BTEC
HIGHER NATIONALS

Computing

Specification

First Teaching from September 2017

First Certifi cation from **September** 2018

**Higher National
Certificate** Lvl 4

**Higher National
Diploma** Lvl 5

P Pearson

Summary of changes in Pearson BTEC Higher Nationals in Computing Issue 4

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Branding	1–511
Added new front cover	
Applied updated Pearson BTEC Higher Nationals branding colour, font and tables throughout the spec	
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Correction. Changed word from moderated to verified	
Meeting local needs and centre devised units	53–54
Updated section and guidance	
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Correction. Changed word from moderated to 'verified'	
Correction. Changed word from mark to 'grade'	
Correction. Changed word from marks to 'grades'	
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Correction to LO2. Removed the second part of the LO, *'Conduct an analysis of a suitable development Environment (IDE)'*	
Added essential content to assist centres. Text editors that can be used to view source code.	
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If you need further information on these changes or what they mean, contact us via our website at: qualifications.pearson.com/en/support/contact-us.html.

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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 thirty 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 redeveloping the Pearson BTEC Higher National qualifications in Computing, we collaborated with a wide range of students, employers, higher education providers, colleges and subject experts to ensure that the new qualifications meet their needs and expectations. We also worked closely with the relevant professional bodies, to ensure alignment with recognised professional standards.

There is now a greater emphasis on employer engagement and work readiness. The new Pearson BTEC Higher National qualifications in Computing are designed to reflect this increasing need for high quality professional and technical education pathways at Levels 4 and 5, thereby providing students with a clear line of sight to employment and to progression to a degree at Level 6.

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. They represent the latest in professional standards and provide opportunities for students to develop behaviours for work, for example by undertaking a group project, or responding to a client brief. A student may even achieve exemption from professional or vendor qualifications, or student membership of selected professional bodies, to help them on their journey to professional competence.

At the same time the 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. They 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 qualification descriptors at level 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 some are set by the centre to meet local needs, while others are set by Pearson).

- An approach to demand at level 4 and 5 which is aligned with the Framework for Higher Education Qualifications (FHEQ).

- Support for student and tutors including Schemes of Work and Example Assessment Briefs.

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. These are available from the HN Global website http://www.highernationals.com/.

With HN Global, tutors can access programme specifications which contain useful information on programme planning and quality assurance processes. Tutors can also view schemes of work and example assessment briefs, helping them create meaningful courses and assessments. HN Global also allows tutors to create and annotate reading lists for their students and also keep up-to-date on the latest news regarding HN programmes.

1.4   Qualification titles

Pearson BTEC Level 4 Higher National Certificate in Computing

Pearson BTEC Level 5 Higher National Diploma in Computing

Specialist pathways are included within brackets in the qualification title:

- Pearson BTEC Level 5 Higher National Diploma in Computing
- Pearson BTEC Level 5 Higher National Diploma in Computing (Network Engineering)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Software Engineering)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Data Analytics)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Security)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Intelligent Systems)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Applications Development)

1.5   Qualification codes

Ofqual Regulated Qualifications Framework (RQF) Qualification numbers:
Pearson BTEC Level 4 Higher National Certificate in Computing: **603/0472/8**
Pearson BTEC Level 5 Higher National Diploma in Computing: **603/0471/6**

1.6   Awarding institution

Pearson Education Ltd.

1.7   Key features

Pearson BTEC Higher National qualifications in Computing offer:

- 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 successfully into further study or the world of work.
- A simplified structure: students undertake a substantial core of learning in the BTEC Higher National Certificate and can build on this in the BTEC Higher National Diploma, with specialist and optional units linked to their area of study.
- Six specialist pathways in the BTEC Level 5 Higher National Diploma, so there is something to suit each student's preference of study and future progression plans.

- Refreshed content that is closely aligned with Professional Body, vendor, employer 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 also 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 of this Programme Specification – to ensure that all stakeholders (e.g. professional bodies, vendors, universities, businesses, colleges and students) can feel confident in the integrity and value of the qualifications.

- A qualification 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 Computing will be aiming to go on to employment or progress to a final year at university. Therefore, it was essential that we developed these qualifications in close collaboration with experts from professional bodies, vendors, businesses and universities, and with the providers who will be delivering the qualifications.

We are very 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.

British Computing Society (BCS)

Institution of Engineering and Technology (IET)

University of Kent

University of Hull

ISC^2

Uxbridge College

The Tech Partnership

CompTIA

QA Apprenticeships

CISCO

Imago Solutions

National College for Digital Skills

These qualifications have also been approved by the following professional bodies as suitable qualifications for students wanting to gain membership. The professional bodies include:

- The British Computing Society
- The Institution of Engineering and Technology.

2 Programme purpose and objectives

2.1   Purpose of the Pearson BTEC Higher Nationals in Computing

The purpose of Pearson BTEC Higher Nationals in Computing is to develop students as professional, self-reflecting individuals able to meet the demands of employers in the computing sector and 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 Computing

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

- To equip students with computing skills, knowledge and the understanding necessary to achieve high performance in the global computing environment.

- To provide education and training for a range of careers in computing, including network engineering, software engineering, data analytics, security, intelligent systems, and applications development.

- To provide insight and understanding into international computing operations and the opportunities and challenges presented by a globalised market place.

- To equip students with knowledge and understanding of culturally diverse organisations, cross-cultural issues, diversity and values.

- To provide opportunities for students to enter or progress in employment in computing, or progress to higher education qualifications such as an Honours degree in computing or a related area.

- 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 computing principles at Level 4 that leads the student to a range of specialist progression pathways at Level 5 relating to individual professions within the 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 computing areas by mapping to units in a range of vendor accredited certificates.

Who is this qualification for?

The Pearson BTEC Higher National qualifications in Computing are aimed at students wanting to continue their education through applied learning. Pearson BTEC Higher Nationals provide a wide-ranging study of the computing sector and are designed for students who wish to pursue or advance their career in computing. In addition to the knowledge, understanding and skills that underpin the study of the computing sector, Pearson BTEC Higher Nationals in 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 Computing

The Pearson BTEC Level 4 Higher National Certificate in 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 effectively builds underpinning core skills while preparing the student 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 computing sector through six core units, which include one unit assessed by a Pearson-set assignment. The units are:

- Programming

- Networking

- Professional Practice

- Database Design & Development

- Security

- Managing a Successful Computing Project (Pearson-set unit).

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

- Strategic Information Systems
- Computer Systems Architecture
- Software Development Lifecycles
- Website Design & Development
- Maths for Computing
- Data Analytics.

Graduates successfully completing the Pearson BTEC Higher National Certificate in Computing will be able to demonstrate a sound knowledge of the basic concepts of computing. They will be able to communicate accurately and appropriately and they will have the qualities needed for employment that requires some degree of personal responsibility. They will have developed a range of transferable skills to ensure effective team working, independent initiatives, 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 Computing

The Pearson BTEC Level 5 Higher National Diploma in Computing offers students six specialist pathways designed to support progression into relevant occupational areas or on to degree-level study. These pathways are linked to Professional Body standards and vendor accredited certification (where appropriate) and can 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 computing:

- Network Engineering
- Software Engineering
- Data Analytics
- Security
- Intelligent Systems
- Applications Development.

There is also a non-specialist 'Computing' pathway, which allows students to complete a Pearson BTEC Higher National Diploma without committing to a particular professional specialism. This offers additional flexibility to providers and students.

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 those 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 necessary for employment in situations requiring the exercise of personal responsibility and decision-making.

2.5   Use of Maths and English within the curriculum

Those working within the computing sector cannot just rely on their technical skills and must ensure **all** skills are relevant to increase employment opportunities. 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 and below are some examples of how these skills are developed in the BTEC Higher Nationals Curriculum:

- Written reports
- Formal presentations
- Informal conversations
- Use of professional, sector-specific language
- Using binary data
- Understanding algorithms
- Calculating costs

Some aspects of computing require higher level maths skills than others, but throughout your studies you will be using some level of maths within the curriculum. It is vital that students taking a BTEC Higher National in Computing are aware that these skills will be required throughout their studies, and as part of learning activities and assessments to ensure their skills are in line with current industry standards.

2.6   The Skills Framework for the Information Age (SFIA)

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 are divided according to generic levels of responsibility and skills.

The SFIA Level 3 responsibilities would correlate with those expected from an employer of a 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 would 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

    o 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 3*.

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

The National Occupational Standards for IT professionals are industry standards for skills, developed for the Trailblazer Apprenticeships which have been developed in line with the SFIA framework.

CompTIA and BCS have mapped their membership schemes to the SFIA framework.

By using the SFIA framework the Pearson BTEC Higher Nationals in Computing will be aligned with both the Trailblazer Apprenticeships in Digital Industries and Professional Body memberships.

2.7 What could these qualifications lead to?

The Pearson BTEC Higher National Certificate provides a solid grounding in computing at Level 4, vendor-accredited certification and Professional Body membership, all of which students can build on 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 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 computing-related courses.

Details of entry requirements for BTEC Higher National graduates into degree programmes at institutions in the UK and internationally can be found on the Degree Course Finder website (http://degreecoursefinder.pearson.com/).

The skills offered as part of the Pearson BTEC Higher National Diploma can provide graduates with the opportunity to work in many different areas of the computing sector. Below are some examples of job roles each qualification could lead to:

Pathway	Job Roles
Network Engineering	Network Engineer
	Systems Architect
	Computer Service and Repair Technician
	Network Manager
Software Engineering	Software Developer
	Systems Designer
	Business Analyst
	Games Developer
	Web Developer
Data Analytics	Data Analyst
	Business Analyst
	Marketing Analyst
	Data Engineer
	Fraud Analyst
	Operation Research Scientist
Security	Forensic Computer Analysts
	IT Security Coordinator
	Ethical Hacker
	Fraud Analyst
Intelligent Systems	Software Developer
	Online Reputation Manager
	Machine Learning Software Engineer
	Data Scientist
	Robotics Engineer

Applications Development	HCI Designer
	Games Developer
	Web Developer
General / All Pathways	Systems Analyst
	Data Designer
	Systems Tester
	Database Administrator
	IT Project Manager
	IT Support Technician
	Web Designer

These job roles are based on descriptions from The National Occupational Standards for IT professionals – 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. The development of IT Professional Standards was undertaken by The Tech Partnership.

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

Students need both relevant qualifications and employability skills to enhance their career prospects and contribute to their personal development. Pearson BTEC Higher National 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, this generally refers 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, within 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 moderated 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 you in developing these skills in your students, we have developed a map of higher education relevant transferable and academic study skills, available in appendices.

3 Planning your programme

3.1 Delivering the Pearson BTEC Higher Nationals in 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.

While there are six named pathways within the Pearson BTEC Higher National Diploma, centres can accommodate other routes through the qualification using the optional units within the pathways.

For example:

- A centre could deliver the Pearson BTEC Level 5 Higher National Diploma in Computing (Applications Development) and choose between 'Unit 31: Games Engine & Scripting', 'Unit 32: Game Design Theory' and 'Unit 47: Games Development' as the two optional units to make up this qualification which would give the student a games computing experience.

- A centre could deliver the Pearson BTEC Level 5 Higher National Diploma in Computing and choose 'Unit 39: E-Commerce & Strategy' as one of the five optional units to make up this qualification which would give the student a business computing experience.

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.

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
- 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 on a Pearson BTEC Higher Nationals, through Recognition of Prior Learning. (For further information please refer to **Section 8** of this document.)

3.2.1   English language requirements

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

The following clarifies the requirements for all centres when recruiting applicants on 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 clarifies the requirements for all centres when recruiting applicants on to new Pearson BTEC Higher National qualifications which are taught in a language other than English, but 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 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 (http://qualifications.pearson.com/).

3.2.3 Level of sector knowledge required

We do not set any requirements for tutors, but we do 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 work spaces 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 of this Programme Specification.

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
- 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. There are suggestions in section 5.2 about how employers could become involved in delivery and/or assessment, but these are not intended to be exhaustive and there will be other possibilities at 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 *Appendices 1 & 2*).

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 our Pearson Equality and Diversity Policy, which can be found in the support section of our website (http://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 (http://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 (http://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 he or she has 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 (http://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 previous paragraph). You can provide special consideration related to the period of time given for evidence to be provided, or for the format of the assessment (if it is equally valid). You may not substitute alternative forms of evidence to that required in a unit, or omit the application of any assessment criteria to judge attainment. Pearson can consider applications for special consideration in line with the policy, which can be found in the document linked above.

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 (http://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 s/he 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 that may damage the authority of those responsible for delivering the assessment and certification. Malpractice may arise, or be suspected, in relation to any unit or type of assessment within the qualification.

Pearson does not tolerate actions (or attempted actions) of malpractice by students, centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on students, centre staff or centres where incidents (or attempted incidents) of malpractice have been proven.

Further details regarding malpractice and advice on preventing malpractice by students, can be found in the support section of our website (http://qualifications.pearson.com/).

In the interests of students and centre staff, centres need to respond effectively and openly to all requests relating to an investigation into an incident of suspected malpractice. The procedures we ask you to adopt when tackling malpractice vary between units that are internally assessed and those that are externally assessed.

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 (http://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 above document gives further information, provides examples, and details the penalties and sanctions that may be imposed.

3.7.2   Student malpractice

Heads of centres are required to report incidents of any suspected student malpractice that occur during Pearson external assessments. We ask that centres do so by completing *JCQ Form M1* from the Joint Council for Qualifications website (http://www.jcq.org.uk/) and emailing it, along with any accompanying documents, (signed statements from the student, invigilator, copies of evidence, etc.), to the Investigations Team at pqsmalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on students lies with Pearson.

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

3.7.3 Tutor/centre malpractice

Heads of centres are required to inform Pearson's Investigations Team of any incident of suspected malpractice by centre staff, before any investigation is undertaken. Heads of centres are requested to inform the Investigations Team by submitting a *JCQ Form M2b* from the Joint Council for Qualifications website (http://www.jcq.org.uk/) with supporting documentation to pqsmalpractice@pearson.com. Where Pearson receives allegations of malpractice from other sources (for example, Pearson staff or anonymous informants), the Investigations Team will conduct the investigation directly or may ask the head of centre to assist.

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

Heads of centres/Principals/Chief Executive Officers or their nominees are required to inform students and centre staff suspected of malpractice of their responsibilities and rights; see 6.15 of *JCQ Suspected Malpractice in Examinations and Assessments Policies and Procedures* (www.jcq.org.uk).

Pearson reserves the right in cases of suspected malpractice to withhold the issue of results and/or certificates while an investigation is in progress. Depending on the outcome of the investigation, results and/or certificates may be released or withheld. We reserve the right to withhold certification when undertaking investigations, audits and quality assurances processes. You will be notified within a reasonable period of time if this occurs.

3.7.4 Sanctions and appeals

Wherever malpractice is proven, we may impose sanctions or penalties. Where student malpractice is evidenced, penalties may be imposed such as:

- Disqualification from the qualification
- Being barred from registration for Pearson qualifications for a specified period of time.

If we are concerned about your centre's quality procedures, we may impose sanctions such as:

- Working with you to create an improvement action plan
- Requiring staff members to receive further training
- Placing temporary blocks on your certificates
- Placing temporary blocks on registrations of students
- Debarring staff members or the centre from delivering Pearson qualifications
- Suspending or withdrawing centre approval status.

Your centre will be notified if any of these apply.

Pearson has established procedures for centres that are considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from heads of centres (on behalf of students 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 our Enquiries and Appeals Policy available in the support section on our website (http://qualifications.pearson.com/).

In the initial stage of any aspect of malpractice, please notify the Investigations Team by email (pqsmalpractice@pearson.com), who will inform you of the next steps.

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 the 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 a 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 Total Qualification Time (TQT). TQT includes undertaking each of the activities of Guided Learning, Directed Learning and Invigilated Assessment. Each 15-credit unit approximates to a 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 which can contribute to Total Qualification Time 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; this includes 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 which 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 which 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
- The minimum credit to be achieved at the level of the qualification
- The core units
- The specialist units
- The optional units
- The 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 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
- **Total Guided Learning Hours (GLH)** Higher National Certificate (HNC) = 480
- 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.
- Please note that some specialist units are available as optional units and some optional units are available as specialist units.

Pearson BTEC Level 4 Higher National Certificate in Computing		Unit credit	Level
Core Unit Mandatory	**1 Programming**	15	4
Core Unit Mandatory	**2 Networking**	15	4
Core Unit Mandatory	**3 Professional Practice**	15	4
Core Unit Mandatory	**4 Database Design & Development**	15	4
Core Unit Mandatory	**5 Security**	15	4
Core Unit Mandatory	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Plus TWO optional units which can be selected from the optional units given below. (See section on *combination rules* below for some guidance)			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4

4.2.2 Pearson BTEC Level 5 Higher National Diploma in 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 13: Computing Research Project' which is weighted at 30 credits, and 'Unit 14: Business Intelligence', 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 and some

- optional units are available as specialist 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 the general Computing pathway or one of the following six specialist pathways:

- Network Engineering

- Software Engineering

- Data Analytics

- Security

- Intelligent Systems

- Applications Development.

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

4.2.3 Units of combination

In order to ensure 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 (Network Engineering), BTEC Higher National Diploma (Software Engineering) or the BTEC Higher National Diploma (Data Analytics) also study 'Unit 11: Maths for Computing' at Level 4.

We also advise that students intending to study the BTEC Higher National Diploma (Data Analytics) also study 'Unit 12: Data Analytics' at Level 4.

Students studying on the BTEC Higher National Diploma (Security) are required to study 'Unit 23: Cryptography', before they study 'Unit 25: Information Security Management'.

Pearson BTEC Level 5 Higher National Diploma in Computing		Unit credit	Level
Level 4 units:			
Core Unit Mandatory	**1 Programming**	15	4
Core Unit Mandatory	**2 Networking**	15	4
Core Unit Mandatory	**3 Professional Practice**	15	4
Core Unit Mandatory	**4 Database Design & Development**	15	4
Core Unit Mandatory	**5 Security**	15	4
Core Unit Mandatory	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4

Level 5 Units: *** Please note that centres can choose any of the 5 optional units from the units listed in the optional unit bank. The units have been grouped according to sector specialism for ease of recognition. It is strongly advised to choose one unit from each optional group to deliver a comprehensive general computing qualification.**			
Core Unit Mandatory	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**14 Business Intelligence**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit Bank			
Optional Level 4 units:			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4

Optional Level 5 units:			
Group A: Network Engineering			
Optional Unit	**15 Transport Network Design**	15	5
Optional Unit	**16 Cloud Computing**	15	5
Optional Unit	**17 Network Security**	15	5
Group B: Software Engineering			
Optional Unit	**18 Discrete Maths**	15	5
Optional Unit	**19 Data Structures & Algorithms**	15	5
Optional Unit	**20 Advanced Programming**	15	5
Group C: Data Analytics			
Optional Unit	**18 Discrete Maths**	15	5
Optional Unit	**21 Data Mining**	15	5
Optional Unit	**22 Applied Analytical Models**	15	5
Group D: Security			
Optional Unit	**23 Cryptography**	15	5
Optional Unit	**24 Forensics**	15	5
Optional Unit	**25 Information Security Management**	15	5
Group E: Intelligent Systems			
Optional Unit	**26 Machine Learning**	15	5
Optional Unit	**27 Artificial Intelligence**	15	5
Optional Unit	**19 Data Structures & Algorithms**	15	5
Group F: Application Development			
Optional Unit	**28 Prototyping**	15	5
Optional Unit	**29 Application Program Interfaces**	15	5
Optional Unit	**30 Application Development**	15	5

Other Optional Units			
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**33 Analytical Methods**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5
Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5
Optional Unit	**38 Database Management Systems**	15	5
Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating Systems**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Network Engineering)		Unit credit	Level
Level 4 units:			
Core Unit Mandatory	**1 Programming**	15	4
Core Unit Mandatory	**2 Networking**	15	4
Core Unit Mandatory	**3 Professional Practice**	15	4
Core Unit Mandatory	**4 Database Design & Development**	15	4
Core Unit Mandatory	**5 Security**	15	4
Core Unit Mandatory	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Level 5 units:			
Core Unit Mandatory	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**14 Business Intelligence**	15	5
Specialist Unit *Mandatory*	**15 Transport Network Design**	15	5
Specialist Unit *Mandatory*	**16 Cloud Computing**	15	5
Specialist Unit Mandatory	**17 Network Security**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5

Optional Unit Bank				
Optional units Level 4:				
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4
Optional units Level 5:				
Optional Unit	**19 Data Structures & Algorithms**	15	5
Optional Unit	**20 Advanced Programming**	15	5
Optional Unit	**21 Data Mining**	15	5
Optional Unit	**22 Applied Analytical Models**	15	5
Optional Unit	**23 Cryptography**	15	5
Optional Unit	**24 Forensics**	15	5
Optional Unit	**25 Information Security Management**	15	5
Optional Unit	**27 Artificial Intelligence**	15	5
Optional Unit	**28 Prototyping**	15	5
Optional Unit	**29 Application Program Interfaces**	15	5
Optional Unit	**30 Application Development**	15	5
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**33 Analytical Methods**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5
Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5

Optional Unit	**38 Database Management Systems**	15	5
Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating Systems**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Software Engineering)		Unit credit	Level
Level 4 units:			
Core Unit *Mandatory*	**1 Programming**	15	4
Core Unit *Mandatory*	**2 Networking**	15	4
Core Unit *Mandatory*	**3 Professional Practice**	15	4
Core Unit *Mandatory*	**4 Database Design & Development**	15	4
Core Unit *Mandatory*	**5 Security**	15	4
Core Unit *Mandatory*	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Level 5 units:			
Core Unit *Mandatory*	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit *Mandatory*	**14 Business Intelligence**	15	5
Specialist Unit *Mandatory*	**18 Discrete Maths**	15	5
Specialist Unit *Mandatory*	**19 Data Structures & Algorithms**	15	5
Specialist Unit Mandatory	**20 Advanced Programming**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5

Optional Unit Bank			
Optional units Level 4:			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4
Optional units Level 5:			
Optional Unit	**17 Network Security**	15	5
Optional Unit	**21 Data Mining**	15	5
Optional Unit	**22 Applied Analytical Models**	15	5
Optional Unit	**23 Cryptography**	15	5
Optional Unit	**24 Forensics**	15	5
Optional Unit	**25 Information Security Management**	15	5
Optional Unit	**26 Machine Learning**	15	5
Optional Unit	**27 Artificial Intelligence**	15	5
Optional Unit	**28 Prototyping**	15	5
Optional Unit	**29 Application Program Interfaces**	15	5
Optional Unit	**30 Application Development**	15	5
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5

Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5
Optional Unit	**38 Database Management Systems**	15	5
Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating Systems**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Data Analytics)		Unit credit	Level
Level 4 units:			
Core Unit *Mandatory*	**1 Programming**	15	4
Core Unit *Mandatory*	**2 Networking**	15	4
Core Unit *Mandatory*	**3 Professional Practice**	15	4
Core Unit *Mandatory*	**4 Database Design & Development**	15	4
Core Unit *Mandatory*	**5 Security**	15	4
Core Unit *Mandatory*	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Level 5 units:			
Core Unit *Mandatory*	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit *Mandatory*	**14 Business Intelligence**	15	5
Specialist Unit *Mandatory*	**18 Discrete Maths**	15	5
Specialist Unit Mandatory	**21 Data Mining**	15	5
Specialist Unit Mandatory	**22 Applied Analytical Models**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5

