider different aspects of:</p> <ul style="list-style-type: none"> • a theme or topic; how they interrelate; and the extent to which they are important.
Demonstrate	Show knowledge and understanding.
Design	Plan and present ideas to show the layout/function/workings/object/system/process.
Develop	Grow or progress a plan, ideas, skills and understanding
Differentiate	Recognise or determine what makes something different.
Discuss	Give an account that addresses a range of ideas and arguments
Evaluate	<p>Work draws on varied information, themes or concepts to consider aspects, such as:</p> <ul style="list-style-type: none"> • strengths or weaknesses • advantages or disadvantages • alternative actions • relevance or significance. <p>Students' inquiries should lead to a supported judgement showing relationship to its context. This will often be in a conclusion. Evidence will often be written but could be through presentation or activity.</p>
Explain	To give an account of the purposes or reasons.
Explore	Skills and/or knowledge involving practical research or testing.
Identify	Indicate the main features or purpose of something by recognising it and/or being able to discern and understand facts or qualities.
Illustrate	Make clear by using examples or provide diagrams.
Indicate	Point out, show.
Interpret	State the meaning, purpose or qualities of something through the use of images, words or other expression.

Term	Definition
Investigate	Conduct an inquiry or study into something to discover and examine facts and information.
Justify	Students give reasons or evidence to: <ul style="list-style-type: none">• support an opinion; or prove something right or reasonable.
Outline	Set out the main points/characteristics.
Plan	Consider, set out and communicate what is to be done.
Produce	To bring into existence.
Reconstruct	To assemble again/reorganise/form an impression.
Report	Adhere to protocols, codes and conventions where findings or judgements are set down in an objective way.
Review	<p>Make a formal assessment of work produced. The assessment allows students to:</p> <ul style="list-style-type: none"> • appraise existing information or prior events; reconsider information with the intention of making changes, if necessary.
Show how	Demonstrate the application of certain methods/theories/concepts.
Stage & Manage	Organisation and management skills, for example running an event or a business pitch.
State	Express.
Suggest	Give possible alternatives, produce an idea, put forward, for example an idea or plan, for consideration
Undertake/ carry out	Use a range of skills to perform a task, research or activity.

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

Type of evidence	Definition
Case study	A specific example to which all students must select and apply knowledge.
Project	A large-scale activity requiring self-direction of selection of outcome, planning, research, exploration, outcome and review.
Independent research	An analysis of substantive research organised by the student from secondary sources and, if applicable, primary sources.
Written task or report	Individual completion of a task in a work-related format, for example a report, marketing communication, set of instructions, giving information.
Simulated activity/role play	A multi-faceted activity mimicking realistic work situations.
Team task	Students work together to show skills in defining and structuring activity as a team.
Presentation	Oral or through demonstration.
Production of plan/business plan	Students produce a plan as an outcome related to a given or limited task.
Reflective journal	Completion of a journal from work experience, detailing skills acquired for employability.
Poster/leaflet	Documents providing well-presented information for a given purpose.

Appendix 3: Assessment Methods and Techniques for Pearson BTEC Higher Nationals

Assessment technique	Description	Transferable skills development	Formative or summative
Academic graphic display	This technique asks students to create documents, providing well-presented information for a given purpose. Could be a hard or soft copy.	Creativity Written communication Information and communications Technology Literacy	Formative Summative
Case study	This technique presents students with a specific example to which they must select and apply knowledge.	Reasoning Critical thinking Analysis	Formative Summative
Discussion forum	This technique allows students to express their understanding and perceptions about topics and questions presented in the class or digitally, for example online groups, blogs.	Oral/written communication Appreciation of diversity Critical thinking and reasoning Argumentation	Formative
Independent research	This technique is an analysis of research organised by the student from secondary sources and, if applicable, primary sources.	Information and communications technology Literacy Analysis	Formative
Oral/viva	This technique asks students to display their knowledge of the subject via questioning.	Oral communication Critical thinking Reasoning	Summative
Peer-review	This technique asks students to provide feedback on each other's performance. This feedback can be collated for development purposes.	Teamwork Collaboration Negotiation	Formative Summative