Optional Unit Bank			
Optional units Level 4:			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4
Optional units Level 5:			
Optional Unit	**17 Network Security**	15	5
Optional Unit	**19 Data Structures & Algorithms**	15	5
Optional Unit	**20 Advanced Programming**	15	5
Optional Unit	**23 Cryptography**	15	5
Optional Unit	**24 Forensics**	15	5
Optional Unit	**25 Information Security Management**	15	5
Optional Unit	**26 Machine Learning**	15	5
Optional Unit	**27 Artificial Intelligence**	15	5
Optional Unit	**28 Prototyping**	15	5
Optional Unit	**29 Application Program Interfaces**	15	5
Optional Unit	**30 Application Development**	15	5
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5
Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5
Optional Unit	**38 Database Management Systems**	15	5

Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating Systems**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Security)		Unit credit	Level
Level 4 units:			
Core Unit *Mandatory*	**1 Programming**	15	4
Core Unit *Mandatory*	**2 Networking**	15	4
Core Unit *Mandatory*	**3 Professional Practice**	15	4
Core Unit *Mandatory*	**4 Database Design & Development**	15	4
Core Unit *Mandatory*	**5 Security**	15	4
Core Unit *Mandatory*	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Level 5 units:			
Core Unit *Mandatory*	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit *Mandatory*	**14 Business Intelligence**	15	5
Specialist Unit *Mandatory*	**23 Cryptography**	15	5
Specialist Unit *Mandatory*	**24 Forensics**	15	5
Specialist Unit Mandatory	**25 Information Security Management**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5

Optional Unit Bank			
Optional units Level 4:			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4
Optional units Level 5:			
Optional Unit	**17 Network Security**	15	5
Optional Unit	**19 Data Structures & Algorithms**	15	5
Optional Unit	**20 Advanced Programming**	15	5
Optional Unit	**21 Data Mining**	15	5
Optional Unit	**22 Applied Analytical Models**	15	5
Optional Unit	**26 Machine Learning**	15	5
Optional Unit	**27 Artificial Intelligence**	15	5
Optional Unit	**28 Prototyping**	15	5
Optional Unit	**29 Application Program Interfaces**	15	5
Optional Unit	**30 Application Development**	15	5
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**33 Analytical Methods**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5
Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5
Optional Unit	**38 Database Management Systems**	15	5

Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating Systems**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Intelligent Systems)		Unit credit	Level
Level 4 units:			
Core Unit *Mandatory*	**1 Programming**	15	4
Core Unit *Mandatory*	**2 Networking**	15	4
Core Unit *Mandatory*	**3 Professional Practice**	15	4
Core Unit *Mandatory*	**4 Database Design & Development**	15	4
Core Unit *Mandatory*	**5 Security**	15	4
Core Unit *Mandatory*	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Level 5 units:			
Core Unit *Mandatory*	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit *Mandatory*	**14 Business Intelligence**	15	5
Specialist Unit *Mandatory*	**19 Data Structures & Algorithms**	15	5
Specialist Unit *Mandatory*	**26 Machine Learning**	15	5
Specialist Unit *Mandatory*	**27 Artificial Intelligence**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5

Optional Unit Bank			
Optional units Level 4:			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4
Optional units Level 5:			
Optional Unit	**17 Network Security**	15	5
Optional Unit	**18 Discrete Maths**	15	5
Optional Unit	**20 Advanced Programming**	15	5
Optional Unit	**21 Data Mining**	15	5
Optional Unit	**22 Applied Analytical Models**	15	5
Optional Unit	**23 Cryptography**	15	5
Optional Unit	**24 Forensics**	15	5
Optional Unit	**25 Information Security Management**	15	5
Optional Unit	**28 Prototyping**	15	5
Optional Unit	**29 Application Program Interfaces**	15	5
Optional Unit	**30 Application Development**	15	5
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5
Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5
Optional Unit	**38 Database Management Systems**	15	5

Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating Systems**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Applications Development)		Unit credit	Level
Level 4 units:			
Core Unit *Mandatory*	**1 Programming**	15	4
Core Unit *Mandatory*	**2 Networking**	15	4
Core Unit *Mandatory*	**3 Professional Practice**	15	4
Core Unit *Mandatory*	**4 Database Design & Development**	15	4
Core Unit *Mandatory*	**5 Security**	15	4
Core Unit *Mandatory*	**6 Managing a Successful Computing Project (Pearson-set)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Optional Unit	**Plus ONE Optional Level 4 unit from Optional Unit Bank (see below)**	15	4
Level 5 units:			
Core Unit *Mandatory*	**13 Computing Research Project (Pearson-set)**	30	5
Core Unit *Mandatory*	**14 Business Intelligence**	15	5
Specialist Unit *Mandatory*	**28 Prototyping**	15	5
Specialist Unit *Mandatory*	**29 Application Program Interfaces**	15	5
Specialist Unit *Mandatory*	**30 Application Development**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5
Optional Unit	**Plus ONE Optional Level 5 unit from Optional Unit Bank (see below)**	15	5

Optional Unit Bank			
Optional units Level 4:			
Optional Unit	**7 Strategic Information Systems**	15	4
Optional Unit	**8 Computer Systems Architecture**	15	4
Optional Unit	**9 Software Development Lifecycles**	15	4
Optional Unit	**10 Website Design & Development**	15	4
Optional Unit	**11 Maths for Computing**	15	4
Optional Unit	**12 Data Analytics**	15	4
Optional units Level 5:			
Optional Unit	**17 Network Security**	15	5
Optional Unit	**19 Data Structures & Algorithms**	15	5
Optional Unit	**20 Advanced Programming**	15	5
Optional Unit	**21 Data Mining**	15	5
Optional Unit	**22 Applied Analytical Models**	15	5
Optional Unit	**23 Cryptography**	15	5
Optional Unit	**24 Forensics**	15	5
Optional Unit	**25 Information Security Management**	15	5
Optional Unit	**26 Machine Learning**	15	5
Optional Unit	**27 Artificial Intelligence**	15	5
Optional Unit	**31 Games Engine & Scripting**	15	5
Optional Unit	**32 Game Design Theory**	15	5
Optional Unit	**33 Analytical Methods**	15	5
Optional Unit	**34 Systems Analysis & Design**	15	5
Optional Unit	**35 Network Management**	15	5
Optional Unit	**36 Client/Server Computing Systems**	15	5
Optional Unit	**37 Architecture**	15	5
Optional Unit	**38 Database Management Systems**	15	5

Optional Unit	**39 E-Commerce & Strategy**	15	5
Optional Unit	**40 User Experience & Interface Design**	15	5
Optional Unit	**41 Analytic Architecture Design**	15	5
Optional Unit	**42 Risk Analysis & System Testing**	15	5
Optional Unit	**43 Internet of Things**	15	5
Optional Unit	**44 Robotics**	15	5
Optional Unit	**45 Emerging Technologies**	15	5
Optional Unit	**46 Virtual & Augmented Reality Development**	15	5
Optional Unit	**47 Games Development**	15	5
Optional Unit	**48 Systems Integration**	15	5
Optional Unit	**49 Operating 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 within 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, centres 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* of our website http://qualifications.pearson.com or get in touch 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 Computing** and **Pearson BTEC Level 5 Higher National Diploma in 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 Computing	**Computing (general)**	30	-
Pearson BTEC Level 5 Higher National Diploma in Computing	**Computing (general)**	30	30
	Data Analytics	30	30
	Application Development	30	30
	Network Engineering	30	30
	Software Engineering	30	30
	Security	30	30
	Intelligent Systems	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 or 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 http://qualifications.pearson.com

Once the centre is ready to proceed with a commissioned development, an application must be made, which provides 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 Business:

- Theme: "Corporate Social Responsibility (CSR) and its importance for sustainability and competitive advantage"

Level 4 Topics:

- How to start up a socially responsible company

- The impact of CSR on a functional area (e.g. HR, Marketing, Finance) within an organisation to promote profitability and financial sustainability.

- Implementing CSR activities within organisations to meet sustainability objectives.

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* of this document.

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 in *Section 10* of this programme specification.

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 students 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 − referencing:

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

[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 exemptions

In redeveloping the Pearson BTEC Higher National qualifications in Computing, we have worked closely with the following professional bodies:

- British Computing Society (BCS)

- The Institution of Engineering & Technology (IET).

The BCS represents IT professionals both in the UK and internationally and are a member organisation of CEPIS (Council of European Professional Informatics Societies). The BCS have mapped their membership schemes to the SFIA framework.

With their agreement we have secured exemptions from certain memberships for students achieving Pearson BTEC Higher National qualifications in Computing. Members of the BCS can join various Specialist Groups within the Society. Specialist Groups give BCS members the opportunity to keep up to date on all sector relevant topics. Specialist Group meetings give members the opportunity to complement existing knowledge, contribute towards Continuing Professional Development (CPD), and build exposure to both people in and information on various computing fields. The BCS has 50+ Specialist Groups. Details of BCS membership and Specialist Groups can be found in Appendix 1.

Offering membership to the BCS adds value to the qualification by offering students access to CPD.

4.6   Vendor Accreditation

In redeveloping the Pearson BTEC Higher National qualifications in Computing, we have worked closely with vendors to offer students the skills required to gain accredited certifications. Certifications from the following vendors will be available:

- CompTIA

- CISCO

- Microsoft

- Oracle

- AXELOS

Students will not automatically gain vendor accredited certificates as a result of studying a BTEC HNC and/or a BTEC HND.

The skills required to achieve a vendor accredited certificate have been included in specific units (see *Appendix 2* for unit combination details). Once these units have been completed a student can then put themselves forward for vendor accreditation via the vendor-specific route. Details of these routes are available below.

CompTIA's vendor-neutral certifications are the starting point for a career in IT. They show employers you have the skills to do the job, regardless of the vendor hardware or software. Earning a CompTIA certification proves you have the right skills, and is the starting place for a career in IT.

- CompTIA A+: validates understanding of the most common hardware and software technologies and certifies the skills necessary to support complex IT infrastructures.

- Network+: validates the essential knowledge and skills needed to confidently design, configure, manage and troubleshoot any wired and wireless networks.

- CompTIA Security+: validates foundational, vendor-neutral IT security knowledge and skills. Covers the essential principles for Network Security and risk management.

- CompTIA Cloud+: validates the skills and expertise of IT practitioners in implementing and maintaining cloud technologies.

- CompTIA Server+: validates planning, securing and maintaining a variety of server equipment.

- CompTIA Linux+: certifies foundational skills and knowledge of Linux.

Details of how to take CompTIA Certification exams can be found on the Pearson Vue website (http://www.pearsonvue.com/comptia/).

CISCO is the largest networking company in the world and sponsor IT Professional certifications for CISCO products. CISCO Certifications and specialist qualifications are an IT industry standard used to validate knowledge of CISCO products and technologies. Getting certified brings measurable rewards and opens up further professional opportunities.

- CISCO IT Essentials: covers fundamental computer and career skills for entry-level IT jobs.

- CISCO CCNA Routing & Switching: covers knowledge of foundational technologies and skill sets needed for the adoption of next generation networking technologies.

- CISCO CCNA Security: covers skills required to develop a security infrastructure, recognise threats and vulnerabilities to networks, and mitigate security threats.

For students to be in a position to achieve CISCO accredited certification the relevant units must be delivered using CISCO technologies.

Students who study these units with non-CISCO technologies will achieve a BTEC Higher National Diploma, but will not have the skills necessary to take CISCO Certification assessments.

Details of how to take CISCO Certification exams can be found on the Pearson Vue website (http://www.pearsonvue.com/cisco/).

Microsoft Office is a bundled set of applications which includes Microsoft Word, Microsoft Excel, and Microsoft PowerPoint. A Microsoft Certification validates your expertise in Microsoft technology. Passing your first Microsoft Certification exam automatically makes you a member of the Microsoft Certified Professional (MCP) community, with access to all of the benefits provided through the MCP.

- Microsoft Office Specialist: allows you demonstrate the skills needed to get the most out of Microsoft Office.

Details of how to take the various Microsoft Office exams can be found on the Microsoft learning website (https://www.microsoft.com/en-us/learning/).

Oracle is a leading database software company and has developed technologies into the entire technology stack. The Oracle Certification Program certifies candidates on skills and knowledge related to Oracle products and technologies.

- Java SE 8 Fundamentals: validates skills in object-oriented programming using the Java language.

- Oracle Database Introduction to SQL: validates skills in the SQL programming language.

- Oracle Database 12c Administration: validates understanding of the Oracle Database architecture.

For students to be in a position to achieve Oracle accredited certification the relevant units must be delivered using Java and/or SQL.

Students who study these units with non-Oracle technologies will achieve a BTEC Higher National Diploma, but will not have the skills necessary to take Oracle's certification assessments.

Details of how to take Oracle Certification exams are available on the Pearson Vue website (http://www.pearsonvue.com/oracle/).

AXELOS is a joint venture set up by the Government of the UK and Capita, to develop, manage and operate qualifications in best practice methodologies.

- Prince 2 Foundation Qualification: confirms sufficient knowledge and understanding of the PRINCE2 method to be able to work effectively with, or as a member of, a project management team.

- RESILIA Foundation Qualification: verifies understanding of how decisions impact good/bad cyber resilience.

Details of how to take the various exams are available in the links below:

- Prince 2 Foundation (http://www.axelos.com/certifications/).

- RESILIA Foundation (https://www.axelos.com/certifications/).

See *Appendix 2* for an outline of the unit combinations students must take to be in a position to gain the relevant vendor certifications.

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 effectively 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 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 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 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 would be used to inform and enhance future practice within a programme of study and within 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 also 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 they can analyse data and information, make sense of this 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). It also meets requirements set by the Regulated Qualifications Framework (RQF). The first stage of a Pearson BTEC Higher National in 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 has, 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 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 onto their BTEC Higher National programme. This induction should include an introduction to the course programme and 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 out of their tutor

- Assignment requirements

- Referencing and plagiarism

- Centre policies

- Academic study skills.

Pearson offer 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.highernationals.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 the Pearson BTEC Higher Nationals in Computing. This input should extend into 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 local employer.

While detailed guidance on assessment has been provided in this specification (see 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 this, 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 to 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 completing 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 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 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 the 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 these 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, and 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 within a unit is benchmarked to recognised standards. This applies to all units within a level of study, and this 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 BTEC Higher National Diploma in 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.

Within 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 requiring 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, or to deliver units over an extended period, or 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													Assessment
Unit 2					Assessment	Unit 3							
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 into 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	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.	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.
Virtual Learning Environments (VLEs)	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 hand-outs, 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.	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.
Blended learning	The combination of traditional face-to-face learning and online learning. This can enable the students to gain personalised support, instruction and guidance while completing assigned activities and tasks remotely.	Offline learning enables students to develop autonomy and self-discipline by completing set activities and tasks with limited direction and traditional classroom-based constraints.
Work-based learning	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.	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.

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 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 of this Programme Specification). 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 recognises the strengths a student has. 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. All formative assessment feeds directly into the summative assessment for each unit and lays the foundations from which students develop the necessary knowledge and skills required for the summative assessment.

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 marking criteria to also help students understand how these 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 valid and reliable assignments are designed and 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 tests and exams are not replicated during 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 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

Each unit has supporting Example Assessment Briefs that are available to download from the course materials section on our website (http://qualifications.pearson.com). The Example Assessment Briefs 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 Example Assessment Briefs, 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 (http://qualifications.pearson.com/). All 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 hand-out 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 5* 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), and 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 (http://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

- How assignments relate to the teaching programme

- How 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 provide online EABs for each unit 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 plays

- 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* in this Programme Specification 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 5* of this document
- 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 course work, 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 discretion and Assessment Board, 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 only be repeated once.

6.3.7 Assessment Boards

Each centre is expected by Pearson 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 grades achieved by students on the individual units

- Extenuating circumstances

- Cases of cheating and plagiarism

- Progression of students on 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 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 will wish to consider:

- 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 though 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 (http://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 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

	Credits	Level	Grade point	STUDENT 1 Grade	STUDENT 1 Unit points	STUDENT 2 Grade	STUDENT 2 Unit points	STUDENT 3 Grade	STUDENT 3 Unit points	STUDENT 4 Grade	STUDENT 4 Unit points	STUDENT 5 Grade	STUDENT 5 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		810
GRADE					M		P		M		D		M

Pearson BTEC Level 5 Higher National Diploma

	Credits	Level	Grade point	STUDENT 1 Grade	STUDENT 1 Unit points	STUDENT 2 Grade	STUDENT 2 Unit points	STUDENT 3 Grade	STUDENT 3 Unit points	STUDENT 4 Grade	STUDENT 4 Unit points	STUDENT 5 Grade	STUDENT 5 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		840
GRADE					M		M		M		P		D

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 comprise 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 implications 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, 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 upon 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 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 Quality Assurance Agency 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 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 (APMR)

The 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 document available in the support section of our website (https://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 within 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 (http://qualifications.pearson.com/).

10 Pearson BTEC Higher Nationals Computing Units

Unit 1: Programming

Unit code	**D/615/1618**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Programming involves describing processes and procedures which 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 and 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 & 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 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:

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

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

LO3. Implement basic algorithms in code using an IDE.

LO4. 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, etc

LO3 Implement basic algorithms in code using an IDE

Implementation:

Developing simple applications which implements basic algorithms covered in LO1, using the features of a suitable language and IDE. Consider possible security concerns and how these 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 which 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. **P5** Outline the coding standard you have used in your code.	**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.

Recommended Resources

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

Examples of languages that are used in industry are C#, Python, Ruby, Java, but any language which will allow the student 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 19: Data Structures & Algorithms

Unit 20: Advanced Programming

Unit 28: Prototyping

Unit 2: Networking

Unit code	**H/615/1619**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Computer networks are the driving force behind the evolution of computer systems and allow users to access data, hardware and services regardless of their location. Being knowledgeable about the underlying principles of networking is of vital importance to all IT professionals. Networking is an environment that is increasingly complex and under continuous development.

Complex computer networking has connected the world by groups of small networks through internet links to support global communications. It supports access to digital information anytime, anywhere using many applications like e-mail, audio and video transmission, including the World Wide Web, and this has opened the floodgates to the availability of information.

The aim of this unit is to provide students with wider background knowledge of computer networking essentials, how they operate, protocols, standards, security considerations and the prototypes associated with a range of networking technologies.

Students will explore a range of hardware, with related software, and will configure and install these to gain knowledge of networking systems. A range of networking technologies will be explored to deliver a fundamental knowledge of Local Area Networking (LAN), Wide Area Networking (WAN) and their evolution to form large-scale networks and the protocol methodologies related to IP data networks will be explored.

On successful completion of this unit students will gain knowledge and skills to successfully install, operate and troubleshoot a small network; and the operation of IP data networks, router, switching technologies, IP routing technologies, IP services and basic troubleshooting. Supporting a range of units in the Higher National suite, this unit underpins the principles of networks for all and enables students to work towards their studies in vendor units, if applicable.

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:

LO1. Examine networking principles and their protocols.

LO2. Explain networking devices and operations.

LO3. Design efficient networked systems.

LO4. Implement and diagnose networked systems.

Essential Content

LO1 Examine networking principles and their protocols

Role of networks:

Purpose, benefits, resource implications, communications, working practice, commercial opportunity, information sharing, collaboration.

System types:

Peer-based, client-server, cloud, cluster, centralised, virtualised.

Networking standards:

Conceptual models e.g. OSI model, TCP/IP model; standards: e.g. IEEE 802.x.

Topology:

Logical e.g. Ethernet, Token Ring; physical e.g. star, ring, bus, mesh, tree, ring.

Protocols:

Purpose of protocols; routed protocols e.g. IPv4, IPv6, IPv6 addressing, Global unicast, Multicast, Link local, Unique local, EUI 64, Auto configuration, FTP, HTTP, SMTP, POP3, SSL; management of protocols for addressing.

LO2 Explain networking devices and operations

Networking devices:

Servers; hub, routers; switches; multilayer switch, firewall, HIDS, repeaters; bridges; wireless devices; access point (wireless/wired), content filter, Load balancer, Modem, Packet shaper, VPN concentrator.

Networking software:

Client software, server software, client operating system, server operating system, Firewall.

Server type:

Web, file, database, combination, virtualisation, terminal services server.

Server selection:

Cost, purpose, operating system requirement.

Workstation:

Hardware e.g. network card, cabling; permissions; system bus; local-system architecture e.g. memory, processor, I/O devices.

LO3 Design efficient networked systems

Bandwidth:

Expected average load; anticipated peak load; local internet availability; cost constraints, throughput.

Users:

Quality expectations, concept of system growth.

Networking services and applications:

DHCP; static vs dynamic IP addressing, reservations, scopes, leases, options (DNS servers, Suffixes), IP helper, DHCP relay, DNS records, Dynamic DNS.

Communications:

Suited to devices, suited to users, supportive of lifestyle desires, supportive of commercial requirements, security requirements, quality of service needs.

Scalable:

Able to support device growth, able to support addition of communication devices, able to cope with bandwidth use and trend changes, protocol utilisation, addressing.

Selection of components:

Supporting infrastructure needs; supporting connectivity requirements.

Implement and diagnose networked systems

Devices:

Installation of communication devices, allocation of addresses, local client configuration, server configuration, server installation, security considerations.

Verification of configuration and connectivity:

Installation of internet work communication medium, ping, extended ping, traceroute, telnet, SSH.

System monitoring:

Utilisation, bandwidth needs, monitoring user productivity and security of the system.

Maintenance schedule:

Backups, upgrades, security, auditing.

Diagnose and resolve layer 1 problems:

Framing, CRC, Runts, Giants, Dropped packets, late collisions, Input/Output errors.

Policy review:

Bandwidth, resource availability.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine networking principles and their protocols		**LO1 & 2**
P1 Discuss the benefits and constraints of different network types and standards. **P2** Explain the impact of network topology, communication and bandwidth requirements.	**M1** Compare common networking principles and how protocols enable the effectiveness of networked systems.	**D1** Critically evaluate the topology protocol selected for a given scenario to demonstrate the efficient utilisation of a networking system.
LO2 Explain networking devices and operations		
P3 Discuss the operating principles of networking devices and server types. **P4** Discuss the inter-dependence of workstation hardware with relevant networking software.	**M2** Explore a range of server types and justify the selection of a server, considering a given scenario regarding cost and performance optimisation.	
LO3 Design efficient networked systems		
P5 Design a networked system to meet a given specification. **P6** Test and evaluate the design to meet the requirements and analyse user feedback with the aim of improving efficiency.	**M3** Install and configure network services and applications on your choice.	**D2** Design a maintenance schedule to support the networked system.
LO4 Implement and diagnose networked systems		
P7 Implement a networked system based on a prepared design. **P8** Document and analyse test results against expected results.	**M4** Recommend potential enhancements for the networked systems.	**D3** Use critical reflection to evaluate own work and justify valid conclusions.

Recommended Resources

Textbooks

Burgess, M. (2003) *Principles of Network and System Administration*. 2nd Ed.
John Wiley and Sons Ltd.

Hallberg, B. (2005) *Networking: A Beginner's Guide*. 4th Ed. Osborne/McGraw-Hill US.

Limoncelli, T. and Hogan, C. (2001) *The Practice of System and Network Administration*.
Addison-Wesley.

Lowe, D. (2005) *Networking All-in-One Desk Reference for Dummies*. 2nd Ed.
Hungry Minds Inc.

Olifer, N. and Olifer, V. (2005) *Computer Networks: Principles, Technologies and Protocols
for Network Design*. John Wiley and Sons Ltd.

Stallings, W. (2003) *Data and Computer Communications*. 7th Ed. (Prentice Hall)

Subramanian, M. (2000) *Network Management: An Introduction to Principles and Practice.*
Addison-Wesley.

Tanenbaum, A. (2002) *Computer Networks*. Prentice Hall PTR.

Journals

The Institute of Engineering and Technology

Links

This unit links to the following related units:

Unit 8: Computer Systems Architecture

Unit 15: Transport Network Design

Unit 17: Network Security

Unit 35: Network Management

Unit 36: Client/Server Computing Systems

Unit 3:   Professional Practice

Unit code	**Y/615/1620**
Unit type	**Core**
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 also 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:

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

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

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

LO4   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, judgemental 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		**D1** Evaluate the effectiveness and application of interpersonal skills during the design and delivery of a training event.
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.	
LO2 Apply critical reasoning and thinking to a range of problem-solving scenarios		**D2** Critique the process of applying critical reasoning to a given task/activity or event.
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.	

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

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

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

Links

This unit links to the following related units:

Unit 6: Managing a Successful Computing Project

Unit 13: Computing Research Project

Unit 4: Database Design & Development

Unit code	**H/615/1622**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Organisations depend on their databases to provide information 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 technologies is an essential skill for designing and developing systems to support them.

Database systems continue to demand more complex data structures and interfaces, as applications get increasingly sophisticated. Most organisations collect and store large volumes of data, either on their own systems or in the cloud, and this data is used not just for the operational running of their business but also mined for other more intelligent and complex applications. Databases stand as the back-end of most systems used by organisations for their operations.

Database design and development is a fundamental and highly beneficial skill for computing students to master, regardless of their specialism.

The aim of this unit is to give students opportunities to develop an understanding of the concepts and issues relating to database design and development, as well as to provide the practical skills to translate that understanding into the design and creation of complex databases.

Topics included in this unit are: examination of different design tools and techniques; examination of different development software options; considering the development features of a fully functional robust solution covering data integrity, data validation, data consistency, data security and advanced database querying facilities across multiple tables; appropriate user interfaces for databases and for other externally linked systems; creating complex reports/dashboards, testing the system against the user and system requirements; and elements of complete system documentation.

On successful completion of this unit students will be able to use appropriate tools to design and develop a relational database system for a substantial problem. They will be able to test the system to ensure 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 and related tools and techniques. A brief overview of object-oriented databases will also be covered.

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:

LO1.   Use an appropriate design tool to design a relational database system for a substantial problem.

LO2.   Develop a fully functional relational database system, based on an existing system design.

LO3.   Test the system against user and system requirements.

LO4.   Produce technical and user documentation.

Essential Content

LO1 Use an appropriate design tool to design a relational database system for a substantial problem

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

Determining user and system requirements.

Design tools and techniques for a relational database system.

Logical design for relational databases e.g. tables, data elements, data types, indexes, primary/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.

Output designs for user requirements.

Overview of object-oriented databases and their design tools.

LO2 Develop a fully functional relational database system, based on an existing system design

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.

Data stores, internal storage and external storage (e.g. the cloud).

Implementation of security elements in databases.

Relational databases with controls like data validation using; input masks, drop down lists, option buttons.

User interface for requirements, 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: inserts, updates, amendments, deletions, data backup and recovery.

System reports using report writing tools and report generators, dashboards.

LO3 Test the system against user and system requirements

Identify elements of the system that need to be tested.

Consider data that should be used to fully test the system.

Match tests against user and system requirements.

Test procedures to be used: test plans, test models e.g. white box, black box; testing documentation.

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

LO4 Produce technical and user documentation

Technical and user documentation and their contents.

The documentation can include diagrams showing movement of data through the system, and flowcharts describing how the system works. Documentation could also extend to user guides and any initial design and implementation plans.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Use an appropriate design tool to design a relational database system for a substantial problem		
P1 Design a relational database system using appropriate design tools and techniques, containing at least four interrelated tables, with clear statements of user and system requirements.	**M1** Produce a comprehensive design for a fully functional system which includes interface and output designs, data validations and data normalisation.	**D1** Evaluate the effectiveness of the design in relation to user and system requirements.
LO2 Develop a fully functional relational database system, based on an existing system design		
P2 Develop the database system with evidence of user interface, output and data validations, and querying across multiple tables.	**M2** Implement a fully functional database system which includes system security and database maintenance.	**LO2 & 3** **D2** Evaluate the effectiveness of the database solution in relation to user and system requirements, and suggest improvements.
P3 Implement a query language into the relational database system.	**M3** Assess whether meaningful data has been extracted through the use of query tools to produce appropriate management information.	
LO3 Test the system against user and system requirements		
P4 Test the system against user and system requirements.	**M4** Assess the effectiveness of the testing, including an explanation of the choice of test data used.	
LO4 Produce technical and user documentation		
P5 Produce technical and user documentation.	**M5** Produce technical and user documentation for a fully functional system, including diagrams showing movement of data through the system, and flowcharts describing how the system works.	**D3** Evaluate the database in terms of improvements needed to ensure the continued effectiveness of the system.

Recommended Resources

Textbooks

Churcher, C. (2012) *Beginning Database Design: From Novice to Professional.* 2nd Ed. Apress.

Connolly, T. and Begg, C. (2014) *Database Systems: A Practical Approach to Design, Implementation and Management*. 6th Ed. Global Edition. Pearson.

Kroemke, D. and Auer, D. (2012) *Database Concepts: International Edition.* 6th Ed. Pearson.

Paulraj, P (2008). *Database Design and Development: An Essential Guide for IT Professional.* Wiley.

Stephens, R. (2008) *Beginning Database Design Solutions.* Wrox.

Journals

International Journal of Database Management Systems

Journal of Database Management

The Computer Journal

Journal of Systems Analysis and Software Engineering

Journal of Emerging Trends in Computing and Information Sciences

Websites

www.lynda.com	Database Training (Tutorials)
mva.microsoft.com	Microsoft Virtual Academy "Database Development" (Training)
mva.microsoft.com/ebooks	Microsoft Virtual Academy "Microsoft Press" (E-Books)

Links

This unit links to the following related units:

Unit 7: Strategic Information Systems

Unit 38: Database Management Systems

Unit 5: Security

Unit code	**K/615/1623**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Security is one of the most important challenges modern organisations face. Security is about protecting organisational assets, including personnel, data, equipment and networks from attack through the use of prevention techniques in the form of vulnerability testing/security policies and detection techniques, exposing breaches in security and implementing effective responses.

The aim of this unit is to provide students with knowledge of security, associated risks and how security breaches impact on business continuity. Students will examine security measures involving access authorisation, regulation of use, implementing contingency plans and devising security policies and procedures.

This unit introduces students to the detection of threats and vulnerabilities in physical and IT security, and how to manage risks relating to organisational security.

Among the topics included in this unit are Network Security design and operational topics, including address translation, DMZ, VPN, firewalls, AV and intrusion detection systems. Remote access will be covered, as will the need for frequent vulnerability testing as part of organisational and security audit compliance.

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:

LO1   Assess risks to IT security.

LO2   Describe IT security solutions.

LO3   Review mechanisms to control organisational IT security.

LO4   Manage organisational security.

Essential Content

LO1 Assess risks to IT security

IT security risks:

Risks: unauthorised use of a system; unauthorised removal or copying of data or code from a system; damage to or destruction of physical system assets and environment; damage to or destruction of data or code inside or outside the system; naturally occurring risks.

Organisational security: business continuance; backup/restoration of data; audits; testing procedures e.g. data, network, systems, operational impact of security breaches, WANs, intranets, wireless access systems.

LO2 Describe IT security solutions

IT security solution evaluation:

Network Security infrastructure: evaluation of NAT, DMZ, FWs.

Network performance: RAID, Main/Standby, Dual LAN, web server balancing.

Data security: explain asset management, image differential/incremental backups, SAN servers.

Data centre: replica data centres, virtualisation, secure transport protocol, secure MPLS routing and remote access methods/procedures for third-party access.

Security vulnerability: logs, traces, honeypots, data mining algorithms, vulnerability testing.

LO3 Review mechanisms to control organisational IT security

Mechanisms to control organisational IT security:

Risk assessment and integrated enterprise risk management: network change management, audit control, business continuance/disaster recovery plans, potential loss of data/business, intellectual property, hardware and software; probability of occurrence e.g. disaster, theft; staff responsibilities; Data Protection Act; Computer Misuse Act; ISO 31000 standards.

Company regulations: site or system access criteria for personnel; physical security types e.g. biometrics, swipe cards, theft prevention.

LO4 Manage organisational security

Manage organisational security:

Organisational security: policies e.g. system access, access to internet email, access to internet browser, development/use of software, physical access and protection, 3rd party access, business continuity, responsibility matrix.

Controlling security risk assessments and compliance with security procedures and standards e.g. ISO/IEC 17799:2005 Information Technology (Security Techniques – code of practice for information security management); informing colleagues of their security responsibilities and confirming their understanding at suitable intervals; using enterprise risk management for identifying, evaluating, implementing and follow up of security risks according to ISO 31000 standards.

Security: tools e.g. user log-on profiles to limit user access to resources; online software to train and update staff; auditing tools to monitor resource access; security audits; penetration testing; ethical hacking; gathering and recording information on security; initiating suitable actions for remediation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Assess risks to IT security		**LO1 & 2** **D1** Evaluate a minimum of three of physical and virtual security measures that can be employed to ensure the integrity of organisational IT security.
P1 Identify types of security risks to organisations. **P2** Describe organisational security procedures.	**M1** Propose a method to assess and treat IT security risks.	
LO2 Describe IT security solutions		
P3 Identify the potential impact to IT security of incorrect configuration of firewall policies and third-party VPNs. **P4** Show, using an example for each, how implementing a DMZ, static IP and NAT in a network can improve Network Security.	**M2** Discuss three benefits to implement network monitoring systems with supporting reasons.	
LO3 Review mechanisms to control organisational IT security		**D2** Consider how IT security can be aligned with organisational policy, detailing the security impact of any misalignment.
P5 Discuss risk assessment procedures. **P6** Explain data protection processes and regulations as applicable to an organisation.	**M3** Summarise the ISO 31000 risk management methodology and its application in IT security. **M4** Discuss possible impacts to organisational security resulting from an IT security audit.	
LO4 Manage organisational security		**D3** Evaluate the suitability of the tools used in an organisational policy.
P7 Design and implement a security policy for an organisation. **P8** List the main components of an organisational disaster recovery plan, justifying the reasons for inclusion.	**M5** Discuss the roles of stakeholders in the organisation to implement security audit recommendations.	

Recommended Resources

Textbooks

Alexander, D. et al. (2008) *Information Security Management Principles*. BSC.

Steinberg, R. (2011) *Governance, Risk Management, and Compliance: It Can't Happen to Us – Avoiding Corporate Disaster While Driving Success*. Wiley.

Tipton, H. (2010) *Information Security Management Handbook*. 4th Ed. Auerbach Pubs.

Websites

www.bcs.org	British Computer Society (General Reference)
www.bsa.org.uk	Business Software Alliance (General Reference)
www.fast.org.uk	Federation Against Software Theft (General Reference)
www.ico.gov.uk	Information Commissioners Office (General Reference)

Links

This unit links to the following related units:

Unit 17: Network Security

Unit 23: Cryptography

Unit 24: Forensics

Unit 25: Information Security Management

Unit 6: Managing a Successful Computing Project

Unit code	**T/615/1625**
Unit type	**Core unit**
Unit level	**4**
Credit value	**15**

Introduction

This unit is assessed by a Pearson-set assignment. The project brief will be set by the centre, based on a theme provided by Pearson (this will change annually). The theme and chosen project within the theme will enable students to explore and examine a relevant and current topical aspect of computing in the context of a business environment.

In order to ensure that client expectations are met in terms of requirements, deadlines and the estimated cost, the work to deliver new computer systems or services to business organisations, or to revamp the existing ones, is always organised in projects. Therefore, skilful, knowledgeable and experienced project managers have always been in demand. It is projected that 15.7 million new project management roles will be created around the world by 2020.

The aim of this unit is to offer students an opportunity to demonstrate the skills required for managing and implementing a project. They will undertake independent research and investigation for carrying out and executing a computing project which meets appropriate aims and objectives.

On successful completion of this unit students will have the confidence to engage in decision-making, problem-solving and research activities using project management skills. They will have the fundamental knowledge and skills to enable them to investigate and examine relevant computing concepts within a work-related context, determine appropriate outcomes, decisions or solutions and present evidence to various stakeholders in an acceptable and understandable format.

Learning Outcomes

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

LO1   Establish project aims, objectives and timeframes based on the chosen theme.

LO2   Conduct small-scale research, information gathering and data collection to generate knowledge to support the project.

LO3   Present the project and communicate appropriate recommendations based on meaningful conclusions drawn from the evidence findings and/or analysis.

LO4   Reflect on the value gained from conducting the project and its usefulness to support sustainable organisational performance.

Essential Content

LO1 **Establish project aims, objectives and timeframes based on the chosen theme**

Project management:

What is project management and what does it involve?

The key stages of project management.

The advantages of using project management and why it is important.

Initiation of the project and project planning phase:

Scoping a project − defining objectives, scope, purpose and deliverables to be produced.

Steps and documentation required in the initiation phase.

Developing the project plan, including planning for timescales and time management, cost, quality, change, risk and issues.

The work breakdown structure.

Use of Bar and Gantt Charts for effective planning.

LO2 **Conduct small-scale research, information gathering and data collection to generate knowledge to support the project**

Project execution phase:

Selecting appropriate methods of information gathering, data collection and material resourcing.

The distinct phases which support a coherent and logical argument.

Use of secondary research to inform a primary empirical study.

Qualitative and quantitative research methods.

Field work:

Selecting a sample of the consumer market, businesses or individuals (those who meet certain characteristics relevant to the research theme) is used to gather data (qualitative or quantitative).

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

Ethics, reliability and validity:

All research should be conducted ethically − how is this achieved and reported?

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

Analysing information and data:

Using data collection tools such as interviews and questionnaires.

Using analytical techniques such as trend analysis, coding or typologies.

LO3 **Present the project and communicate appropriate recommendations based on meaningful conclusions drawn from the evidence findings and/or analysis**

Communicating outcomes:

Consider the method (e.g. written, verbal) and the medium (e.g. report, online, presentation).

Both method and medium will be influenced by the project research and its intended audience.

Convincing arguments:

All findings/outcomes should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the project process.

Developing evaluative conclusions.

Critical and objective analysis and evaluation:

Secondary and primary data should be critiqued and considered with an objective mindset.

Objectivity results in more robust evaluations where an analysis justifies a judgement.

LO4 Reflect on the value gained from conducting the project and its usefulness to support sustainable organisational performance

Reflection for learning and practice:

The difference between reflecting on performance and evaluating a project – the former considers the research process, information gathering and data collection, the latter the quality of the research argument and use of evidence.

The cycle of reflection:

To include reflection in action and reflection on action.

How to use reflection to inform future behaviour, particularly directed towards sustainable performance.

Reflective writing:

Avoiding generalisation and focusing on personal development and the research journey in a critical and objective way.

Generalisation:

Many studies result in generalised findings. Research which has its basis in a specific field such as Human Resource Management (HRM) and in a specific context should avoid generalised conclusions.

Outcomes should be specific and actionable.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Establish project aims, objectives and timeframes based on the chosen theme		
P1 Devise project aims and objectives for a chosen scenario. **P2** Produce a project management plan that covers aspects of cost, scope, time, quality, communication, risk and resources. **P3** Produce a work breakdown structure and a Gantt Chart to provide timeframes and stages for completion.	**M1** Produce a comprehensive project management plan, milestone schedule and project schedule for monitoring and completing the aims and objectives of the project.	**LO1 & 2** **D1** Critically evaluate the project management process and appropriate research methodologies applied.
LO2 Conduct small-scale research, information gathering and data collection to generate knowledge to support the project		
P4 Carry out small-scale research by applying qualitative and quantitative research methods appropriate for meeting project aims and objectives.	**M2** Evaluate the accuracy and reliability of different research methods applied.	

Pass	Merit	Distinction
LO3 Present the project and communicate appropriate recommendations based on meaningful conclusions drawn from the evidence findings and/or analysis		
P5 Analyse research and data using appropriate tools and techniques. **P6** Communicate appropriate recommendations as a result of research and data analysis to draw valid and meaningful conclusions.	**M3** Evaluate the selection of appropriate tools and techniques for accuracy and authenticity to support and justify recommendations.	**LO3** **D2** Critically evaluate the research and data analysis tools used in the project development stages..
LO4 Reflect on the value gained from conducting the project and its usefulness to support sustainable organisational performance		
P7 Reflect on the value of undertaking the research to meet stated objectives and own learning and performance.	**M4** Evaluate the value of the project management process and use of quality research to meet stated objectives and support own learning and performance.	**LO4** **D3** Critically evaluate how the project supports sustainable organisational performance.

Additional Evidence Requirements

In addition to the above assessment criteria, students will also be required to complete a project logbook to record ideas, changes and developments as they progress and complete the project.

Recommended Resources

Textbooks

Costley, C., Elliot, G. and Gibbs, P. (2010) *Doing Work Based Research: Approaches to Enquiry for Insider-researchers*. London: SAGE.

Dawson, C. (2016) *Projects in Computing and Information Systems: A Student's Guide*. UK: Pearson Education.

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.

Guay, M., Schreiber, D. and Briones, S. (2016) *The Ultimate Guide to Project Management: Learn everything you need to successfully manage projects and get them done*. Free Kindle Edition. US: Zapier Inc.

Lock, D. (2013) *Project Management 8th Edition*. UK: Routledge.

Pinto, J.K. (2015) *Project Management: Achieving Competitive Advantage* 4th Ed. Pearson.

Journals

International Journal of Quantitative and Qualitative Research
Qualitative Research Journal

Websites

www.gov.uk/government/publications	Department of Business Innovations and Skills "Guidelines for managing projects – How to organise, plan and control projects." (Report)

Links

This unit links to the following related units:

Unit 3: Professional Practice

Unit 13: Computing Research Project

Unit 14: Business Intelligence

Unit 34: Systems Analysis & Design

Unit 7: Strategic Information Systems

Unit code	**A/615/1626**
Unit type	**Optional**
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 are able to 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:

LO1   Analyse the information requirements of organisations.

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

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

LO4   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:

Porters 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.

Pass	Merit	Distinction
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 4: Database Design & Development

Unit 38: Database Management Systems

Unit 8: 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:

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

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

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

LO4 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:

Introduction to network protocols (HTTP, SMTP, TCP, UDP, etc.) including the OSI and TCP/IP models.

> Students should have an understanding about the five layers for the TCP/IP model to include the application layer, transport layer, network layer, data link layer and physical layer in terms of functionality and links to the OSI model and layers.

> OSI understand that it is a conceptual model, dividing network architecture into seven progressive layers.

Hardware and network addresses (physical/MAC addresses, 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.	**LO1 & 2** **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. **P6** Setup, configure and document appropriate hardware and software systems to establish computer based network connectivity.	**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.		**D3** Assess any future improvements that may be required to ensure the continued effectiveness of a computer system.
P7 Use information gathering methods to assess, troubleshoot and document solutions to a number of different technical hardware, software and networking issues. **P8** Conduct and document a range of maintenance activities with regards to computer hardware and software.	**M4** Review different diagnostic and troubleshooting skills including data gathering methods and techniques.	

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

Unit 15: Transport Network Design

Unit 17: Network Security

Unit 35: Network Management

Unit 36: Client/Server Computing Systems

Unit 9: Software Development Lifecycles

Unit code	J/615/1631
Unit level	4
Credit value	15

Introduction

The software development lifecycle is an integrated process that promotes building good quality, secure software throughout the entire development process. The aim of this unit is to provide students with the knowledge and skills needed to understand software development lifecycles and to demonstrate their knowledge by implementing a software development lifecycle with a suitable methodology.

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 which project environments they are most appropriate for. Theoretical understanding will be translated into practical skills through an actual software development lifecycle project and students will become confident in the use of particular tools and techniques relevant to a chosen methodology.

Among the topics included in this unit are iterative and sequential models of software development lifecycles and reference frameworks for initially capturing conceptual data and information through a feasibility study and requirement gathering techniques through to analysis, design and software implementation activities.

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:

LO1   Describe different software development lifecycles.

LO2   Explain the importance of a feasibility study.

LO3   Undertake a software development lifecycle.

LO4   Discuss the suitability of software behavioural design techniques.

Essential Content

LO1 Describe different software development lifecycles

Software development lifecycles:

Lifecycle models: understanding and use of predictive (Waterfall, Prototyping, RAD) and adaptive (Spiral, Agile, DSDM) software development models.

Lifecycle stage and connectivity: feasibility study, analysis, design, implementation, testing, review or analysis, design, implementation, maintenance, planning; requirements traceability.

Test and integration: building test environments; developing test harnesses; black box/white box testing; incremental testing; acceptance test and integration approaches; changeover strategies, trials and Go-Live prerequisites.

LO2 Explain the importance of a feasibility study

Importance of feasibility study:

Requirement gathering techniques: e.g., interviews, observation, investigation

Key drivers: performance and efficiency; legacy systems upgrade; automation; elimination of human error.

Feasibility criteria: issues e.g. legal, social, economic, technical, timescales; organisational constraints.

Components: purpose; structure; intended audience; outcomes.

Requirements: MosCow; Functional; non-functional; user; constraints.

LO3 Undertake a software development lifecycle

Carry out software development lifecycle:

Identify requirements: stakeholders; requirements identification; requirements specification e.g. scope, inputs, outputs, processes and process descriptors; consideration of alternate solutions and security considerations; quality assurance required.

Constraints: specific to activity e.g. costs, organisational policies, legacy systems, hardware requirements.

Report documentation: structure e.g. background information, problem statements, data collection process and summary, recommendations, appendices.

Systems analysis terminology and tools: data stores and entities; data flows; process representation techniques relationships – 1:1, 1:Many (1:M) and Many:Many (M:M).

Investigation: e.g. upgrading computer systems, designing new systems.

Techniques: examples relevant to methodology chosen e.g. Context Diagrams, Data Flow Diagrams (DFDs), Entity Relationship Diagrams (ERDs); Business Systems Options (BSOs); Technical Systems Options (TSOs); quality considerations e.g. Total Quality Management (TQM).