Assessment technique	Description	Transferable skills development	Formative or summative
Presentation	This technique asks students to deliver a project orally or through demonstration.	Oral communication Critical thinking Reasoning Creativity	Formative Summative
Production of an artefact/ performance or portfolio	This technique requires students to demonstrate that they have mastered skills and competencies by producing something. Some examples are: computing plans, using a piece of equipment or a technique, building models, developing, interpreting, using maps.	Creativity Interpretation Written and oral communication Interpretation decision making Initiative Information and communications Technology Literacy	Summative
Project	This technique is a large-scale activity requiring self-direction, planning, research, exploration, outcome and review.	Written communication Information Literacy Creativity Initiative	Summative
Role playing	This technique is a type of case study, in which there is an explicit situation established, with students playing specific roles, understanding what they would say or do in that situation.	Written and oral communication Leadership Information literacy Creativity Initiative	Formative

Assessment technique	Description	Transferable skills development	Formative or summative
Self-reflection	<p>This technique asks students to reflect on their performance, for example to write statements of their personal goals for the course at the beginning of the course, what they have learned at the end of the course and their assessment of their performance and contribution; completion of a reflective journal from work experience, detailing skills acquired for employability.</p>	<p>Self-reflection Written communication Initiative Decision making Critical thinking</p>	Summative
Simulated activity	<p>This technique is a multi-faceted activity based on realistic work situations.</p>	<p>Self-reflection Written communication Initiative Decision making Critical thinking</p>	<p>Formative Summative</p>
Team assessment	<p>This technique asks students to work together to show skills in defining and structuring an activity as a team. All team assessment should be distributed equally, each of the group members performing their role, and then the team collates the outcomes, and submits it as a single piece of work.</p>	<p>Collaboration Teamwork Leadership Negotiation Written and oral communication</p>	<p>Formative Summative</p>
Tiered knowledge	<p>This technique encourages students to identify their gaps in knowledge. Students record the main points they have captured well and those they did not understand.</p>	<p>Critical thinking Analysis Interpretation Decision making Oral and written communication</p>	Formative

Assessment technique	Description	Transferable skills development	Formative or summative
Time-constrained assessment	This technique covers all assessment that needs to be carried out within a centre-specified, time-constrained period on site.	Reasoning Analysis Written communication Critical thinking Interpretation	Summative
Top ten	This technique asks students to create a 'top ten' list of key concepts presented in the assigned reading list.	Teamwork Creativity Analysis Collaboration	Formative
Written task or report	This technique asks students to complete an assignment in a structured written format, for example a computing plan, a report, marketing communication, a set of instructions, giving information.	Reasoning Analysis Written communication Critical thinking, interpretation.	Summative

Appendix 4: Mapping of Pearson BTEC HND in Cloud Computing against FHEQ Level 5

Key	
KU	Knowledge and Understanding
CS	Cognitive Skills
AS	Applied Skills
TS	Transferable Skills

The qualification will be awarded to students who have demonstrated the following.

FHEQ Level 5 descriptor		Cloud Computing HND Programme Outcome
Knowledge and critical understanding of the well-established principles of their area(s) of study, and of the way in which those principles have developed.	KU1	Knowledge and understanding of the fundamental principles and practices of the contemporary global computing environment.
	KU2	Understanding and insight into different organisations, their diverse nature, purposes, structures and operations, and their influence on the external environment.
	KU3	A critical understanding of the evolving concepts, theories and models within the study of cloud computing across a range of practical and hypothetical scenarios.
	KU4	An ability to evaluate and analyse a range of concepts, theories and models to make appropriate decisions.
	KU5	An appreciation of the concepts and principles of CPD, staff development, leadership and reflective practice as methods and strategies for personal and people development.
	KU6	Knowledge and understanding of vital concepts, principles and theories relating to computing and computer applications, software development, networking and media systems in relation to the cloud.

FHEQ Level 5 descriptor		Cloud Computing HND Programme Outcome
	KU7	Critical understanding of how cloud-based technologies interrelate and communicate with one another, support processes and lead to a computerised solution to a problem.
	KU8	Understanding of the application of appropriate mathematical techniques in the design and development of software and computer systems.
	KU9	Critical understanding of the use of industry standard technical documentation and practices.
	KU10	Develop a range of multi-disciplined programming and coding skills.
	KU11	Deploy appropriate tools, theories, principles and methodologies to analyse, specify, construct, test and evaluate a computer-based system in a cloud-appropriate context.
	KU12	An ability to apply industry-standard methods in human-computer interaction to inform the development of usable interfaces.
Ability to apply underlying concepts and principles outside the context in which they were first studied, including, where appropriate, the application of those principles in an employment context.	AS1	Evidence the ability to show client relationship management and develop appropriate policies and strategies to meet stakeholder expectations.
	AS2	Apply innovative ideas to develop and create new systems or services that respond to the changing nature of organisations.
	AS3	Integrate theory and practice through the investigation and examination of practices in the workplace.
	AS4	Develop outcomes for clients using appropriate practices and data to make justified recommendations.
	AS5	Apply IT concepts and principles to critically evaluate and analyse complex practical problems and provide IT based solutions.
	AS6	Effectively apply appropriate computer-based technologies to analyse, develop and maintain reliable software in the cloud.
	CS1	Deploy appropriate theory, practices and tools in order to analyse, specify, design and implement cloud-based computing systems and software applications.