LO4 **Discuss the suitability of software behavioural design techniques**

Evaluate suitability of software behavioural design techniques:

Techniques: Flowcharts; Pseudocode; Formal specification Methods; Event/State/Data Driven; Finite State Machines (extended-FSM)/FSP; problem of e-FSM state explosion; reachability analysis, safety, liveness properties; Automatic analysis and animation tools.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe different software development lifecycles		
P1 Describe two iterative and two sequential software lifecycle models. **P2** Explain how risk is managed in these models.	**M1** Discuss, with an example, why a particular lifecycle model is selected for a development environment.	**D1** Assess the merits of applying the Waterfall lifecycle model to a large software development project.
LO2 Explain the importance of a feasibility study		
P3 Explain the purpose of a feasibility report. **P4** Describe how technical solutions can be compared.	**M2** Discuss the components of a feasibility report.	**D2** Assess the impact of different feasibility criteria on a software investigation.
LO3 Undertake a software development lifecycle		
P5 Undertake a software investigation to meet a business need. **P6** Use appropriate software analysis tools/techniques to carry out a software investigation and create supporting documentation.	**M3** Analyse how software requirements can be traced throughout the software lifecycle. **M4** Discuss two approaches to improving software quality.	**M3** Evaluate the process of undertaking a systems investigation with regards to its effectiveness in improving a software quality.
LO4 Discuss the suitability of software behavioural design techniques		
P7 Discuss using examples the suitability of software behavioural design techniques.	**M5** Analyse a range of software behavioural tools and techniques. **M6** Differentiate between a finite state machine (FSM) and an extended-FSM, providing an application for both.	**D4** Present justifications of how data driven software can improve the reliability and effectiveness of software.

Recommended Resources

Textbooks

Ferguson, J. (2014) *BDD in Action: Behavior-driven development for the whole software lifecycle*. Manning.

Dennis, A. and Haley, W. (2009) *Systems Analysis and Design*. John Wiley & Sons Ltd.

Lejk, M. and Deeks, D. (2002) *An Introduction to System Analysis Techniques*. 2nd Ed. Addison-Wesley.

Murch, R. (2012) *The Software Development Lifecycle: A Complete Guide*. Kindle.

Websites

www.freetutes.com	FreeTutes "Systems Analysis and Design – Complete Introductory Tutorial for Software Engineering" (Tutorial)
www.ijcsi.org	IJCSI International Journal of Computer Science Vol. 7, Issue 5, September 2010 "A Comparison Between Five Models Of Software Engineering" (Research)
www.ijcsi.org	IJCSI International Journal of Computer Science Vol. 6, Issue 1, 2015 "Software Development Life Cycle Models – Comparison, Consequences" (Research)

Links

This unit links to the following related units:

Unit 6: Managing a Successful Computing Project

Unit 13: Computing Research Project

Unit 28: Prototyping

Unit 30: Application Development

Unit 32: Game Design Theory

Unit 34: Systems Analysis & Design

Unit 47: Games Development

Unit 10:　　　　　　Website Design & Development

Unit code	**R/615/1633**
Unit level	**4**
Credit value	**15**

Introduction

Wireless, public hotspots, mobile broadband and unlimited network connections means that accessing and using the internet to request, use and post information has never been so easy, or so important. As public, organisational and business demand increases, so does user expectation. Designers need to successfully use technology to deliver a high quality and consistent User Experiences (UX) through friendly and functional User Interfaces (UI). However, as the software and hardware evolves, so does the challenge of design.

This unit introduces students to the underpinning services required to host, manage and access a secure website before introducing and exploring the methods used by designers and developers to blend back-end technologies (server-side) with front-end technologies (client-side). To help ensure new designers are able to design and deliver a site that offers an outstanding User Experience (UX) supported by an innovative User Interface (UI) this unit also discusses the reasons, requirements, relationships, capabilities and features of the systems they will be using and gives them an opportunity to explore various tools, techniques and technologies with 'good design' principles to plan, design and review a multipage website.

Among the topics included in this unit are: domain structure, domain name systems, web protocols, database servers, development frameworks, website publishing, content management, search engine optimisation, web browsers, HTML standards, CSS and CSS pre-processing (LESS, SASS), presentation models, responsive design, integrated development environments, user requirements, interface design, user experience, branding, navigation, optimisation and validation.

On successful completion of this unit students will be able to explain 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 good design principles to create a multipage website and create and use a Test Plan to review the performance and design of a multipage website.

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:

LO1　Explain server technologies and management services associated with hosting and managing websites.

LO2　Categorise website technologies, tools and software used to develop websites.

LO3　Utilise website technologies, tools and techniques with good design principles to create a multipage website.

LO4　Create and use a Test Plan to review the performance and design of a multipage website.

Essential Content

LO1 Explain server technologies and management services associated with hosting and managing websites

Hosting and website management:

Investigate relationships between domain names, DNS services and communication protocols used to access a website.

Overview of publishing and managing secure websites, including search engine indexing and ranking.

Different server technologies:

Differences between web server hardware, software and host operating systems.

Advantages of an integrated database system with regards to expanding website capability.

Common web development technologies and frameworks.

LO2 Categorise website technologies, tools and software used to develop websites

Website technologies:

Using front-end technologies, presentation layers and client-side programming to build a User Interface (UI) and effect User Experience (UX).

How back-end technologies, application layers and server-side programming can be used to enable personalisation and deliver dynamic content.

Tools, techniques and software used to develop websites:

Improving User Experience (UX) through Rich Internet Application (RIA) design using JavaScript and CSS frameworks and packages.

Overview of online content management systems including possible advantages and limitations with regards to design.

Using web design and development software to design and build a secure website.

LO3 Utilise website technologies, tools and techniques with good design principles to create a multipage website

Establish the client and user requirements:

Differentiate client and user requirements from behaviours.

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.

Research and create good content combined with good design principles to create a multipage website:

Introduce and use recognised design principles, incorporating accessibility guidelines to implement an appropriately branded, multipage site.

Discuss why and how the quality of content can affect the performance of a website.

LO4 Create and use a Test Plan to review the performance and design of a multipage website

Consider factors that influence website performance:

Review how intuitive interfaces and actions, user-friendly designs, appropriate graphics, effective navigation and good quality content can help establish user trust and deliver an improved User Experience (UX).

Consider the effects of good and bad search engine optimisation (SEO) and indexing on the performance of a website.

W3C Validation (HTML and CSS) and how it influences website design and performance.

Establish a Test Plan and use it to assess the performance of a website:

Assess the impact of poorly optimised website graphics.

Research and conduct Quality Assurance (QA) and usability testing on a multipage website.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain server technologies and management services associated with hosting and managing websites		
P1 Identify the purpose and types of DNS, including explanations on how domain names are organised and managed. **P2** Explain the purpose and relationships between communication protocols, server hardware, operating systems and web server software with regards to designing, publishing and accessing a website.	**M1** Evaluate the impact of common web development technologies and frameworks with regards to website design, functionality and management. **M2** Review the influence of search engines on website performance and provide evidence-based support for improving a site's index value and rank through search engine optimisation.	**LO1 & LO2** **D1** Justify the technologies, management services, tools and software chosen to realise a custom built website.
LO2 Categorise website technologies, tools and software used to develop websites		
P3 Discuss the capabilities and relationships between front-end and back-end website technologies and explain how these relate to presentation and application layers. **P4** Discuss the differences between online website creation tools and custom built sites with regards to design flexibility, performance, functionality, User Experience (UX) and User Interface (UI).	**M3** Evaluate a range of tools and techniques available to design and develop a custom built website.	

Pass	Merit	Distinction
LO3 Utilise website technologies, tools and techniques with good design principles to create a multipage website		
P5 Create a design document for a branded, multipage website supported with medium fidelity wireframes and a full set of client and user requirements. **P6** Use your design document with appropriate principles, standards and guidelines to produce a branded, multipage website supported with realistic content.	**M4** Compare and contrast the multipage website created to the design document.	**D2** Critically evaluate the design and development process against your design document and analyse any technical challenges.
LO4 Create and use a Test Plan to review the performance and design of a multipage website		
P7 Create a suitable Test Plan identifying key performance areas and use it to review the functionality and performance of your website.	**M5** Evaluate the Quality Assurance (QA) process and review how it was implemented during your design and development stages.	**D3** Critically evaluate the results of your Test Plan and include a review of the overall success of your multipage website; use this evaluation to explain any areas of success and provide justified recommendations for areas that require improvement.

Recommended Resources

Textbooks

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

Krug, S. (2013) *Don't Make Me Think: 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.

Links

This unit links to the following related units:

Unit 40: User Experience & Interface Design

Unit 11: 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:

LO1   Use applied number theory in practical computing scenarios.

LO2   Analyse events using probability theory and probability distributions.

L03   Determine solutions of graphical examples using geometry and vector methods.

LO4   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 18: Discrete Maths

Unit 22: Applied Analytical Models

Unit 12:   Data Analytics

Unit code   **K/615/1637**

Unit level   **4**

Credit value   **15**

Introduction

Like the physical universe, the digital universe is enormous and is doubling in size every two years. By 2020 the digital universe – the data we create and copy annually – is projected to reach 44 zettabytes or 44 trillion gigabytes.

Data is everywhere in the world. Without knowing how to interpret this data it would be difficult to understand its meaning or make use of the data to increase the productivity of an organisation. Data analytics is a range of processes that converts data into actionable insight using a range of statistical techniques. Data analytics is a relatively new term – it is an overarching term for all decision support and problem-solving techniques. Most of the time the term 'data analytics' and 'business analytics' are used interchangeably.

This unit will introduce the theoretical foundation of data analytics and a range of data analytic processes and techniques to provide hands-on experience for enhancing students' skills.

Topics included in this unit are: data analytic terminologies, types of data analytics, data exploration and visualisation, understanding data with descriptive, predictive and prescriptive analytics.

On successful completion of this unit students will be able to understand the theoretical foundation of data analytics, data analytic processes and techniques. Moreover they will gain hands-on experience of implementing data analytic processes and techniques using a programming language such as Python, R, or a tool such as Weka, KNIME, PowerBI, Excel 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:

LO1   Discuss the theoretical foundation of data analytics that determine decision-making processes in management or business environments.

LO2   Apply a range of descriptive analytic techniques to convert data into actionable insight using a range of statistical techniques.

LO3   Investigate a range of predictive analytic techniques to discover new knowledge for forecasting future events.

LO4   Demonstrate prescriptive analytic methods for finding the best course of action for a situation.

Essential Content

LO1 **Discuss the theoretical foundation of data analytics that determine decision-making processes in management or business environments**

Data analytics terminologies:

Population, sample, categorical data, nominal data, ordinal data, continuous data, discrete data etc.

Types of data analytics:

Descriptive data analytics, predictive data analytics and prescriptive data analytics.

Exploratory data analysis (EDA):

Variable identification, univariate and bi-variate analysis, missing values treatment, etc.

Data visualisation:

Graphs, charts, plots.

LO2 **Apply a range of descriptive analytic techniques to convert data into actionable insight using a range of statistical techniques**

Descriptive statistics:

Measures of central tendency, measure of position and measures of dispersion.

Probability distribution:

Cumulate distribution, discrete distribution, continuous distribution.

Sampling and estimation:

Random sampling, systematic sampling, point estimate, interval estimate and so forth.

Statistical inferences:

Models and assumptions.

LO3 Investigate a range of predictive analytic techniques to discover new knowledge for forecasting future events

Regression analytics:

Linear regression, multiple linear regression and logistic regression.

Forecasting techniques:

Qualitative, average approach, naïve approach, time series methods, causal relationship and so forth.

LO4 Demonstrate prescriptive analytic methods for finding the best course of action for a situation

Optimisation:

Classical optimisation, linear programming techniques, nonlinear programming techniques, dynamic programming.

Decision analysis:

Models, justifiable decisions and defensible decisions.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the theoretical foundation of data analytics that determine decision-making processes in management or business environments		
P1 Identify data analytic activities, techniques, and tools. **P2** Demonstrate an ability to use a popular programming language or tool used in the data analytics industry.	**M1** Investigate the three types of data analytic methods and their use in industry.	**LO1 & LO2** **D1** Evaluate the importance of data analytical techniques to the decision-making process..
LO2 Apply a range of descriptive analytic techniques to convert data into actionable insight using a range of statistical techniques		
P3 Investigate descriptive analytic techniques and explain with appropriate examples. **P4** Apply an appropriate tool or programming language to demonstrate these descriptive analytics techniques.	**M2** Show how these descriptive analytic techniques contribute to decision-making.	

Pass	Merit	Distinction
LO3 Investigate a range of predictive analytic techniques to discover new knowledge for forecasting future events		
P5 Identify predictive analytic techniques and describe these techniques with examples. **P6** Apply an appropriate tool or programming language to demonstrate these predictive analytic techniques.	**M3** Compare a range of predictive analytical techniques for forecasting purposes.	**D2** Evaluate how predictive analytic techniques can be used for forecasting purposes.
LO4 Demonstrate prescriptive analytic methods for finding the best course of action for a situation		
P7 Analyse prescriptive analytic techniques with appropriate examples. **P8** Demonstrate these techniques using an appropriate programming language or tool.	**M4** Describe how these prescriptive analytic techniques are used to find the best course of action in a situation.	**D3** Apply an appropriate programming language or tool to demonstrate how these prescriptive analytic techniques are used to find the best course of action in a situation.

Recommended Resources

Textbooks

Evans, J. (2016) *Business Analytics.* 2nd Ed. Pearson.

Runkler, T. (2016) *Data Analytics: Models and Algorithms for Intelligent Data Analysis*. 2nd Ed. Vieweg+Teubner Verlag.

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)
powerbi.microsoft.com	Microsoft Power BI "Power BI Desktop" (Development Tool)

Links

This unit links to the following related units:

Unit 14: Business Intelligence

Unit 21: Data Mining

Unit 13: Computing Research Project

Unit code	**T/615/1639**
Unit type	**Core**
Unit level	**5**
Credit value	**30**

Introduction

This unit is assessed by a Pearson-set assignment. Students will choose their own project based on a theme provided by Pearson (this will change annually). The project must be related to their specialist pathway of study (unless the student is studying the general computing pathway). This will enable students to explore and examine a relevant and current topical aspect of computing in the context of a business environment and 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. The unit also encourages students 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:

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

LO2   Conduct and analyse research relevant to a computing research project.

LO3   Communicate the outcomes of a research project to identified stakeholders.

LO4   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's 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.

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		**LO1 & LO2** **D1** Critically evaluate research methodologies and processes in application to a computing research project to justify chosen research methods and analysis.
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.	
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.	

Pass	Merit	Distinction
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.
LO4 Reflect on the application of research methodologies and concepts		
P6 Reflect on the effectiveness of research methods applied for meeting objectives of the computing research project. **P7** Consider alternative research methodologies and lessons learnt in view of the outcomes.	**M4** Analyse results in recommended actions for improvements and future research considerations.	**D3** Demonstrate reflection and engagement in the resource process leading to recommended actions for future improvement.

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

Qualitative Research Journal

Links

This unit links to the following related units:

Unit 3: Professional Practice

Unit 6: Managing a Successful Computing Project

Unit 9: Software Development Lifecycles

Unit 14:   Business Intelligence

Unit code	**M/615/1641**
Unit type	**Core**
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:

LO1   Discuss business processes and the mechanisms used to support business decision-making.

LO2   Compare the tools and technologies associated with business intelligence functionality.

LO3   Demonstrate the use of business intelligence tools and technologies.

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.

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.

Pass	Merit	Distinction
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.
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 6: Managing a Successful Computing Project

Unit 12: Data Analytics

Unit 22: Applied Analytical Models

Unit 33: Analytical Methods

Unit 15: Transport Network Design

Unit code	**T/615/1642**
Unit level	**5**
Credit value	**15**

Introduction

The exponential growth of the World Wide Web has put unprecedented demands on private and public networking infrastructures. The traffic generated by private and commercial networks has become dominated by Voice-over-IP and video on demand. These developments require existing infrastructures to be adapted and that the design of new networks mitigate best-effort delivery issues, avoid low bandwidths and high latency problems and be based on traffic priority. In order for enterprise networks and internet infrastructures to meet expected demands, their design will have to take into consideration principles such as availability, scalability, resiliency, reliability and quality of service (QoS). As a result, network engineers designing and supporting enterprise or Internet Service Provider networks will need the knowledge and skills to support diverse business needs, such as converged network traffics, centralised control and mission-critical applications.

This unit introduces students to the enterprise network design principles, design models, scalable networks and their effectiveness in supporting business requirements. After evaluating the features of scalable networks, such as availability, reliability and hierarchy, the students are expected to apply network design principles in the design and implementation of redundant networks to provide Layer 2 and Layer 3 redundant solutions. The students are also expected to evaluate Wide Area Network (WAN) technologies and make choices based on specific enterprise requirements, and to implement a range of WAN connections and protocols such as Point-to-Point, Frame Relay and VPN with IPSec using network simulators or network lab equipment. In addition, they will also solve network-related issues using network monitoring and troubleshooting methods and techniques.

Among the topics included in this unit are: network design principles, network design modules, features of enterprise IT networks, such as scalability, reliability, availability and hierarchy, LAN redundancy and related issues, spanning tree protocols, router redundancy protocols, link aggregation, in-band and out-of-band network device management, features and characteristics of WAN networks, WAN technologies and protocols, such as PPP, Frame Relay and VPN with IPSec, network monitoring tools, Network Security, network documentation, network troubleshooting methods and LAN and WAN connectivity issues.

On successful completion of this unit students will be able to evaluate LAN design principles and their application in the network design process, implement a network using LAN design principles based on a predefined set of requirements, produce an appropriate WAN solution to a set of organisational requirements and solve a range of network-related problems using appropriate troubleshooting techniques and methods.

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:

LO1   Explore LAN design principles and their application in the network design process.

LO2   Implement a network using LAN design principles based on a predefined set of requirements.

LO3   Produce an appropriate WAN solution to a set of organisational requirements.

LO4   Solve a range of network related problems using appropriate troubleshooting techniques and methods.

Essential Content

LO1 Explore LAN design principles and their application in the network design process

Discuss and evaluate LAN design principles based on business needs:

Analysing diverse business needs: support critical applications, support converged network traffic, centralised administrative control.

Network features: bandwidth, delay, load.

Evaluate LAN design models:

Review of OSI and TCP/IP models, three-layer design model, enterprise architecture design model, features of scalable networks (redundancy, hierarchy, scalability, availability, reliability and small failure domains).

Analyse LAN redundancy:

Issues related to redundancy, spanning tree concepts, Spanning Tree Protocols.

Solving bandwidth and load related issues:

Examine link aggregation concepts and operations, configure link aggregation using EtherChannel technology.

Evaluate the need for redundancy at router level:

Default Gateway related issues, router redundancy protocols.

LO2 Implement a network using LAN design principles based on a predefined set of requirements

Application of LAN design principles in network design and configuration:

Selecting network devices to implement a LAN design: use modularity, stackability, port density, multi-layer switching and router requirements in the selection process.

Configuring LAN devices:

Compare out-of-band and in-band management, evaluate user interfaces, examine operating system management and licencing issues, basic device configuration.

Implementing Layer 2 LAN redundancy:

Configuration of different Spanning Tree Protocols (STP and Rapid STP).

Implementing Layer 3 LAN redundancy for IPv4:

Configuring First Hop Redundancy Protocols (Hot Standby Routing Protocol, Virtual Router Redundancy Protocol and Gateway Load Balancing Protocol).

Implementing Layer 3 LAN redundancy for IPv6:

Configuring the 'new generation' of redundancy routing protocols.

LO3 **Produce an appropriate WAN solution to a set of organisational requirements**

WAN networks and protocols:

Analyse features and requirements of enterprise networks: analyse WAN enterprise architecture, uptime, bandwidth, ISPs, traffic flows, prioritisation, queuing, latency, QoS, teleworking.

WAN Technologies:

Examine WAN operations and services, analyse and compare private and public WAN technologies, select the appropriate WAN protocol and service for a specific network requirement.

WAN serial connections:

Configuring Point-to-Point connections using Point-to-Point Protocol (PPP): explain point-to-point serial WAN serial communication, analyse and configure HDLC, analyse and configure PPP.

Configuring Frame Relay:

Analyse and compare Frame Relay and leased lines benefits and drawbacks, explain Frame Relay protocol Permanent Virtual Circuits (PVC), Link Management Interface (LMI) extensions, Data Link Connection Identifier (DLCI) mappings, configure static Frame Relay, implement advanced Frame Relay configurations.

VPN over a public infrastructure connection:

Explaining Virtual Private Network (VPN) features and benefits, compare VPN types, configure site-to-site secure tunnel connections, configure VPN with IP Security (IPSec) and compare IPSec and SSL VPNs (Secure Socket Layer).

LO4 Solve a range of network related problems using appropriate troubleshooting techniques and methods

Network Security considerations:

Network Security issues, their impacts and solutions.

Network monitoring and troubleshooting methods:

Network monitoring tools: analyse, compare and configure Syslog, Network Time Protocol (NTP), NetFlow and Simple Network Management Protocol (SNMP).

Network troubleshooting: establishing network baselines, troubleshooting methods with a systematic approach, gathering information, questioning end users, preparing network documentation, comparing network troubleshooting tools.

Troubleshooting LAN and WAN connectivity issues:

Physical and Data Link layers networking issues and troubleshooting: examine cable faults, device failures, bottlenecks, congestions, attenuation, noise, power issues (redundant power supplies), encapsulation mismatches, STP related issues, etc.

Network layer issues and troubleshooting:

Evaluate divide and conquer method, importance of ipconfig, ping and traceroute commands, subnetting issues, troubleshooting routing protocols, PPP, Frame Relay and VPN configuration issues.

Transport and Application layers networking issues and troubleshooting:

Examine the use of port numbers in Access Control Lists, denying and allowing errors, ACL misconfigurations, NAT, DNS and DHCP related issues.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore LAN design principles and their application in the network design process		
P1 Examine the network design models and features of scalable networks based on a given set of business needs. **P2** Discuss LAN redundancy, bandwidth and load related issues and possible solutions with reference to Layer 2 and Layer 3 of the OSI Model.	**M1** Analyse the switch and router redundancy protocols and their effectiveness in supporting scalable networks.	**LO1 & LO2** **D1** Evaluate different implementations of link aggregation using EtherChannel to solve bandwidth and load issues.
LO2 Implement a network using LAN design principles based on a predefined set of requirements		
P3 Select LAN devices based on features and requirements, and apply basic configuration commands for network connectivity. **P4** Implement a LAN design with Layer 2 and Layer 3 redundancy using switch and router redundancy protocols.	**M2** Analyse different switch redundancy protocols and their effectiveness in solving redundancy issues. **M3** Analyse Layer 3 redundancy implementations for IPv4 and IPv6.	

Pass	Merit	Distinction
LO3 Produce an appropriate WAN solution to a set of organisational requirements		
P5 Examine WAN technologies and select the appropriate one for a set of enterprise requirements. **P6** Configure WAN protocols as part of an enterprise network solution.	**M4** Analyse the benefits and drawbacks of private and public WAN technologies. **M5** Evaluate features and benefits of different VPN types based on organisational needs.	**LO3 & 4** **D2** Evaluate troubleshooting methods and their effectiveness in solving enterprise-wide networking issues.
LO4 Solve a range of network related problems using appropriate troubleshooting techniques and methods		
P7 Deploy network monitoring tools and troubleshooting methods to establish network baselines and produce network documentation. **P8** Troubleshoot LAN and WAN connectivity issues at different networking layers.	**M6** Develop effective documentation of troubleshooting methods and steps based on a given scenario.	