FHEQ Level 5 descriptor		Cloud Computing HND Programme Outcome
	CS2	Recognise and critically evaluate the professional, economic, social, environmental, moral and ethical issues that influence the sustainable exploitation of computer-based technologies.
	AS7	Employ a range of analytical techniques and design tools in the development of secure software in a cloud-based setting.
Knowledge of the main methods of enquiry in the subject(s) relevant to the named award, and ability to evaluate critically the appropriateness of different approaches to solving problems in the field of study.	CS3	Critique a range of systems and operations, and their application, especially in a cloud setting, to maximise and successfully meet strategic objectives.
	KU13	An understanding of the appropriate techniques and methodologies used to resolve real-life problems in the workplace.
	TS1	Develop a skill set to enable the evaluation of appropriate actions taken for solving problems in a specific organisational context.
An understanding of the limits of their knowledge, and how this influences analysis and interpretations based on that knowledge.	TS2	Self-reflection, including self-awareness; the ability to become an effective student and appreciate the value of the self-reflection process.
	TS3	Undertake independent learning to expand on own skills and delivered content.

Typically, holders of the qualification will be able to do the following.

FHEQ Level 5 descriptor		Cloud Computing HND Programme Outcomes
Use a range of established techniques to initiate and undertake critical analysis of information, and to propose solutions to problems arising from that analysis.	TS4	Competently use digital literacy to access a broad range of research sources, data and information.
	CS4	Interpret, analyse and evaluate a range of data, sources and information to inform evidence-based decision making.
	CS5	Synthesise knowledge and critically evaluate strategies and plans to understand the relationship between theory and real-world scenarios.
Effectively communicate information, arguments and analysis in a variety of forms to specialist and non-specialist audiences, and deploy key techniques of the discipline effectively.	TS5	Communicate confidently and effectively, both orally and in writing, both internally and externally with organisations and other stakeholders.
	TS6	Communicate ideas and arguments in an innovative manner using a range of digital media.
	AS8	Locate, receive and respond to a variety of information sources (e.g. textual, numerical, graphical, computer-based) in defined contexts.
	TS7	Communicate effectively, verbally and in writing and articulate well-defined issues, for a variety of purposes, taking into account the audience viewpoint.
	TS8	Demonstrate strong interpersonal skills, including effective listening and oral communication skills, as well as the associated ability to persuade, present, pitch and negotiate.
Undertake further training, develop existing skills and acquire new competences that will enable them to assume significant responsibility within organisations	TS9	Identify personal and professional goals for CPD in order to enhance competence to practise within a chosen computing field.
	TS10	Take advantage of available pathways for continuing professional development through higher education, professional body qualifications and vendor accredited certifications.

Holders will also have the following.

FHEQ Level 5 descriptor		Cloud Computing HND Programme Outcomes
The qualities and transferable skills necessary for employment requiring the exercise of personal responsibility and decision making.	TS11	Develop a range of skills to ensure effective team working, independent initiatives, organisational competence and problem-solving strategies.
	TS12	Show an ability to work as a member of a development team, recognising the different roles within a team and the different ways of organising teams.
	TS13	Reflect adaptability and flexibility in approach to work; showing resilience under pressure and meeting challenging targets within given deadlines.
	TS14	Use quantitative skills to manipulate data, evaluate and verify existing theory.
	TS15	Show awareness of current developments within the computing industry and their impact on employability and CPD.
	TS16	Manage small- to medium-scale projects using appropriate planning and time-management techniques.
	CS6	Evaluate the changing needs of the business environment and have confidence to self-evaluate and undertake additional CPD as necessary.
	TS17	Display emotional intelligence and sensitivity to diversity in relation to people and cultures.