Recommended Resources

Textbooks

Meyers, M. (2015) *CompTIA Network+ Guide to Managing and Troubleshooting Networks, Fourth Edition*. London, UK: McGraw Hill Professional.

Subramanian, M. (2012) *Network Management: Principles and Practices*.
USA: Prentice Hall.

Thomatis, M. (2015) *Network Design Cookbook: Architecting Cisco Networks*.
USA: Lulu Press, Inc.

White, R. and Donohue, D. (2014) *The Art of Network Architecture: Business-Driven Design.* USA: Cisco Press.

Links

This unit links to the following related units:

Unit 2: Networking

Unit 8: Computer Systems Architecture

Unit 17: Network Security

Unit 35: Network Management

Unit 36: Client/Server Computing Systems

Unit 16:　　　　　Cloud Computing

Unit code	**F/615/1644**
Unit level	**5**
Credit value	**15**

Introduction

Cloud Computing has revolutionised the way IT services are delivered and has become an important part of the computing sector. Cloud Computing is internet-hosted computing, which means it uses the internet to deliver data and other IT services such as storage, printing, server facilities and so forth. In other words, the end users or organisations no longer need to have their own extensive network environment on the premises, but can get the same services provided virtually over the internet.

The fundamental difference between traditional networking and Cloud Computing is that the technical details of the system are hidden from the end user. That means the networking infrastructure does not have to be on the premises as it would be hosted off-site in the cloud. However, the end user can use the services without the fear of technical difficulties or disasters as it would be managed by the cloud service provider. Cloud Computing is a natural evolution of networking and is adapting the modern network-oriented technologies such as virtualisation, service-oriented architecture, utility computing and ubiquitous computing among others.

This unit is designed to develop an understanding of the fundamental concept of Cloud Computing, cloud segments, and cloud deployment models, the need for Cloud Computing, an appreciation of issues associated with managing cloud service architecture and to develop a critical awareness of Cloud Computing based projects.

Topics included in the unit are the paradigms of networking, fundamentals of Cloud Computing, Cloud Computing architecture, deployment models, service models, security, technological drivers, and cloud service providers.

On successful completion of this unit, students will understand the concept, architecture, and services of Cloud Computing and will gain hands-on experience of configuring a cloud service from major providers such as ECM, Google, Amazon, Microsoft, IBM etc., and implementing a simple cloud platform using open source software with an appropriate networking platform.

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:

LO1. Demonstrate an understanding of the fundamentals of Cloud Computing and its architectures.

LO2. Evaluate the deployment models, service models and technological drivers of Cloud Computing and validate their use.

LO3. Develop Cloud Computing solutions using service provider's frameworks and open source tools.

LO4. Analyse the technical challenges for cloud applications and assess their risks.

Essential Content

LO1 Demonstrate an understanding of the fundamentals of Cloud Computing and its architectures

Networking Paradigm: Peer-to-peer Computing, Client-Server Computing, Distributed Computing, Cluster Computing, High-Performance Computing, Parallel Computing, Grid Computing

Cloud Computing Fundamentals: What is cloud computing? Definition of Cloud Computing, Principles of Cloud Computing, Cloud Ecosystem, Cloud Architecture, Network Connectivity in Cloud Computing, Managing the Cloud, Migrating Application to Cloud

LO2 Evaluate the deployment models, service models and technological drivers of Cloud Computing and validate their use

Deployment models:

Private Cloud, Public Cloud, Community Cloud, Hybrid Cloud.

Service models:

IaaS, PaaS, SaaS, AaaS.

Infrastructure as a service (IaaS) is a form of cloud computing that provides virtualized computing resources over the internet. IaaS is one of the three main categories of cloud computing services, alongside software as a service (SaaS) and platform as a service (PaaS)

Software as a service (SaaS) is a cloud computing offering that provides users with access to a vendor's cloud-based software.

Analytics as a service (AaaS) refers to the provision of analytics software and operations through web-delivered technologies.

Technological drivers:

SOA, Virtualisation, Multicore Technology, Memory and Storage Technology, Networking Technology, Web 2.0, & 3.0, Software Process Models for Cloud, Programming Models, Pervasive Computing, Application Environment.

LO3 Develop Cloud Computing solutions using service provider's frameworks and open source tools

Cloud Service Providers:

EMC, Google, Amazon Web Services, Microsoft, IBM, VMware.

Open Source:

Open Source Tools for IaaS, Open Source Tools for PaaS, Open Source Tools for SaaS, Distributed Computing Tools: Cassandra, Hadoop, MongoDB, NGrid, Ganglia.

LO4 Analyse the technical challenges for cloud applications and assess their risks

Security aspects:

Data Security, Virtualisation, Network Security.

Platform related security:

SaaS Security issues, PaaS Security Issues, IaaS Security Issues, Audit and Compliance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Demonstrate an understanding of the fundamentals of Cloud Computing and its architectures		**LO1 & LO2** **D1** Justify the tools chosen to realise a Cloud Computing solution.
P1 Analyse the evolution and fundamental concepts of Cloud Computing. **P2** Design an appropriate architectural Cloud Computing framework for a given scenario.	**M1** Discuss why an organisation should migrate to a Cloud Computing solution.	
LO2 Evaluate the deployment models, service models and technological drivers of Cloud Computing and validate their use		
P3 Define an appropriate deployment model for a given scenario. **P4** Compare the service models for choosing an adequate model for a given scenario.	**M2** Demonstrate these deployment models with real world examples.	

Pass	Merit	Distinction
LO3 Develop Cloud Computing solutions using service provider's frameworks and open source tools		**D2** Critically discuss how one can overcome these issues and constraints.
P5 Configure a Cloud Computing platform with a cloud service provider's framework. **P6** Implement a cloud platform using open source tools.	**M3** Discuss the issues and constraints one can face during the development process.	
LO4 Analyse the technical challenges for cloud applications and assess their risks		**D3** Critically discuss how an organisation should protect their data when they migrate to a cloud solution.
P7 Analyse the most common problems which arise in a Cloud Computing platform and discuss appropriate solutions to these problems. **P8** Assess the most common security issues in cloud environments.	**M4** Discuss how to overcome these security issues when building a secure cloud platform.	

Recommended Resources

Textbooks

Chandrasekaran, K. (2015) *Essentials of Cloud Computing*, CRC Press.

Kapadia, A., Varma, S. and Rajana, K. (2014) *Implementing Cloud Storage with OpenStack*. Packt Publishing.

Patawari, A. (2013) *Getting Started with own Cloud*. Packt Publishing.

Rhoton, J. and De Clercq, J. (2014) *OpenStack Cloud Computing: Architecture*. Recursive Press.

Thomas Eri, T. and Ricardo Puttin, R. (2013) *Cloud Computing: Concept, Technology and Architecture*. Prentice Hall.

Zhu, S-Y. and Hill, R. (2016) *Guide to Security Assurance for Cloud Computing,* Springer.

Links

This unit links to the following related units:

Unit 48: Systems Integration

Unit 17: Network Security

Unit code	**L/615/1646**
Unit level	**5**
Credit value	**15**

Introduction

"Who is accessing my network?" A bank was hacked last week? Did you hear about that? Last night l blocked my neighbours from accessing their internet because they did not have a Wireless Equivalent Protection (WEP) or WPA (Wi-Fi Protected Access) key on their wireless."

It is estimated that Network Security (NS) breaches occur every second worldwide from small home networks to massive corporate networks. The cost to businesses is in billions, if not trillions. There are several methods, techniques and procedures that need to be implemented on a network in order for it to be 'secure'. Sometimes basic procedures such as locking your network room, changing your password regularly, as well as putting a password on all your network devices, is all that is needed to achieve some basic network security.

This unit introduces students to the fundamental principles of Network Security practices. As Systems Administration and Management are important tasks in the day-to-day functioning and security of Information Systems, poor or improper practices can lead to loss of data, its integrity, performance reductions, security breaches or total system failure. Special planning and provisions needs to be made for ongoing support of systems and networks, which account for a significant proportion of the IT budget. With the widespread use of computers and the internet for business customers and home consumers, the topic of security continues to be a source for considerable concern.

Among the topics included in this unit are: historical Network Security (NS) principles and associated aspects such as Firewalls, Routers, Switches, MD5, SSL, VPN, AES, SHA-1/2, RSA, DES, 3DES; different types of public and private key cryptography such as Caesar Cipher, IPSec; types of attacks that can be done on a network and methods of preventing such attacks such as Man-In-the-Middle (eavesdropping), Denial of Service (DoS), Distributed Denial of Service (DDoS) (ping); Certificate Authority (CA); 'The Cloud' Security aspects and associated counter-measures such Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud, Platform-as-a-Service (PaaS), Infrastructure-as-a-Service (IaaS), phishing, spoofing, DNS attack, SQL Injection, MAC Address spoofing/control. Firewalls and other Gateways can be used as a tool for Intrusion Detection and Prevention as they can be situated on the perimeter of the Network to provide security.

On successful completion of this unit students will be able to discuss with confidence several types of Network Security measures as well as associated protocols, cryptographic types and configuration settings of Network Security environments. Finally, students will be able to test the security of a given network to identify and fix vulnerabilities.

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:

LO1. Examine Network Security principles, protocols and standards.

LO2. Design a secure network for a corporate environment.

LO3. Configure Network Security measures for the corporate environment.

LO4 Undertake the testing of a network using a Test Plan.

Essential Content

LO1 Examine Network Security principles, protocols and standards

The history of Network Security.

Discuss CERT's formation and their role, examine firewall development and the increase in cyber threats and attacks. More advanced security required to keep up with modern day threats and breaches.

Network Security devices:

The historical Network Security (NS) principles and associated aspects such as Firewalls, Routers, Switches.

Network Security protocols:

MD5, SSL, VPN, AES, SHA-1/2, RSA, DES, 3DES, IPSec, DNS, DHCP, HTTP, HTTPs, FTP, FTPs, POP3, SMTP, IMAP.

Network Security cryptographic types:

Different types of public and private key cryptography such as Caesar Cipher, Vigenere, Hash.

LO2 Design a secure network for a corporate environment

Build a network

Planning a network:

Considerations must be thought through on what the network will be used for (purpose) according to the scenario.

Hardware and software considerations:

What hardware and software will be used on the network?

LO3 Configure Network Security measures for the corporate environment

Configure Network Security:

Configure Network Security measures such as Firewalls, Routers, Switches, Gateways, SSL, IPSec, HTTPs, FTPs, passwords and backup devices.

LO4 **Undertake the testing of a network using a Test Plan**

Testing methods:

Different testing methods should be understood in terms of checks on network connection speed, ethernet cards, testing for network vulnerabilities etc.

Create a Test Plan, test the Network Security and make some recommendations.

Create a Test Plan:

Testing data, expected results, actual results.

Comprehensively Test all devices and the whole environment:

Tests should be carried out on all devices (Firewall, Servers, Domain Controllers, Email Servers, Routers, Switches, gateways, passwords).

Make recommendations:

Make recommendations for improving the Network Security for your environment (scenario).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine Network Security principles, protocols and standards		**LO1 & LO2** **D1** Review the importance of network security to an organisation.
P1 Discuss the different types of Network Security devices. **P2** Examine Network Security protocols.	**M1** Compare and contrast at least two major Network Security protocols.	
LO2 Design a secure network for a corporate environment		
P3 Investigate the purpose and requirements of a secure network according to a given scenario. **P4** Determine which network hardware and software to use in this network.	**M2** Create a design of a secure network according to a given scenario.	
LO3 Configure Network Security measures for the corporate environment		**D2** Review what is meant by Quality of Service (QoS) in relation to Network Security configuration.
P5 Configure Network Security for your network. **P6** Discuss different cryptographic types of Network Security.	**M3** Provide Network Security configuration scripts/files/screenshots with comments.	
LO4 Undertake the testing of a network using a Test Plan		**D3** Critically evaluate the design, planning, configuration and testing of your network.
P7 Create a Test Plan for your network. **P8** Comprehensively test your network using the devised Test Plan.	**M4** Provide scripts/files/ screenshots of the testing of your network. **M5** Make some improvement recommendations.	

Recommended Resources

Textbooks

Burgess, M. (2003) *Principles of Systems and Network Administration*. Chichester: John Wiley.

Burns, B., Granick, J.S, Manzuik, S., Guersch P., Killion, D., Beauchesne, N., Moret, E., Dhanjani, N., Rios, B. and Hardin, B. (2009) *Hacking: The Next Generation.* O'Reilly.

Cheswick, W. and Bellovin, S. (1994) *Firewalls and Internet Security: Repelling the Wily Hacker*. Wokingham: Addison-Wesley.

Cole, E., Krutz, R.L., Conley, J.W., Reisman, B., Ruebush, M., Gollman, D. and Reese, R. (2008) *Network Security Fundamentals*. John Wiley & Sons, Inc.

Cole, E., Krutz, R.L., Conley, J.W., Reisman, B., Ruebush, M., Gollman, D. and Reese, R. (2008) *Network Security Fundamentals: Project Manual*. John Wiley & Sons, Inc.

Forouzan, B.A. (2008) *Cryptography and Network Security*. New York: McGraw-Hill.

Forouzan, B.A. (2008) *Introduction to Network Security and Cryptography*. London: McGraw-Hill.

Gollmann, D. (2006) *Computer Security*. Chichester: John Wiley.

Harris, S., Harper, A., Eagle, C., Ness, J. and Lester, M. (2004) *Gray Hat Hacking: The Ethical Hacker's Handbook*. McGraw-Hill.

Lammle, T. and Graves, K. (2007) CEH: *Official Certified Ethical Hacker Review Guide*. Sybex.

Lockhart, A. (2007) *Network Security Hacks: Tips & Tools for Protecting your Privacy*, 2nd Ed. O'Reilly.

Manzuik, S., Gold, A. and Gatford, C. (2007) *Network security Assessment: from vulnerability to patch*. Rockland, Ma: Syngress Publishing.

Mather, T., Kumaraswamy, S. and Latif, S. (2009) *Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance*. O'Reilly.

Oppliger, R. (1998) *Internet and Intranet Security*. London: McGraw-Hill.

Scambray, J. and McClure, S. (2008) *Hacking Exposed Windows: Windows Security, Secrets and Solutions*. London: McGraw-Hill.

Schneier, B. (2000) *Secrets and Lies: Digital Secrets in a Networked World*. Chichester: John Wiley.

Sobrier, J., Lynn, M., Markham, E., Iezzoni, C. and Biondi, P. (2007) *Security Power Tools*, O'Reilly.

Stallings, W. (2005) *Cryptography and Network Security*. Rockland, Ma: Syngress Publishing.

Journals

British Computer Society

ISC²

The Register

Links

This unit links to the following related units:

Unit 2: Networking

Unit 5: Security

Unit 8: Computer Systems Architecture

Unit 15: Transport Network Design

Unit 35: Network Management

Unit 36: Client/Server Computing Systems

Unit 18: Discrete Maths

Unit code	**Y/615/1648**
Unit level	**5**
Credit value	**15**

Introduction

Digital computer technologies operate with distinct steps, and data is stored within as separate bits. This method of finite operation is known as 'discrete', and the division of mathematics that describes computer science concepts such as software development, programming languages, and cryptography is known as 'discrete mathematics'. This branch of mathematics is a major part of computer science courses and ultimately aids in the development of logical thinking and reasoning that lies at the core of all digital technology.

This unit introduces students to the discrete mathematical principles and theory that underpin software engineering. Through a series of case studies, scenarios and tasked-based assessments students will explore set theory and functions within a variety of scenarios; perform analysis using graph theory; apply Boolean algebra to applicable scenarios; and finally explore additional concepts within abstract algebra.

Among the topics included in this unit are: set theory and functions, Eulerian and Hamiltonian graphs, binary problems, Boolean equations, Algebraic structures and group theory.

On successful completion of this unit students will be able to gain confidence with the relevant discrete mathematics needed to successfully understand software engineering concepts. 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:

LO1. Examine set theory and functions applicable to software engineering.

LO2. Analyse mathematical structures of objects using graph theory.

LO3   Investigate solutions to problem situations using the application of Boolean algebra.

LO4. Explore applicable concepts within abstract algebra.

Essential Content

LO1 Examine set theory and functions applicable to software engineering

Set theory:

Sets and set operations.

Algebra within set theory.

Set identities and proof of identities.

Bags manipulation functions.

Functions:

Domain, range and mappings.

Inverse relations and the inverse function.

Injective, surjective and transitive functions.

LO2 Analyse mathematical structures of objects using graph theory

Graph theory:

Structure and characterisation of graphs.

Spanning trees and rooted trees.

Eulerian and Hamiltonian graphs.

Vertex and edge colourings of graphs.

Directed graphs:

Directed and directed graphs.

Walks, trails, paths and shortest paths.

LO3 Investigate solutions to problem situations using the application of Boolean algebra

Boolean algebra:

Binary states (e.g. on/off; 1/0; open/closed; high/low).

Identification of binary problems and labelling inputs and outputs.

Produce a truth table corresponding to a problem situation.

Equations:

Express a truth table as a Boolean equation.

Simplify a Boolean equation using algebraic methods.

Represent a Boolean equation using logic gates.

LO4 **Explore applicable concepts within abstract algebra**

Algebraic structures:

Binary operations and associated properties.

Commutative and associative operations.

Algebraic structures and substructures.

Groups:

Introduction to groups, semigroups and monoids.

Families of groups and group codes.

Substructures and morphisms.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine set theory and functions applicable to software engineering		
P1 Perform algebraic set operations in a formulated mathematical problem. **P2** Determine the cardinality of a given bag (multiset).	**M1** Determine the inverse of a function using appropriate mathematical techniques.	**D1** Formulate corresponding proof principles to prove properties about defined sets.
LO2 Analyse mathematical structures of objects using graph theory		
P3 Model contextualised problems using trees, both quantitatively and qualitatively. **P4** Use Dijkstra's algorithm to find a shortest path spanning tree in a graph.	**M2** Assess whether an Eulerian and Hamiltonian circuit exists in an undirected graph.	**D2** Construct a proof of the Five Colour Theorem.

Pass	Merit	Distinction
LO3 Investigate solutions to problem situations using the application of Boolean algebra		**D3** Design a complex system using logic gates.
P5 Diagram a binary problem in the application of Boolean Algebra. **P6** Produce a truth table and its corresponding Boolean equation from an applicable scenario.	**M3** Simplify a Boolean equation using algebraic methods.	
LO4 Explore applicable concepts within abstract algebra		**D4** Explore with the aide of a prepared presentation the application of group theory relevant to your course of study.
P7 Describe the distinguishing characteristics of different binary operations that are performed on the same set. **P8** Determine the order of a group and the order of a subgroup in given examples.	**M4** Validate whether a given set with a binary operation is indeed a group.	

Recommended Resources

Textbooks

Attenborough, M. (2003) *Mathematics for Electrical Engineering and Computing*. Oxford: Newnes.

Piff, M. (2008) *Discrete Maths Software Engineers: An Introduction for Software Engineers*. Cambridge: Cambridge University Press.

Journals

Journal of Graph Theory. Wiley

Journal of Mathematical Modelling and Algorithms in Operations Research. Springer

Links

This unit links to the following related units:

Unit 11: Maths for Computing

Unit 22: Applied Analytical Models

Unit 19: 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:

LO1.   Examine abstract data types, concrete data structures and algorithms.

LO2.   Specify abstract data types and algorithms in a formal notation.

LO3.   Implement complex data structures and algorithms.

LO4.   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. **P2** Determine the operations of a memory stack and how it is used to implement function calls in a computer.	**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.

Pass	Merit	Distinction
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. **P5** Implement error handling and report test results.	**M4** Demonstrate how the implementation of an ADT/algorithm solves a well-defined problem.	**D3** Critically evaluate the complexity of an implemented ADT/algorithm.
LO4 Assess the effectiveness of data structures and algorithms		
P6 Discuss how asymptotic analysis can be used to assess the effectiveness of an algorithm. **P7** Determine two ways in which the efficiency of an algorithm can be measured, illustrating your answer with an example.	**M5** Interpret what a trade-off is when specifying an ADT using an example to support your answer.	**D4** Evaluate three benefits of using implementation independent data structures.

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.

Sedgewick, R. (1983) *Algorithms*. Addison-Wesley.

Wirth, N. (2004) *Algorithms and Data Structures*. Oberon.

Links

This unit links to the following related units:

Unit 1: Programming

Unit 20: Advanced Programming

Unit 23: Cryptography

Unit 20: Advanced Programming

Unit code	**Y/615/1651**
Unit level	**5**
Credit value	**15**

Introduction

Features of programming languages that are considered advanced are used to develop software that is efficient; it can affect the performance of an application as well as the readability and extensibility of the code, improving productivity and therefore reducing cost. Many commercial applications available today, whether for productivity or entertainment, will have used one or more design pattern in their development. A design pattern is a description of how to solve a problem that can be used in many different situations and can help deepen the understanding of object-orientated programming and help improve software design and reusability.

The aim of this unit is to familiarise students with these features 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; polymorphism, encapsulation, class aggregation/association, constructors/destructors, inheritance, abstract classes, interfaces, containers, generics, introduction to design patterns and Unified Modelling Language (UML).

On successful completion of this unit students will be able to write code in an object-orientated fashion using design patterns where necessary and be able to model their code structure in UML class diagrams. 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:

LO1. Examine the key components related to the object-orientated programming paradigm, analysing design pattern types.

LO2. Design a series of UML class diagrams.

LO3. Implement code applying design patterns.

LO4 Investigate scenarios with respect to design patterns.

Essential Content

LO1 Examine the key components related to the object-orientated programming paradigm, analysing design pattern types

Outline the object-orientated paradigm characteristics:

Encapsulation, polymorphism, constructors/destructors, sub objects, abstract/concrete, interface, method redefinition, generics/templates, containers.

Object-orientated class relationships:

Generalisation/inheritance, realisation, dependency, aggregation, composition.

Design patterns:

Creational, structural and behavioural.

LO2 Design a series of UML class diagrams

UML class design:

Analyse a code scenario and utilise a suitable UML tool to develop class diagrams.

LO3 Implement code applying design patterns

Implementation:

Using an appropriate language & IDE to develop code that implements design patterns and utilises techniques to produce secure code.

LO4 Investigate scenarios with respect to design patterns

Review the usage of design patterns:

Relating design patterns to a range of given scenarios

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the key components related to the object-orientated programming paradigm, analysing design pattern types		**D1** Analyse the relationship between the object-orientated paradigm and design patterns.
P1 Examine the characteristics of the object-orientated paradigm as well as the various class relationships.	**M1** Determine a design pattern from each of the creational, structural and behavioural pattern types.	
LO2 Design a series of UML class diagrams		**D2** Analyse how class diagrams can be derived from a given code scenario using a UML tool.
P2 Design and build class diagrams using a UML tool.	**M2** Define class diagrams for specific design patterns using a UML tool.	
LO3 Implement code applying design patterns		**D3** Evaluate the use of design patterns for the given purpose specified in M3.
P3 Build an application derived from UML class diagrams.	**M3** Develop code that implements a design pattern for a given purpose.	
LO4 Investigate scenarios with respect to design patterns		**D4** Critically evaluate a range of design patterns against the range of given scenarios with justification of your choices.
P4 Discuss a range of design patterns with relevant examples of creational, structural and behavioural pattern types.	**M4** Reconcile the most appropriate design pattern from a range with a series of given scenarios.	

Recommended Resources

Textbooks

Freeman, E. et al. (2008) *Head First Design Patterns*. 4th Ed. United Stated of America: O'Reilly Media.

Gamma, E. et al. (1995) *Design Patterns: Elements of Reusable Object-Oriented Software.* 1st Ed. New Jersey: Addison-Wesley.

Mclaughlin, B.D. et al. (2007). *Head First Object-Oriented Analysis and Design*. 1st Ed. United States of America: O'Reilly Media.

Links

This unit links to the following related units:

Unit 1: Programming

Unit 19: Data Structures & Algorithms

Unit 28: Prototyping

Unit 41: Analytic Architecture Design

Unit 21: Data Mining

Unit code	**H/615/1653**
Unit level	**5**
Credit value	**15**

Introduction

Data mining is the process of discovering new knowledge in the forms of patterns and relationships in large data sets. It helps find knowledge from a data set that was previously impossible to obtain with traditional methods. Modern data mining is well equipped to discover useful knowledge or patterns from unstructured data such as web traffic, emails and social media content. Data mining uses a range of machine learning algorithms and modern statistical techniques to discover knowledge from data sets.

This unit will introduce the theoretical foundation of data mining and a range of data mining processes and techniques. The unit will also provide hands-on experience in developing data mining applications using an appropriate programming language or data mining tool.

Topics included in this unit are: data mining terminologies, scope of data mining such as classification, regression and clustering methods and techniques, associate pattern mining, mining time series data, and mining text data.

On successful completion of this unit, students will appreciate the theoretical and technical concepts of data mining and its techniques and processes, gain hands-on experience in implementing data mining techniques using a programming language such as Python, R, or a tool such as Weka, KNIME, Excel 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.

It is assumed that students will have some knowledge of data analytics and machine learning, or will have completed Unit 12: Data Analytics and Unit 26: Machine Learning.

Learning Outcomes

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

LO1. Discuss the historical and theoretical foundation of data mining, its scope, techniques, and processes.

LO2. Investigate a range of data mining techniques to discover patterns and relationships in large data sets.

LO3. Illustrate how a data mining algorithm performs text mining to identify relationships within text.

LO4. Evaluate a range of graph data mining techniques that recognise patterns and relationships in graph-based technologies.

Essential Content

LO1 Discuss the historical and theoretical foundation of data mining, its scope, techniques, and processes

Data mining terminologies.

Historical background of data mining:

Traditional approach, modern approach.

Theoretical background of data mining.

Ethics of data mining:

Fundamentals of data mining, the major building blocks of data mining.

LO2 Investigate a range of data mining techniques to discover patterns and relationships in large data sets

Scope of data mining:

Classification, regression and clustering.

Data mining algorithms:

Classification algorithms, regression algorithms and clustering algorithms.

LO3 Illustrate how a data mining algorithm performs text mining to identify relationships within text

Introduction to text mining.

A brief overview to natural language processing.

Document preparation and similarities.

Clustering methods.

Topic Modelling.

Presentation methods of text (final outcome of the mining): charts, graphs, word cloud and so forth.

LO4 **Evaluate a range of graph data mining techniques that recognise patterns and relationships in graph-based technologies**

Unstructured data and graph-based technologies.

Networks and network analysis.

Graph algorithms: graph pattern mining, graph classification, graph clustering, and so forth.

Content mining, structure mining and usage mining.

Graph data mining tools.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the historical and theoretical foundation of data mining, its scope, techniques, and processes		
P1 Investigate the historical background of data mining. **P2** Analyse the theoretical background of data mining and identify data mining tools used in industry.	**M1** Evaluate traditional and modern approaches to data mining and show the building blocks of both approaches.	**D1** Review how an organisation benefits from data mining.
LO2 Investigate a range of data mining techniques to discover patterns and relationships in large data sets		
P3 Demonstrate various scopes of data mining. **P4** Investigate a range of data mining algorithms and their uses.	**M2** Investigate a tool or programming language that can support data mining. **M3** Apply an appropriate tool or programming language to demonstrate how data mining algorithms work.	**D2** Develop a complete data mining application for a real world issue.

Pass	Merit	Distinction
LO3 Illustrate how a data mining algorithm performs text mining to identify relationships within text		
P5 Discuss what is meant by text mining and explain with appropriate examples. **P6** Analyse how data mining algorithms, techniques, methods and approaches work.	**M4** Show how text mining works using a tool or programming language.	**D3** Develop a complete text mining application for a real world issue.
LO4 Evaluate a range of graph data mining techniques that recognise patterns and relationships in graph based technologies		
P7 Discuss what is meant by graph data mining and explain with appropriate examples. **P8** Assess how graph mining algorithms work and identify appropriate programming languages and tools used by industry for graph data mining.	**M5** Demonstrate how graph data mining works using a tool or programming language.	**D4** Develop a complete graph data mining application for a real world scenario.

Recommended Resources

Textbooks

Aggarwal, C. (2015) *Data Mining: The Textbook*. Springer.

Hofmann, M. and Chisholm, A. (2015) *Text Mining and Visualization: Case Studies Using Open-Source Tools*. Chapman and Hall/CRC.

Russell, M. (2013) *Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Google+, GitHub, and More*. 2nd Ed. O'Reilly Media.

Witten, I., Eibe, F. and Hall, M. (2011) *Data Mining: Practical Machine Learning Tools and Techniques*. 3rd Ed. Morgan Kaufmann.

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)
gephi.org	Open Graph Viz Platform "Gephi" (Development Tool)

Links

This unit links to the following related units:

Unit 12: Data Analytics

Unit 22: Applied Analytical Models

Unit 26: Machine Learning

Unit 22: Applied Analytical Models

Unit code	**K/615/1654**
Unit level	**5**
Credit value	**15**

Introduction

Applied analytical modelling has become prevalent in many industries and has developed in the mathematical techniques used and the diversity of modelling tools and techniques. Applied analytical modelling is carried out by a data scientist utilising modelling data, model building and model reporting skills. The aim of this unit is to provide students with knowledge and analytical modelling skills using computers to discover and interpret meaningful patterns in data by creating computer models.

This unit introduces students to applied analytical models used in business to discover, interpret and communicate meaningful patterns of data held in silos or data warehouses, and to derive knowledge to gain competitive advantage. Organisations may apply analytical methods and models to predict/prescribe business outcomes and improve performance in diverse areas such as stock control, financial risk and fraud analysis. Analytical models use mathematical algorithms and require extensive computation to process large amounts of data.

Among the topics included in this unit are: data preparation, fundamentals of applied analytical models and development of predictive or prescriptive models using a suitable algorithm, operating on a large data set.

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:

LO1.   Examine applied analytical modelling methods.

LO2.   Prepare a large data set for use in an applied analytical model.

LO3.   Demonstrate the use of an analytical model with a large data set.

LO4.   Investigate improvements to an applied analytical model.

Essential Content

LO1 Examine applied analytical modelling methods

Decision/descriptive analytics.

Prescriptive analytics:

Confirmatory data analysis (CDA).

Predictive analytics:

Forecasting or classification algorithms, machine learning, scoring, correlation, causation, regression analysis.

Algorithms:

Filtering, sorting clustering; Data visualisation.

Business Domains:

Behavioural analytics; cohort analytics; collections analytics; cyber analytics; enterprise optimisation; financial analytics; fraud analytics; marketing analytics; pricing analytics; retail analytics; risk analytics; supply chain analytics; talent analytics; telecoms analytic; transportation analytics.

LO2 Prepare a large data set for use in an applied analytical model

Identify and evaluate applied analytical model data requirements:

Data requirements; data collection, data processing; semi-structured/unstructured metadata processing, cleaning; aggregation; exploratory data analysis (EDA); data product; data visualisation; information displays; dashboards.

LO3 Demonstrate the use of an analytical model with a large data set

Define analytic model requirements:

Data set selection; carry out cleaning, aggregation and EDA; identification of algorithm, selection and configuration of data mining software; model implementation; communication of results; data visualisation; graphical reports/dashboards.

LO4 **Investigate improvements to an applied analytical model**

Data quality; data assumptions; sampling; segmentation; uplift data modelling; algorithm selection; pattern and relationship discovery; qualitative/quantitative use; validating results; output communication methods; tailoring data visualisation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine applied analytical modelling methods		**D1** Using a case study example, critically evaluate the derived benefits from the use of an applied analytic model.
P1 Discuss the prescriptive and predictive analytical models, using examples. **P2** Illustrate three analytical methods, describing how they function.	**M1** Compare prescriptive and predictive analytical models, stating their advantages and disadvantages.	
LO2 Prepare a large data set for use in an applied analytical model		**D2** Review the primary reasons for carrying out data transformation before input to an applied analytical model.
P3 Describe the process of analytical model data preparation, describing data cleaning, discretisation, aggregation and data reduction stages. **P4** Suggest two methods to visualise the output from an applied analytical model, using illustrations to describe your answer.	**M2** Analyse three potential issues in preparation of data for use in an applied analytical model.	

Pass	Merit	Distinction
LO3 Demonstrate the use of an analytical model with a large data set		
P5 Select a suitable algorithm to analyse a large data set to meet a business need. **P6** Use an appropriate analytical modelling tool to carry out an investigation (e.g. R, RapidMiner, Hadoop).	**M3** Propose how the data set will be prepared for the analytical model used in the investigation.	**D3** Review the results of the investigation, assessing the quality of the obtained knowledge.
LO4 Investigate improvements to an applied analytical model		
P7 Investigate improvements to an applied analytical model.	**M4** Propose three improvements to the approach used in the investigation. **M5** Discuss two ways to increase the performance and limits of the analytical model used in the investigation.	**D4** Present the results of your investigation promoting the benefits of using applied analytical models in a business.

Recommended Resources

Textbooks

Carlberg, C. (2012) *Predictive Analytics: Microsoft Excel*. QUE.

Marr, B. (2015) *Big Data: Using SMART Big Data, Analytics and Metrics To Make Better Decisions and Improve Performance*. Wiley.

Runkler, T. (2012) *Data Analytics: Models and Algorithms for Intelligent Data Analysis*. Springer Vieweg.

Websites

www.ericsson.com	Ericsson White paper "Big Data Analytics – Actionable Insights for the Communication Service Provider" (Research)
www.thearling.com	Kurt Thearling "Information about analytics and data science" (General Reference)
aisel.aisnet.org	Association of Information Systems "Big Data Analytics: Concepts, Technologies, and Applications" (Tutorial)
www.fujitsu.com	Fujitsu "The White Book of Big Data" (E-Book)

Links

This unit links to the following related units:

Unit 11: Maths for Computing

Unit 12: Data Analytics

Unit 14: Business Intelligence

Unit 18: Discrete Maths

Unit 23:　　　　　Cryptography

Unit code	**T/615/1656**
Unit level	**5**
Credit value	**15**

Introduction

Although confidentiality in the communication between two parties is very often linked with electronic data transfer, methods for ensuring confidentiality have been used for centuries. That is how cryptography started as a methodology, practice and discipline, ensuring confidential communication in the presence of third parties called 'adversaries'. However, encrypting the message for confidentiality purposes is only one aspect of cryptography. It also provides means of ensuring that the parties involved in communication are 'who they say they are'. Cryptography underpins many aspects of security, and is a crucial component in protecting the confidentiality and integrity of information. It is now a prevalent part of our day-to-day lives despite many people being unaware of its usage or importance. 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.

This unit introduces students to the theoretical principles of cryptography and looks at some practical applications, many of which we use on a daily basis. Students are expected to investigate the inner workings of cryptographic systems and how to correctly use them in real-world applications. Students are expected to explore the mathematical algorithms in relation to cryptography and their applications. Students are also expected to analyse the symmetric and asymmetric encryption methods and ciphers, public key cryptography and the security issues related to their implementation. In addition, students are expected to investigate advanced encryption protocols and their applications.

Among the topics included in this unit are: the mathematical algorithms used in cryptography, the mechanisms by which symmetric and asymmetric cryptography work, 3DES and AES block ciphers, the operations of public key cryptography, Public Key Infrastructure (PKI), primality testing and factoring, discreet logarithms, El Gamal encryption, security issues with cryptography, common attacks on cryptographic schemes, and some practical applications of cryptography.

On successful completion of this unit students will be able to examine the symmetric encryption algorithms and ciphers, assess public key encryption protocols and signatures and their uses in the message and key exchanges, analyse the security issues related to symmetric and asymmetric encryption methods and evaluate advanced encryption protocols and their applications in secure message exchanges.

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:

LO1.   Examine the symmetric encryption algorithms and ciphers.

LO2.   Assess public key encryption protocols and signatures and their uses in the message and key exchanges.

LO3.   Analyse the security issues related to symmetric and asymmetric encryption methods.

LO4   Evaluate advanced encryption protocols and their applications in secure message exchanges.

Essential Content

LO1 Examine the symmetric encryption algorithms and ciphers

Exploring mathematical algorithms:

Examining modular arithmetic, groups, finite fields and probability; random number generation, exploring elliptic curves and projective coordinates.

Examining symmetric encryption and ciphers:

Exploring historical ciphers, Cezar cipher, Enigma machine and information theoretic security (probability and ciphers, entropy and spurious keys); explaining one time pad.

Investigating stream ciphers, the historical Lorenz cipher, modern stream ciphers (linear feedback shift registers and their combinations, RC4).

Examining block ciphers, Feistel cipher and Data Encryption Standard (DES), operation of 3DES, Rijndael cipher and its mode of operation, explaining Advanced Encryption System (AES).

Analysing symmetric key distributions, hash functions and message authentication codes – key management, secret key distribution, designing hash functions, investigating message authentication codes.

LO2 Assess public key encryption protocols and signatures and their uses in the message and key exchanges

Analysing public key cryptography:

Examining public key encryption algorithms, one-way functions, Rivest Shamir Adleman (RSA) algorithm; explaining El Gamal encryption.

Explaining primality testing and factoring and discrete logarithms, prime numbers, factoring algorithms, modern factoring methods; examining Pohlig-Hellman logarithm, logarithmic methods for finite fields, methods for elliptic curves.

Examining key exchange and signature schemes, Diffie-Hellman key exchange, explore digital signatures, using hash functions in signature schemes, digital signature algorithm (DSA), and authenticated key agreement.

Analysing implementation issues and, exponentiation in RSA and DSA, finite field arithmetic.

Obtaining authentic public keys, confidentiality and integrity, digital certificates and Public Key Infrastructure (PKI), analysing examples of PKI.

LO3 Analyse the security issues related to symmetric and asymmetric encryption methods

Analysing attacks on public key schemes:

Exploring most common attacks on public key encryption schemes, Wiener's attack on RSA, Lattice-based attacks on RSA, partial key exposure attacks, Meet-in-the-Middle attack, brute force attack and fault analysis.

Analysing 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, signature schemes and encryption schemes.

Analysing hybrid encryption, security of symmetric ciphers, security of hybrid ciphers, explaining the construction of Key Encapsulation Mechanisms (KEMs)

LO4 Evaluate advanced encryption protocols and their applications in secure message exchanges

Assessing advanced encryption protocols and their applications:

Evaluating access structures for secret sharing schemes, general secret sharing, Reed-Solomon codes, Shamir sharing scheme.

Applying shared RSA signature generation; explaining commitment schemes and oblivious transfers.

Analysing Zero-Knowledge proofs, demonstrating a Graph Isomorphism in Zero-Knowledge, Sigma protocols, electronic voting systems.

Examining secure multi-party computation, the two-party case, multi-party cases: honest-but-curious adversaries, malicious adversaries.

Evaluating different applications of cryptography, quantum cryptography, digital cash, Bitcoin, Transport Layer Security and IPSec.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the symmetric encryption algorithms and ciphers		**LO1 & LO2** **D1** Evaluate the improvement introduced by AES compared to DES and 3DES encryption standards and public key and private key encryption.
P1 Examine mathematic algorithms and their use in cryptography. **P2** Explain, with the use of examples, the operation of stream cipher and block cipher.	**M1** Compare the operational differences between stream cipher and block cipher. **M2** Analyse issues with symmetric key distribution and how they are solved by hash functions and message authentication codes.	
LO2 Assess public key encryption protocols and signatures and their uses in the message and key exchanges		
P3 Discuss common public key cryptographic methods and their uses. **P4** Explain by the use of examples public key exchange and digital signatures, and their implementation issues.	**M3** Analyse, with examples, the Public Key Infrastructure (PKI).	

Pass	Merit	Distinction
LO3 Analyse the security issues related to symmetric and asymmetric encryption methods		
P5 Discuss the common attacks on public key encryption schemes. **P6** Explain, with examples, provable security in signature schemes and encryption schemes.	**M4** Critically analyse the security of hybrid ciphers and the construction of Key Encapsulation Mechanisms (KEMs).	**D2** Evaluate different definitions of provable security.
LO4 Evaluate advanced encryption protocols and their applications in secure message exchanges		
P7 Examine, by the use of examples, secret sharing schemes. **P8** Evaluate secure multi-party computation using the two-party and multi-party cases.	**M5** Analyse the implementation of public key cryptography in electronic voting systems.	**D3** Critically evaluate the access structures for secret sharing schemes.

Recommended Resources

Textbooks

Martin, K. (2012) *Everyday Cryptography: Fundamental Principles and Applications*. UK: Oxford.

Stallings, W. (2013) *Cryptography and Network Security: Principles and Practice*. UK: Pearson.

Journals

International Association for Cryptologic Research, Online

International Journal of Applied Cryptography, Online

Websites

www.gov.uk/government/publications	Department of Business Innovations and Skills "Guidelines for managing projects – How to organise, plan and control projects." (Report)

Links

This unit links to the following related units:

Unit 5: Security

Unit 19: Data Structures & Algorithms

Unit 24: Forensics

Unit 25: Information Security Management

Unit 24:   Forensics

Unit code	**F/615/1658**
Unit level	**5**
Credit value	**15**

Introduction

This unit introduces students to digital forensics involving the use of specialised techniques to investigate the recovery, authentication and analysis of data on electronic data storage devices as well as Network Security breaches and cyberattacks using different tools and techniques.

With the current widespread use of digital devices, digital forensics has become an important part of the detection of crime by being able to identify details of what has been stored on a digital device(s) in the past. Students will have the opportunity to learn about some of the lower level structures of data storage devices, and techniques used to investigate them.

Among the topics included in this unit are: describing the process of carrying out digital forensics; Forensic Investigation legal guidelines and procedures; understanding low level file structures of several Operating Systems (OS); creating a book disk to enable forensic examination of devices; and undertaking a forensic examination of a device(s) and/or Network Security breaches and cyberattacks.

On successful completion of this unit students will be able to carry out digital forensics in accordance with industry and legal guidelines and procedures using different tools as well as understand low-level file structures of several Operating Systems and undertake digital Forensic Investigation of devices.

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:

LO1. Examine the processes and procedures for carrying out digital Forensic Investigation.

LO2. Discuss the legal and professional guidelines and procedures for carrying out digital Forensic Investigation.

LO3. Use a tool or tools to conduct digital Forensic Investigation on devices or networks or cyberattacks.

LO4. Develop a Test Plan and make some recommendations for use in digital Forensic Investigation.

Essential Content

LO1 Examine the processes and procedures for carrying out digital Forensic Investigation

The process of carrying out digital Forensic Investigation:

Discuss what is meant by Digital Forensics.

Identity the processes and procedures for carrying out digital Forensic Investigation.

LO2 Discuss the legal and professional guidelines and procedures for carrying out digital Forensic Investigation

Processes and procedures for carrying out digital Forensic Investigation:

Law enforcement:

Give a summary of the APCO guidelines in relation to evidence collection, evidence preservation in a Forensic Investigation case. Discuss the activities of authorities (e.g. MI5/MI6, GCHQ and NSA) in relation to Forensic Investigations.

Legal and ethical considerations:

Discuss the following legal and ethical considerations when conducting a Forensic Investigation; Data Protection Act; Computer Misuse Act and the Freedom of Information Act.

Other stakeholders:

Forensic Science's Society guidelines

British Computer Society

LO3 Use a tool or tools to conduct digital Forensic Investigation on devices or networks or cyberattacks

Tools required to conduct digital Forensic Investigation:

Hardware and software tools.

Conduct digital Forensic Investigation:

Conduct digital Forensic Investigation of devices, networks or cyberattacks.

LO4 Develop a Test Plan and make some recommendations for use in digital Forensic Investigation

Develop a Test Plan for digital devices or networks or cyberattacks:

Digital Forensics Test Plan

Recommendations for improving digital Forensic Investigations.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the processes and procedures for carrying out digital Forensic Investigation		**D1** Investigate the advantages and disadvantages of conducting digital Forensic Investigation.
P1 Discuss what is meant by Digital Forensics with the aid of diagrams/pictures. **P2** Examine the processes and procedures for conducting digital Forensic investigation.	**M1** Discuss the importance of following a process or procedure when conducting digital Forensic Investigation.	
LO2 Discuss the legal and professional guidelines and procedures for carrying out digital Forensic Investigation		**D2** Discuss why NOT following guidelines might jeopardise a legal case with regards to digital Forensic evidence.
P3 Examine several law enforcement guidelines for conducting digital Forensic Investigations. **P4** Discuss several legal and ethical requirements for conducting digital Forensic Investigations.	**M2** Assess how ethical it is to conduct digital Forensic Investigations on a suspected individual with reference to their legal rights.	

Pass	Merit	Distinction
LO3 Use a tool or tools to conduct digital Forensic Investigation on devices or networks or cyberattacks		**LO3 & 4** **D3** Critically evaluate your work and suggest improvements to the current digital Forensic Investigation guidelines, processes and procedures.
P5 Determine hardware and software tools that can be used to conduct digital Forensic Investigation. **P6** Examine the file system structure of several Operating Systems e.g. MS-DOS, Windows, UNIX, Linux, MacOS, Android, etc.	**M3** Compare two tools that can be used to conduct digital Forensic Investigation. **M4** Conduct a digital Forensic Investigation on a device or network or cyberattack.	
LO4 Develop a Test Plan and make some recommendations for use in digital Forensic Investigation		
P7 Develop a Test Plan for conducting a test on digital devices or networks or cyberattacks. **P8** Suggest recommendations for best practices for conducting digital Forensics.	**M5** Compare the recommendations for best practices for conducting digital Forensics.	

Recommended Resources

Textbooks

Carrier. B. (2005) *File System Forensic Analysis*. Harlow: Addison-Wesley.

Carvey, H. (2004) *Windows Forensics and Incident Recovery*. Harlow: Addison-Wesley.

Farmer, D. and Venema, W. (2005) *Forensic Discovery*. Harlow: Addison-Wesley.