Appendix 5: Pearson BTEC HNC/HND Cloud Computing Programme Outcomes for Students

Unit	Knowledge and Understanding													Cognitive skills					Applied skills					Transferable skills																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	X	X		X		X	X			X							X			X								X	X	X	X	X	X	X			X		X				
2	X	X	X	X		X	X	X		X				X	X	X	X			X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X				
3	X	X	X	X		X	X	X		X				X	X	X	X			X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X					
4	X		X	X		X	X	X	X	X	X	X		X	X	X	X			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					
5	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X			X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					
6	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
7	X	X	X	X		X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
8	X	X	X	X	X	X		X		X	X	X		X	X	X	X		X					X	X	X	X	X	X	X	X	X	X	X	X	X							
9			X	X		X	X							X										X	X	X	X					X	X	X	X								
10	X		X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
11	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
12	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
13	X	X		X		X	X			X			X		X	X			X		X	X	X	X	X			X		X		X	X	X									
14					X	X		X												X				X	X	X	X	X		X		X											
15	X	X		X		X	X		X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
16	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
17	X	X		X		X	X										X		X		X		X	X	X	X	X	X	X	X	X	X	X	X	X								
18	X	X	X	X		X	X	X						X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
19	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
20	X		X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
21	X		X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							
22	X	X		X										X	X				X				X	X	X	X	X	X	X	X	X	X	X	X	X								

	Knowledge and Understanding													Cognitive skills						Applied skills						Transferable skills																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
23	X	X	X	X		X		X								X				X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
24	X		X	X		X		X		X				X		X		X		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X				
25	X		X			X	X		X	X	X			X		X		X		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					
26	X		X			X		X		X				X		X		X		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					
27	X			X		X				X													X					X	X	X	X	X	X	X	X	X	X	X	X	X				
28	X	X	X	X	X	X			X					X		X	X	X	X	X	X			X		X	X	X	X	X	X	X	X	X	X	X	X	X						
29	X	X	X	X	X	X		X						X		X		X		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					
30	X			X		X	X																X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X				
31	X	X		X										X	X	X	X		X		X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
32	X	X												X		X		X		X					X	X	X	X	X	X	X	X	X	X	X	X	X	X						
33	X	X		X												X		X	X						X	X	X	X	X	X	X	X	X	X	X	X	X							
34	X	X		X	X		X							X						X	X				X		X	X	X	X					X									

Appendix 6: Transferable skills mapping

Level 5 Higher National Diploma in Cloud Computing: mapping of transferable employability and academic study skills

Unit	Cognitive skills							Intra-personal skills				Interpersonal skills		
	Problem solving	Critical thinking/analysis	Decision making	Effective communication	Digital literacy	Numeracy	Creativity	Plan prioritise	Self-management	Independent learning	Self-reflection	Team work	Leadership	Cultural awareness
1	X	X	X		X		X	X	X	X	X			
2	X	X	X		X		X	X	X	X	X			
3	X	X	X		X			X	X	X	X			
4	X	X	X		X		X	X	X	X	X			
5	X	X	X		X	X	X	X	X	X	X			
6	X	X	X	X	X		X	X	X	X	X	X	X	X
7	X	X	X	X	X		X	X	X	X	X		X	X
8		X	X	X			X	X	X	X	X	X	X	X
9	X	X	X			X		X	X	X				
10	X	X	X	X	X	X	X	X	X	X	X			
11	X	X	X		X	X		X	X	X	X			
12	X	X	X	X	X		X	X	X	X	X		X	
14	X	X	X	X	X			X	X	X	X	X	X	
15	X	X	X	X	X		X	X	X	X	X			
16	X	X	X	X	X			X	X	X	X		X	
17	X	X	X	X	X			X	X	X	X		X	X
18		X		X	X	X			X	X	X			
19	X	X	X		X	X	X	X	X	X	X	X	X	

Unit	Cognitive skills							Intra-personal skills				Interpersonal skills		
	Problem solving	Critical thinking/analysis	Decision making	Effective communication	Digital literacy	Numeracy	Creativity	Plan prioritise	Self-management	Independent learning	Self-reflection	Team work	Leadership	Cultural awareness
20	X	X	X		X			X	X	X	X			
21	X	X	X		X	X	X	X	X	X	X			
22	X	X	X	X	X	X		X	X	X	X		X	
23	X	X	X		X	X	X	X	X	X	X			
24	X	X	X	X	X	X	X	X	X	X	X		X	
25	X	X	X	X	X	X	X	X	X	X	X			
26	X	X	X	X	X	X	X	X	X	X	X		X	
27	X	X	X	X	X				X	X	X			
28		X	X	X	X		X	X	X	X	X			X
29	X	X	X	X	X		X	X	X	X	X	X	X	X
30	X	X	X	X	X			X	X	X	X			
31	X	X	X	X				X	X	X				
32	X	X	X	X				X	X	X	X	X	X	X
33	X	X	X	X				X	X	X	X	X	X	X
34	X	X	X	X	X			X	X	X				

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