Jones, R. (2005) *Internet Forensics*. Sebastopol, O'Reilly.

Prosise, C. and Mandia, K. (2003) *Incident Response: Computer Forensics*. Osborne/McGraw-Hill.

Sammes, A. and Jenkinson, B. (2007) *Forensic Computing: A Practitioner's Guide*. 2nd Ed. London, Springer.

Journals

British Computer Society Forensics Specialist Group

GCHQ

NSA

Links

This unit links to the following related units:

Unit 5: Security

Unit 23: Cryptography

Unit 25: Information Security Management

Unit 25: Information Security Management

Unit code	**F/615/1661**
Unit level	**5**
Credit value	**15**

Introduction

Organisations of all sizes need to protect their sensitive information from potential attackers, and simply having up-to-date firewalls, anti-virus, and other infrastructure components is not enough to prevent breaches. All physical security devices, the teams who manage them, and the processes surrounding their management need to be constantly monitored and evaluated to ensure the organisation as a whole is protected. This is the concept behind an Information Security Management System (ISMS). An ongoing process to continually assess what the organisation deems its biggest threats, and what its most important assets are.

This unit introduces students to the basic principles of an ISMS and how businesses use them to effectively manage the ongoing protection of sensitive information they hold. There are many reasons for establishing an ISMS for an organisation, but one of the main goals is to enable the organisation to manage information security as a single entity which can be monitored and continually improved upon.

This unit considers information security management in a business context and will allow students to understand how modern organisations manage the ongoing threats to their sensitive assets.

On successful completion of this unit students will be able to describe what an ISMS is, how one is established, maintained and improved, and describe the role international standards play in developing an ISMS. 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:

LO1. Explore the basic principles of information security management.

LO2. Critically assess how an organisation can implement and maintain an Information Security Management System (ISMS).

LO3. Appraise an ISMS and describe any weaknesses it may contain.

LO4. Examine the strengths and weaknesses of implementing ISMS standards.

Essential Content

LO1 Explore the basic principles of information security management

What is an ISMS? Why is an ISMS important? Policies (privacy, acceptable use, information security, separation of duties, least privilege); risk (impact, likelihood, quantitative, qualitative, vulnerabilities, threats); risk treatment (avoid, transfer, accept, mitigate); compliance; stakeholders.

LO2 Critically assess how an organisation can implement and maintain an Information Security Management System (ISMS)

Asset identification; stakeholder requirements; risk assessment; risk treatment planning; policy development; procedure development; senior management buy-in; audit (internal, external); performance monitoring; continual improvement.

LO3 Appraise an ISMS and describe any weaknesses it may contain

Review ISMS documentation for potential weaknesses; examine audit and performance monitoring output; suggest improvements to an ISMS.

LO4 Examine the strengths and weaknesses of implementing ISMS standards

ISO 27001:2013; the organisation and its context; expectations of interested parties; determining ISMS scope; leadership commitment; policy; organisational roles and responsibilities; actions to address risks; information security objectives; resources; competence; awareness; communications; documented information; operational planning; risk assessment; risk treatment; monitoring, measuring, analysis and evaluation; management review; nonconformity and corrective action; continual improvement; external ISMS audit; advantages and disadvantages of ISO 27001:2013 certification; annex A (ISO 27002:2013) controls.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the basic principles of information security management		**LO1 & LO2** **D1** Demonstrate through critical analysis the steps required to establish and maintain an ISMS in the context of an example organisation, making reference to the requirements of the ISO 27001:2013 standard.
P1 Examine the key principles of an ISMS and its relevance to the successful operation of an organisation.	**M1** Evaluate the benefits an effective ISMS can have on an organisation.	
LO2 Critically assess how an organisation can implement and maintain an Information Security Management System (ISMS)		
P2 Explore the elements of, and processes behind, establishing and maintaining an ISMS.	**M2** Examine the process of implementing an ISMS in a real-world scenario.	

Pass	Merit	Distinction
LO3 Appraise an ISMS and describe any weaknesses it may contain		**LO3 & LO4** **D2** Critically examine the strengths and weaknesses in the context of an example ISMS and provide potential remedial actions to improve its effectiveness.
P3 Recognise strengths and weaknesses in a given ISMS, based on documentation review and audit output.	**M3** Examine the strengths and weaknesses of an ISMS in the context of an organisation, prioritising issues.	
LO4 Examine the strengths and weaknesses of implementing ISMS standards		
P4 Recognise the purpose of the ISO 27000 series and the key clauses of ISO 27001:2013.	**M4** Evaluate the relationship between ISO 27001:2013 and establishing an effective ISMS within an organisation. **M5** Critically assess the advantages and disadvantages of certification against the standard.	

Recommended Resources

Textbooks

Alexander, D., Finch, A., Sutton, D. and Taylor, A. (2013) *Information Security Management Principles* BCS. 2nd Revised Ed. The Chartered Institute for IT.

Calder, A. and Watkins, S. (2015) *IT Governance: An International Guide to Data Security and ISO27001/ISO27002.* 6th Ed. Kogan Page.

Journals

Information Management & Computer Security

Websites

www.iso.org   International Organisation for Standardisation "ISO/IEC 27001 – Information Security Management" (General Reference)

Links

This unit links to the following related units:

Unit 5: Security

Unit 23: Cryptography

Unit 24: Forensics

Unit 26:   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:

LO1. Analyse the theoretical foundation of machine learning to determine how an intelligent machine works.

LO2. Investigate the most popular and efficient machine learning algorithms used in industry.

LO3. Develop a machine learning application using an appropriate programming language or machine learning tool for solving a real-world problem.

LO4. 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: cassification, 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		**LO1 & LO2**
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 Chose 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.	**LO3 & LO4** **D2** Critically evaluate the implemented learning solution and it's 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 21: Data Mining

Unit 27: Artificial Intelligence

Unit 27:   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, Orocos, '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:

LO1. Analyse the theoretical foundation of artificial intelligence, current trends and issues to determine the effectiveness of AI technology.

LO2. Implement an intelligent system using a technique of the top-down approach of AI.

LO3. Implement an intelligent system using a technique of the bottom-up approach of AI.

LO4. 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
LO1 Analyse the theoretical foundation of artificial intelligence, current trends and issues to determine the effectiveness of AI technology		
P1 Investigate the top-down approach of AI and its techniques, and show how these techniques have been used to build intelligent systems. **P2** Investigate the bottom-up approach of AI and its techniques, and show how these techniques have been used to build intelligent systems.	**M1** Discuss how AI has changed the world in the last two decades and evaluate the ethical, social and philosophical issues of AI.	**D1** Review the contribution that AI has had on a global basis to individuals and society with the use of examples.
LO2 Implement an intelligent system using a technique of the top-down approach of AI		
P3 Develop an intelligent system using a top-down approach with a suitable programming language or tool. **P4** Test the system and analyse the results against expected results to identify consistencies.	**M2** Critically evaluate the effectiveness of the intelligent system and suggest methods of improvement.	**D2** Develop an outstanding intelligent system based on a top-down approach to overcome a real-world issue.

Pass	Merit	Distinction
LO3 Implement an intelligent system using a technique of the bottom-up approach of AI		
P5 Develop an intelligent system using a bottom-up approach with a suitable programming language or tool. **P6** Test the system and analyse the test results against expected results to identify consistencies.	**M3** Critically evaluate the effectiveness of the intelligent system and suggest methods of improvement.	**D3** Develop an outstanding, intelligent system based on a bottom-up approach to overcome a real-world issue.
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.

Jain, A. (2011) *Introduction to Biometrics*. Springer.

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.

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 Orocos 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 26: Machine Learning

Unit 28: Prototyping

Unit code	**D/615/1666**
Unit level	**5**
Credit value	**15**

Introduction

A prototype is the first or early sample, model or demonstration version of a concept, design or idea used to test functionality and gather feedback. The objective of prototyping is to build a functional and demonstrable version of a concept and use this version to evaluate different aspects of the concept with end users. A prototype may test a single or multiple facets of a concept and can range in functionality from very basic design mock-ups to fully functional features within complex software applications.

This unit introduces students to the role, basic concepts and benefits of prototyping in the design and development process of software applications. The aim of this unit is to enhance a student's understanding of the methodology, terminology and benefits of prototyping in the design and development of secure software applications.

Among the topics included in this unit are: classification and terminology of prototyping tools and techniques, the relationship between prototypes and release candidate software applications, how prototypes differ from release candidate software applications, categorising prototypes by their intended target end user, functionality and testing requirements, methods of prototyping, most appropriate forms of prototype for the different categories of testing, gathering meaningful insights and results from prototype testing, software release lifecycle and software prototyping concepts.

On successful completion of this unit students will be able to explain the basic concepts of prototyping; plan, build and measure the success of an appropriate prototype with a specific end user in mind; and conduct testing to gather meaningful feedback and data to improve a prototype or final software application.

As a result they will develop skills such as communication literacy, team working, critical thinking, analysis, reasoning and interpretation, business skills, computer software literacy and language, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

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

LO1. Explore forms of prototypes appropriate for various functionality and end user testing requirements.

LO2. Plan a prototype for specific target end users and planned tests.

LO3. Develop multiple iterations of the prototype using appropriate tools.

LO4. Evaluate user feedback and test results from multiple iterations of the prototype and end user testing.

Essential Content

LO1 Explore forms of prototypes appropriate for various functionality and end user testing requirements

Explore formats, characteristics and appropriateness of prototyping:

Present an overview of prototyping, how prototypes are produced and their appropriate use in software development.

Identify what a prototype is by researching the role, purpose, terminology and methodology of prototyping.

Recognise the various forms of prototyping by researching the history of prototyping, current trends and use in the product development lifecycle.

Define the characteristics of a prototype by investigating how they can be used and how they differ from complete applications.

Recognise the use of appropriate prototyping formats to achieve specific end user testing requirements and outcomes.

Recognise specific forms of prototyping functionality and end user testing requirements:

Research, debate and agree current functionality and end user testing trends and appropriate prototyping methodology.

Identify various forms of functionality and end user testing methodology.

Define the advantages and disadvantages of using prototyping to perform end user testing.

Define standard tools available for use in prototyping:

Identify standard tools available to develop prototypes.

The advantages and disadvantages of prototyping tools.

How prototyping tools can be used to rapidly iterate prototypes and capture end user feedback.

Appropriateness of various tools for different end user and functionality testing requirements.

LO2 **Plan a prototype for specific target end users and planned tests**

Identify a specific end user and an appropriate prototyping methodology to test with this user type:

Choose a specific end user to conduct tests against.

Evaluate the benefits, features, advantages and disadvantages of different prototyping methodologies for various end user testing outcomes.

Review different end user categorisations, classifications and behaviour modelling techniques.

Select the most appropriate form of prototyping to achieve desired end user testing and outcomes to ensure the production of a secure end product.

Describe a plan to use appropriate prototyping methodology and tools to conduct end user testing:

Apply end user classification and behaviour modelling to select an appropriate prototyping methodology.

Outline the end user characteristics, desired testing criteria and results your prototype addresses.

Select an appropriate form of prototyping necessary to achieve desired results.

Use your selected end user, appropriate prototyping methodology and desired testing criteria to create a prototyping plan.

LO3 **Develop multiple iterations of the prototype using appropriate tools**

Utilise appropriate tools to develop multiple prototypes:

Employ an appropriate set of tools to develop your plan into a prototype.

Run end user experiments and examine feedback.

Reconcile and evaluate end user feedback and build a new iteration of your prototype modified with the most important feedback and enhancements.

Make multiple iterations of your prototype and modify each iteration with enhancements gathered from user feedback and experimentation.

LO4 Evaluate user feedback and test results from multiple iterations of the prototype and end user testing

Asses the success of your prototype:

Assemble and appraise end use feedback from multiple iterations of your prototype.

Undertake a critical review and compare your final prototype and your test results with the original plan.

Evaluate the advantages, disadvantages, strengths and weaknesses of your prototyping methodology.

Critique the overall success of your prototype and discusses your insight using prototyping.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore forms of prototypes appropriate for various functionality and end user testing requirements		
P1 Recognise specific forms of prototyping functionality and end user testing requirements. **P2** Evaluate standard tools available for use in prototyping.	**M1** Review specific forms of prototyping and the advantages and disadvantages of end user testing requirements for appropriateness to different testing outcomes.	**LO1 & LO2** **D1** Evaluate the impact of common prototyping methodology within the software development lifecycle.
LO2 Plan a prototype for specific target end users and planned tests		
P3 Review different end user categorisations, classifications and behaviour modelling techniques. **P4** Explore a specific end user and an appropriate prototyping methodology to test with this user type.	**M2** Apply end user classification and behaviour modelling to select an appropriate prototyping methodology. **M3** Suggest a plan to use appropriate prototyping methodology and tools to conduct end user testing.	

Pass	Merit	Distinction
LO3 Develop multiple iterations of the prototype using appropriate tools		**D2** Create multiple iterations of your prototype and modify each iteration with enhancements gathered from user feedback and experimentation.
P5 Explore appropriate tools to develop multiple prototypes. **P6** Perform end user experiments and examine feedback.	**M4** Employ an appropriate set of tools to develop your plan into a prototype. **M5** Using end user feedback build a new iteration of your prototype modified using the most important feedback and enhancements.	
LO4 Evaluate user feedback and test results from multiple iterations of the prototype and end user testing		**D3** Critically evaluate the overall success of your prototype and discuss your insight using prototyping.
P7 Analyse end use feedback from multiple iterations of your prototype.	**M6** Undertake a critical review and compare your final prototype and your test results with your original plan.	

Recommended Resources

Textbooks

Hanington, B. (2013) *Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions*. Rockport Publishers.

Kalbach, J. (2015) *Mapping Experiences: A Complete Guide to Creating Value through Journeys, Blueprints, and Diagrams*. 1st Ed. O'Reilly Media.

Lidwell, W. (2010) *Universal Principles of Design, Revised and Updated: 125 Ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach through Design*. 2nd Ed. Rockport Publishers.

Osterwalder, A. (2015) *Value Proposition Design: How to Create Products and Services Customers Want*. 1st Ed. Wiley.

Warfel, T. Z. (2009) *Prototyping a Practitioner's Guide.* 1st Ed. Rosenfield Media.

Links

This unit links to the following related units:

Unit 1: Programming

Unit 9: Software Development Lifecycles

Unit 20: Advanced Programming

Unit 29: Application Program Interfaces

Unit code	**M/615/1669**
Unit level	**5**
Credit value	**15**

Introduction

Many applications in use today are a composite of other software. This is true of an application, be it web based, mobile or on a desktop where the functionality of another is used to build upon. Think of an application that locates nearby restaurants – this may utilise an already existing map service as its basis. Or a game application that enables players to invite other players, chat and post high scores to social media all within the game environment. How an application interacts with another is through an Application Program Interface (API).

Typically, APIs consist of methods and tools which are developed by the software author and can provide services and functionality to other application developers without having to 'reinvent the wheel'. Existing APIs provide a huge range of functionality which can be integrated into an application by following the rules of the relevant API. One of the benefits in using APIs is access to existing and proven services that can help speed up development and help standardisation.

The aim of this unit is to introduce students to the nature of APIs by developing proof-of-concept application that utilises existing APIs for common tasks that can include communication, displaying interactive visuals, audio playback and handling a range of user inputs.

Among the topics included in this unit are: identifying what an API is and the need for APIs; types of APIs; application design and development utilising relevant APIs in a suitable development environment; testing of the application; and a critical review of the APIs used.

On successful completion of this unit students will be able to identify and select relevant APIs to use within an application of their own choice or from a given scenario, in addition to testing and documenting the review process against the initial design requirement.

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:

LO1. Examine what an API is, the need for APIs and types of APIs.

LO2. Apply the knowledge of API research to design an application that incorporates relevant APIs for a given scenario or a substantial student chosen application.

LO3. Implement an application in a suitable development environment.

LO4. Document the testing of the application, review and reflect on the APIs used.

Essential Content

LO1 Examine what an API is, the need for APIs and types of APIs

Research existing APIs, their role and the need for an API.

Identify types of API uses e.g. visual, social media, device manipulation.

Critically evaluate suitable APIs for use in an application (web/mobile/desktop) for a given scenario or a substantial student chosen application.

LO2 Apply the knowledge of API research to design an application that incorporates relevant APIs for a given scenario or a substantial student chosen application

Develop relevant wireframes diagrams, concept the design of the application.

Consider the application design/its purpose.

Consider the target platform (web/mobile/desktop).

Identify the scope of the application.

Justify the selection/relevancy/purpose of the chosen APIs for the application.

Take the security of APIs into consideration.

LO3 Implement an application in a suitable development environment

Introduce different types of implementation processes. to extend knowledge and understanding of the stages involved.

Discuss a range of suitable development environments.

Develop the application based on LO2.

Consider the use of a suitable development environment.

Utilise best practices for implementing the application.

LO4 Document the testing of the application, review and reflect on the APIs used

Document the testing procedure carried out to satisfy the design requirements/purpose of application.

Review/reflect on the application development process; identifying the chosen APIs strengths weaknesses, ease of use, access to features within the APIs.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine what an API is, the need for APIs and types of APIs		
P1 Examine the relationship between an API and a software development kit (SDK).	**M1** Asses a range of APIs for a particular platform that covers a range of uses.	**D1** Evaluate potential security issues surrounding APIs
LO2 Apply the knowledge of API research to design an application that incorporates relevant APIs for a given scenario or a substantial student chosen application		
P2 Analyse an existing application that could be extended with a suitable API.	**M2** Design an application that will utilise an API for a given purpose.	**D2** Create a design for a chosen substantial application that will utilise a range of APIs, justifying choices.
LO3 Implement an application in a suitable development environment		
P3 Build on an existing application framework to implement an API.	**M3** Develop an application that utilises an API.	**D3** Construct an application utilising multiple APIs, following the designs in LO2.
LO4 Document the testing of the application, review and reflect on the APIs used		
P4 Design and complete a 'white box' test of the application, recording the results.	**M4** Conduct 'black box' tests of your application, recording the results. **M5** Update the application accordingly with the results.	**D4** Critically evaluate the APIs used within your application. Provide a data security report of your application.

Recommended Resources

Textbooks

Spencer, T. et al. (2015) *Securing the API Stronghold: The Ultimate Guide to API Security.* 1st Ed. Kindle. Amazon.

Websites

www.khronos.org   The Khronos Group
"Vulkan API" (Development Tool)

developers.google.com   Google Developers (Development Tools)

Links

This unit links to the following related units:

Unit 9: Software Development Lifecycles

Unit 30: Application Development

Unit 30: Application Development

Unit code	**H/615/1670**
Unit level	**5**
Credit value	**15**

Introduction

Software drives business and developers drive software – the world is reliant on software, and programming is at the heart of this. Professionalism and critical thinking, supported by an ability to work independently and as part of a team are core skills of a developer. If you can think logically and you enjoy exploring and dismantling problems, working with others to consider requirements and creating ideas and possible solutions you can gain the experience and learn the skills needed to excel as an Application Developer.

This unit introduces students to Application Development and is designed to simulate the roles and responsibilities of a commercial developer working in a suitable business environment with access to a small team of colleagues. Initially, students are introduced to a business-related problem and will need to adopt and use appropriate methods and practices to analyse, break down and discuss the issues – then, decide, design, create and test a possible solution. Students should be free to debate, evaluate and select different design and development methodologies depending on their own judgement and consideration. On completion, students will be expected to formally evaluate their final application against their design plans and initial requirements.

Among the topics included in this unit are: design and developer documentation; problem analysis; research, system and user requirements; design methodologies and principles; security considerations; development methodologies; Unified Modelling Language (UML), software development lifecycles; teamwork, peer-reviews, development tools and techniques; integrated development environments; debugging, testing, software versions and quality assurance.

On successful completion of this unit students will be able to produce a Software Design Document by analysing a business-related problem and deduce an appropriate solution, including a set of initial requirements, select and use design and development methodologies with tools and techniques associated with the creation of a business application, work individually and as part of a team to plan, prepare and produce a functional business application with support documentation and assess and plan improvements to a business application by evaluating its performance against its Software Design Document and initial requirements.

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:

LO1. Produce a Software Design Document by analysing a business-related problem and deduce an appropriate solution including a set of initial requirements.

LO2. Use design and development methodologies with tools and techniques associated with the creation of a business application.

LO3. Work individually and as part of a team to plan and produce a functional business application with support documentation.

LO4. Evaluate the performance of a business application against its Software Design Document and initial requirements.

Essential Content

LO1 Produce a Software Design Document by analysing a business-related problem and deduce an appropriate solution including a set of initial requirements

Analyse a business-related problem and assess possible solutions:

Discuss and produce a problem definition statement to highlight and describe the issues that need to be addressed.

Research and consider possible solutions and predict the overall success of the application.

Produce a Software Design Document:

Review and discuss the value of Software Design Documents with regards to application development.

Evaluate your possible solutions and synthesise the ideas into a single document that identifies and attempts to solve the business-related problem.

Research and use information relating to software testing to create a suitable test plan for your business application.

LO2 Use design and development methodologies with tools and techniques associated with the creation of a business application

Discuss different design and development methodologies:

Present overviews on current design and development methodologies.

Debate various strengths and weaknesses commonly associated with each methodology.

Select or synthesise a design and development methodology for use with the creation of your application.

Consider the security implications of design and development methodologies.

Use appropriate tools and techniques:

Evaluate different tools and techniques available to create a business application.

Debate the advantages and disadvantages of your preferred or selected tools and techniques.

LO3 Work individually and as part of a team to plan and produce a functional business application with support documentation

Work as a small team to plan and prepare your business application:

Peer-review and debate your development plan by effectively communicating and defending the ideas in your Software Design Document.

Discuss differences with regards to the possible strengths and weakness of each Software Design Document.

Modify your Software Design Document to reflect any new insights or considerations.

Prepare and produce a functional business application:

Use your Software Design Document with your preferred design and development methodology and your selected tools and techniques to develop a functional business application.

Create and quality check appropriate support documents for your application.

LO4 Evaluate the performance of a business application against its Software Design Document and initial requirements

Assess the performance of a business application:

Analyse factors that influence the performance of a business application with regard to its system requirements.

Undertake a critical review of the performance and development of your application against all identified factors and any adopted design and development methodologies.

Measure the overall success of the application against your original prediction and identify any new areas of personal insight.

Plan improvements to a business application:

Evaluate the overall strengths and weaknesses of your business application against its Software Design Document and initial requirements.

Discuss and plan in detail possible revisions (including implementation) with regard to improving your application's performance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Produce a Software Design Document by analysing a business-related problem and deduce an appropriate solution including a set of initial requirements		**LO1 & LO2**
P1 Explore a business-related problem and produce a well-defined Problem Definition Statement supported by a set of user and system requirements. **P2** Determine any areas of risk related to the successful completion of your application.	**M1** Analyse a business-related problem using appropriate methods and produce a well-structured Software Design Document that defines a proposed solution and includes relevant details on requirements, system analysis, system design, coding, testing and implementation.	**D1** Justify your solution to a business-related problem and your preferred software development methodology, by comparing between the various software development tools and techniques researched.
LO2 Use design and development methodologies with tools and techniques associated with the creation of a business application		
P3 Research the use of software development tools and techniques and identify any that have been selected for the development of this application.	**M2** Compare the differences between the various software development tools and techniques researched and justify your preferred selection as well as your preferred software development methodology.	

Pass	Merit	Distinction
LO3 Work individually and as part of a team to plan and produce a functional business application with support documentation		
P4 Create a formal presentation that effectively reviews your business application, problem definition statement, proposed solution and development strategy. Use this presentation as part of a peer-review and document any feedback given. **P5** Develop a functional business application with support documentation based on a specified business problem.	**M3** Interpret your peer-review feedback and identify opportunities not previously considered. **M4** Develop a functional business application based on a specific Software Design Document with supportive evidence of using the preferred tools, techniques and methodologies.	**D2** Evaluate any new insights, ideas or potential improvements to your system and justify the reasons why you have chosen to include (or not to include) them as part of this business application.

Pass	Merit	Distinction
LO4 Evaluate the performance of a business application against its Software Design Document and initial requirements		
P6 Review the performance of your business application against the Problem Definition Statement and initial requirements.	**M5** Analyse the factors that influence the performance of a business application and use them to undertake a critical review of the design, development and testing stages of your application. Conclude your review by reflectively discussing your previously identified risks.	**D3** Critically evaluate the strengths and weaknesses of your business application and fully justify opportunities for improvement and further development.

Recommended Resources

Textbooks

Carmen, T. et al. (2009) *Introduction to Algorithms*. USA: MIT Press.

Martin, R.C. (2011) *The Clean Coder: A Code of Conduct for Professional Programmers*. USA: Prentice Hall.

McConnell, S. (2004) *Code Complete: A Practical Handbook of Software Construction*. USA: Microsoft Press.

Links

This unit links to the following related units:

Unit 6: Managing a Successful Computing Project

Unit 9: Software Development Lifecycles

Unit 31:   Games Engine & Scripting

Unit code	**K/615/1671**
Unit level	**5**
Credit value	**15**

Introduction

Professional game development typically represents a significant investment in time, effort, skill and money. These requirements are further complicated due to the generally increasing differences in hardware platforms (such as PCs, Mac, Xbox, PlayStation, tablets and other mobile devices). Prior to the use of a games engine, a developer would need highly detailed and specific knowledge relating to the platform, device drivers and operating system calls. In addition, they would need to be capable of writing efficient low-level maths functions to simulate physics, gravity, calculate trajectories and determine object collisions in 2D and 3D environments, including designing image transition algorithms. Using a games engine, a developer can implement more features, more quickly and more effectively, and deploy them on more platforms than ever before. However, despite using a games engine there are still plenty of unique challenges to be solved.

This unit introduces students to the origin and evolution of games engines and their effect on game design, it also expects students to project this path into the future to draw conclusions and predict a possible future for engines. After being introduced to the core services of most engines and their advantages, students are expected to evaluate a range of different engines and debate their features. In addition, and while students assimilate, reflect and consider the advantages and technical challenges of a games engine they will be issued with an existing Games Design Document (supported with all appropriate assets) and challenged with planning and using a specific engine to develop the design into a functional game. On completion, and in addition to the student reviewing and reflecting on the experience, they will be expected to formally assess their functional game against the Games Design Document and user expectation.

Among the topics included in this unit are: games engine evolution and purpose, player expectation, types of engine, design documentation, research, system and user requirements, game design, ad management, monetisation, usage analytics, build services, graphics and animation, adding physics, storing world data, artificial and automated intelligence, collision detection, user interface and user control methods, gameplay, assets and asset management, hardware platforms, development tools and techniques, integrated development environments, scripting languages, debugging, testing, software versions and quality assurance.

On successful completion of this unit students will be able to analyse the evolution, impact and possible future of games engines with regard to game development and expectation, evaluate the features and architecture of different games engines, use an existing Game Design Document (with assets) to synthesise key features of a selected games engine into a playable game and assess and plan improvements to a playable game by evaluating its performance against its Game Design Document and user expectation.

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:

LO1. Analyse the evolution, impact and possible future of games engines with regards to game development and expectation.

LO2. Evaluate the features and architecture of different games engines.

LO3. Use an existing Game Design Document (with assets) to synthesise key features of a selected games engine into a playable game.

LO4. Assess and plan improvements to a playable game by evaluating its performance against its Game Design Document and user expectation.

Essential Content

LO1 Analyse the evolution, impact and possible future of games engines with regards to game development and expectation

Analyse the evolution of games engines:

Identify what a games engine is by researching the purpose and history of games engines.

Assemble and evaluate a timeline illustrating milestones and linking the release of pivotal games with the development and use of games engines.

Investigate the possible future of games engines with regards to games development and expectation:

Research, debate and agree current gaming trends.

Discuss the evolution of player expectation and its influence and effect on games development.

Analyse trends and use the information to predict a possible future for games (short, mid and long term) and relate this to the development and use of games engines.

LO2 Evaluate the features and architecture of different games engines

Features and architecture of a games engine:

Introduce and discuss the core features of games engines, such as: ad management, monetisation, usage analytics, build services, multiplayer support, developer collaboration, debugging, 2D and 3D graphics and animation services, particle and lighting systems, physics and database services, multiple language support, virtual reality, artificial and automated intelligence, collision detection, user interface and user control methods.

Select a specific games engine and discuss game engine architecture, including: game and update loops, assets and memory management, graphics manipulation, scripting, collisions and physics engine, math libraries and user interface.

Evaluate a range of different types of published games to determine and agree the type of features commonly embedded in each.

Use your selected games engine to investigate the implementation and technical challenges associated with each of your previously identified features.

Research different games engines:

Debate the features from a range of games engines and evaluate the strengths and weaknesses of each.

LO3 Use an existing Game Design Document (with assets) to synthesise key features of a selected games engine into a playable game

Synthesise ideas defined in an existing Game Design Document with games engine features:

Evaluate and synthesise an existing Game Design Document with the features of a specific games engine to create a development plan.

Peer-review and discuss your development plan by effectively communicating and defending your ideas and reasoning.

Modify your plan to reflect any new insights or considerations.

Create and test a playable game:

Use the Game Design Document (with assets) with your development plan to create a playable game.

Adopt an appropriate level of testing to identify, debug and fix issues.

LO4 Assess and plan improvements to a playable game by evaluating its performance against its Game Design Document and user expectation

Assess the performance of a playable game:

Analyse factors that influence the performance of a playable game with regard to game genre, style and player expectation.

Undertake a critical review of the performance and development of your playable game against all identified factors, including use of any games engine features.

Critique the overall success of your playable game and identify any new areas of personal insight.

Plan improvements to a playable game:

Evaluate the overall strengths and weaknesses of your playable game against its Game Design Document.

Discuss and plan in detail possible revisions (including implementation) with regard to improving your playable game's performance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse the evolution, impact and possible future of games engines with regards to game development and expectation		
P1 Compare different games engines and explain how their evolution has impacted on game design and development.	**M1** Discuss the origin, type and chronological evolution of games engines, associating them with influential titles that had a significant impact on video game design and development and explain how this affected player expectation. **M2** Provide evidence of current gaming trends and technology and use it to predict the future of games engines and explain how this could affect designers, developers and gamers.	**LO1 & LO2** **D1** Critically analyse each of the games engines evaluated in M3.
LO2 Evaluate the features and architecture of different games engines		
P2 Compare the features of different games engines and explain the purpose and operation of each. **P3** Review different published games and determine the types of features embedded in each against the features available in a selected games engine.	**M3** Evaluate the features and architecture of different games engines and explain with technical detail the purpose and operation of each. **M4** Use a selected games engine to create simple prototypes that demonstrate features commonly embedded in games.	

Pass	Merit	Distinction
LO3 Use an existing Game Design Document (with assets) to synthesise key features of a selected games engine into a playable game.		
P4 Use an existing Games Design Document to plan the development and testing of a playable demo and conduct formal peer-reviews regarding your development and testing plan, documenting any feedback given. **P5** Use a Games Design Document supported with a development and test plan and a selected games engine to develop a playable demo.	**M5** Interpret your peer-review feedback and identify opportunities not previously considered. **M6** Extend your playable demo into a game that supports: splash screens, credits, scoring and losing player life.	**D2** Further expand your playable game by adding support for: animation, sound, end of level detection, player victory and loss conditions and level restarting.
LO4 Assess and plan improvements to a playable game by evaluating its performance against its Game Design Document and user expectation		
P6 Review the performance of your playable demo or game against the Games Design Document.	**M7** Evaluate the strengths and weaknesses of your playable game against player expectation.	**D3** Critically evaluate the strengths and weaknesses of your playable game against player expectation and explain opportunities for improvement and further development.

Recommended Resources

Textbooks

Gibson, J. (2014) *Introduction to Game Design, Prototyping, and Development.* New Jersey: Pearson Education.

Gregory, J. (2014) *Game Engine Architecture*. United States: Taylor.

Madhav, S. (2013) *Game Programming Algorithms and Techniques*. USA: Addison-Wesley.

Nystrom, R. (2014) *Game Programming Patterns*. USA: Genever Benning.

Rogers, S. (2014) *Level Up! The Guide to Great Video Game Design*. UK: John Wiley and Sons Ltd.

Schell, J. (2014) *The Art of Game Design: A Book of Lenses*. USA: A K Peters/CRC Press.

Links

This unit links to the following related units:

Unit 32: Game Design Theory

Unit 47: Games Development

Unit 32: Game Design Theory

Unit code	**T/615/1673**
Unit level	**5**
Credit value	**15**

Introduction

What makes a great game? Although it's easy to say, "This is a great game" when your character has just cleared a zone and your friend's voice buzzes in your headset letting you know that everybody is waiting for you to join the party – then another player interrupts suggesting tactics to take down the next objective. However, it is a completely different story when you (the designer) are sitting, staring at a blank sheet of paper and your producer is expecting you to present 'The next big title'.

This unit introduces students to an exploration of the practices, principles and skills needed to successfully design a game. Initially this unit establishes an overall history of games and reviews how they have (and are still) evolving. It also takes the opportunity to introduce and assess common game features and help the students identify the roles, responsibilities and challenges of game design. As part of this unit students will become familiar with a range of standard documents associated with games design including the 'Game Design Document'. Before students embark on defining, designing and documenting their own game ideas they are given opportunities to work in groups to debate and review the elements of game design, introduced to the design process as well as the practices, principles, tools and techniques. As students progress they are given opportunities to evolve their ideas through peer-reviews before finally presenting a 'High Concept' pitch. To help maximise the student involvement, this unit should (where possible) simulate a real-world, design experience.

Among the topics included in this unit are: design documentation, research, requirement gathering, idea generation, world design, storyboards, storytelling, characters, levels, gameplay, assets and asset management, tools and techniques, game engines and environments, genres, game mechanics, player motivation and challenge, rewards, game structure, game design vocabulary, and preparing and presenting a pitch.

On successful completion of this unit students will be able to critically assess the types, practices, principles and skills used in the design of games, analyse the concepts and elements required for the production of a Games Design Document, evaluate the game design process with regards to game development and production and use game design practices and principles to create an original Game Design Document and present a High Concept pitch.

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:

LO1. Critically assess the types, practices, principles and skills used in the design of games.

LO2. Analyse the concepts and elements required for the production of a Games Design Document.

LO3. Evaluate the game design process with regards to game development and production.

LO4. Use game design practices and principles to create an original Game Design Document and present a High Concept pitch.

Essential Content

LO1 Critically assess the types, practices, principles and skills used in the design of games

Review game design and game types:

Identify what game design is and explore the evolution of games over time.

Research and assess game types, trends, player features, control and technology.

Investigate the practices, principles and skills used in the design of games:

Identify the role of a games designer and introduce concepts related to the game design process (including high concept, story and art bible, design document).

Discuss idea generation, world design, storytelling, characters, levels, gameplay, assets and asset management.

Assess the skills needed to successfully design a video game.

LO2 Analyse the concepts and elements required for the production of a Games Design Document

Investigate Games Design Document structure:

Review different Game Design Documents and identify common and shared factors.

Discuss, compare and synthesise your identified factors into an agreed format.

Analyse the concepts and elements required for a Games Design Document:

Examine the purpose of the Game Design Document (including game loops such as: core, dual and compulsion as well as the principles of Metagame design) and identify the stakeholders and their possible expectations.

Debate the content, depth and quality of information expected in a Games Design Document (including age appropriate content and content ratings).

Explain the strengths and possible weaknesses of a Games Design Document.

LO3 **Evaluate the game design process with regards to game development and production**

Introduce key terminologies and define a basic roadmap for the game design process (including: concepts, planning and design, development, testing, distribution):

Debate the value of the concept stage (including idea generation and establishing the audience, game world, narrative, style, features and gameplay, characters, storyboards and player motivation and challenges).

Recap why concepts are reviewed, synthesised and stored as a set of documents.

Investigate design tools and explore issues related to the planning and design stage (including: asset creation and management and possible redevelopment of agreed ideas).

Introduce game development constraints (and possible pitfalls) together with platforms commonly available to support development.

Discuss testing methods and introduce the purpose of Quality Assurance (QA) and business and monetisation models (e.g. Steam, retail, Free-to-Play (F2P) supported by techniques such as: item-purchase, affiliate, advertising, Freemium, restricted access, subscription) with regards to production and distribution taking security issues into consideration.

LO4 **Use game design practices and principles to create an original Game Design Document and present a High Concept pitch.**

Create an original game concept:

Gather and document a range of original game ideas using research on existing game types and styles for inspiration.

Peer-review and evaluate feedback on a number of your game ideas to justify the selection of a specific game idea.

Review and apply game design practices and principles to develop a specific game idea into a full, well-structured concept.

Create an original Game Design Document and present its High Concept pitch:

Produce and quality check a Game Design Document and High Concept presentation based on your selected concept.

Present and defend your High Concept pitch.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Critically assess the types, practices, principles and skills used in the design of games		
P1 Compare different video game types and explain key or influential titles as they were released over time. **P2** Research the skills needed to design, create and produce a video game and compare the roles of a games animator, producer, audio engineer, director, designer, programmer and artist.	**M1** Analyse the evolution of game technology and its impact on video game design and complexity.	**LO1 & LO2** **D1** Evaluate each section of a Games Design Document and explain the effect of game loops and Metagame design with regards to game play.
LO2 Analyse the concepts and elements required for the production of a Games Design Document		
P3 Examine the structure of a Game Design Document.	**M2** Determine the various needs and expectations of the Game Design Document stakeholders.	

Pass	Merit	Distinction
LO3 Evaluate the game design process with regards to game development and production		
P4 Create an illustrated guide explaining the video game design, development and production processes, including an evidence-based comparison between 'AAA' and 'Indie' (independent) budget allocation and development timelines. **P5** Compare different business and monetisation models used with games production and distribution.	**M3** Review different game distribution channels and marketing methods used in games production.	**D2** Evaluate the importance and issues related to idea generation, audience understanding, world design, narrative, style, features, gameplay, characters, storyboards and player motivation and challenge with regards to game design.
LO4 Use game design practices and principles to create an original Game Design Document and present a High Concept pitch		
P6 Create an original game concept and maintain organised evidence of giving appropriate and constructive feedback to others. **P7** Develop an original Game Design Document and High Concept presentation.	**M4** Conduct peer-reviews using your original game concept and document any feedback given. **M5** Develop a detailed, original Game Design Document and formally present and defend your High Concept pitch.	**D3** Critically evaluate the strengths and weaknesses of your finished video game concept, Design Document and High Concept pitch and fully justify opportunities for improvement and further development.

Recommended Resources

Textbooks

Gibson, J. (2014) *Introduction to Game Design, Prototyping, and Development*. New Jersey: Pearson Education.

Gregory, J. (2014) *Game Engine Architecture*. United States: Taylor.

Madhav, S. (2013) *Game Programming Algorithms and Techniques*. USA: Addison-Wesley.

Nystrom, R. (2014) *Game Programming Patterns*. USA: Genever Benning.

Rogers, S. (2014) *Level Up! The Guide to Great Video Game Design*. UK: John Wiley and Sons Ltd.

Schell, J. (2014) *The Art of Game Design: A Book of Lenses*. USA: A K Peters/CRC Press.

Links

This unit links to the following related units:

Unit 9: Software Development Lifecycles

Unit 31: Games Engine & Scripting

Unit 47: Games Development

Unit 33:   Analytical Methods

Unit code	**F/615/1675**
Unit level	**5**
Credit value	**15**

Introduction

John von Neumann, a Hungarian mathematician, outlined the architecture for a stored-program computer in a paper he wrote in 1945. In order to fully develop new software and hardware technologies within this architecture, analytical skills and techniques needed to be applied to any proposed design. In the modern era, analytical methods still underpin theoretical computer science fundamentals, and developing this mathematical knowledge will support development in many aspects of computing.

This unit introduces students to more advanced analytical techniques that are relevant to them as they progress within their studies in computing, and advances knowledge of mathematical modelling and application of theory.

Among the topics included in this unit are: complex numbers, numerical methods, matrices, formal logic and Z specification.

On successful completion of this unit students will be able to use applications of complex number theory, approximate solutions of contextualised examples with numerical methods, apply matrix theory to a variety of different scenarios and use formal methods of logic. 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:

LO1.   Examine complex number theory within practical situations.

LO2.   Approximate solutions using numerical methods.

LO3.   Employ matrix methods to contextualised examples relevant to computing.

LO4.   Investigate the concepts of formal methods within computer science.

Essential Content

LO1 Examine complex number theory within practical situations

Complex number theory:

Introduction to imaginary numbers and complex numbers.

The modulus, argument and conjugate of complex numbers.

The polar form of complex numbers.

The use of de Moivre's Theorem.

Using quaternions for spatial rotation in computer graphics.

LO2 Approximate solutions using numerical methods

Numerical methods:

Using sketches to approximate solutions of equations.

Numerical analysis using the bisection method and the Newton–Raphson method.

Numerical integration, the trapezium rule and Simpson's rule.

Analysis:

Error analysis to determine the accuracy of approximations.

Explanation of numerical method failure and comparison of methodology.

LO3 Employ matrix methods to contextualised examples relevant to computing

Matrix methods:

Introduction to matrices and matrix notation.

Using matrices to represent ordered data and the relationship with program variable arrays.

The process for addition, subtraction and multiplication of matrices.

Calculating the determinant and inverse of a matrix.

Application of matrices to vector transformations and rotation, maps and graphs.

Formal reasoning:

Logic and proof.

Introduction to Hoare logic.

Hoare logic to assess the correctness of computer programs.

Automated proof checking.

Z specification language:

Model-based specification.

The modelling of software systems using Z specification.

Proving properties using Z specification.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine complex number theory within practical situations		
P1 Solve applicable problems using complex number theory. **P2** Perform arithmetic operations using the polar and exponential form of complex numbers.	**M1** Critique the use of quaternions for application in spatial rotation.	**D1** Formulate solutions of problems using de Moivre's Theorem.
LO2 Approximate solutions using numerical methods		
P3 Examine the roots of an equation using two different iterative techniques. **P4** Determine the numerical integral of functions using two different methods.	**M2** Select two different examples that show the failure of numerical techniques.	**D2** Appraise the different methodology that is used for numerical integration.
LO3 Employ matrix methods to contextualised examples relevant to computing		
P5 Utilise matrices to represent ordered data in array form. **P6** Perform addition, subtraction and multiplication of matrices.	**M3** Ascertain the determinant of two different scale matrices.	**D3** Determine solutions to a set of linear equations using the inverse matrix method.
LO4 Investigate the concepts of formal methods within computer science		
P7 Interpret the meaning of given logical statements into plain English. **P8** Examine the modelling of software systems using Z specification.	**M4** Use Hoare's notation to model the correctness of a given computer program.	**D4** Judge the correctness of a given computer program using Hoare logic.

Recommended Resources

Textbooks

Garnier, R. and Taylor, J. (1992) *Discrete Mathematics: For New Technology*. Oxfordshire: Taylor & Francis.

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

Journals

Communications on Pure and Applied Mathematics. Wiley.

Links

This unit links to the following related units:

Unit 14: Business Intelligence

Unit 34: Systems Analysis & Design

Unit code	**L/615/1677**
Unit level	**5**
Credit value	**15**

Introduction

The world is constantly changing, with new and emerging digital technologies bringing many challenges to the commercial world. Organisations have to respond to these changes in addition to responding to new markets and different ways of doing their business. The systems they use to run their businesses have to respond quickly to these transformations. Organisations can find themselves in a situation where they have to regularly upgrade old systems or develop new ones in order to continue operating successfully in the evolving competitive business environment.

Before any system can be upgraded or a new system developed, the system requirements have to be analysed and the system designed, whether this is for a database system, or a web, game or mobile application, and failure to do this adequately could lead to a costly systems failure.

This unit explores the processes of systems analysis and design using two methodologies – the traditional systems development lifecycle methodology providing a comprehensive structured framework and the agile methodology with different framework models developed with the emphasis on variations of iterative incremental modelling. To provide perspective, students will examine the models in both these methodologies. They will consider the particular strengths and weaknesses of the two methodologies and examine the suitability of the methodologies using different examples.

Topics included in this unit are: examining the business case for a new system or for upgrading an existing one, looking at traditional and agile systems analysis methodologies and evaluating the merits of each, considering the implications of moving from using the traditional methods of analysis and design to agile methods on analysts, designers and developers in an organisation, and applying systems design tools and techniques.

On successful completion of this unit, students will be able to produce a business case, and analyse a system and its requirements using a suitable methodology. They will be able to design a system suitable for their application. Theoretical understanding will be translated into practical skills through actual systems investigations and students will become confident in the use of particular tools and techniques relevant to the methodology chosen. Although for practical purposes, it is likely that one particular methodology and related tools and techniques will be used, it is important that students understand that others are available.

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 the unit students will be able to:

LO1. Evaluate the strengths and weaknesses of the traditional and agile systems analysis methodologies.

LO2. Produce a feasibility study for a system for a business-related problem.

LO3. Analyse their system using a suitable methodology.

LO4. Design the system to meet user and system requirements.

Essential Content

LO1 Evaluate the strengths and weaknesses of the traditional and agile systems analysis methodologies

Principles of the traditional Systems Development Life Cycle (SDLC) models, including Waterfall, Prototyping, and Spiral.

Principles of agile methodologies models, including Scrum, Extreme, Lean, Scaled Agile Frameworks (SAFe), Disciplined Agile Delivery (DAD), Kanban, Disciplined Agile Delivery (DAD), Agile Modelling (AM) and DevOps, amongst the many variations.

Strengths and weaknesses of traditional and agile methodologies.

Identify transition problems in organisations of moving from traditional to agile methodology.

Factors that need to be considered when selecting the appropriate methodology to use.

LO2 Produce a feasibility study for a system for a business-related problem

Elements of a business case to explore both business and technical feasibility options.

Desirability, viability and feasibility of systems.

Investigation techniques to use.

Criteria to consider for a business case: vision and goals cost-benefit analysis, legal, economic, technical, operational, timeframes, organisational culture, security considerations.

LO3 Analyse their system using a suitable methodology

Tools used to investigate the system.

Identifying user and system requirements and any constraints, including possible security issues.

Identifying the team members and their roles and responsibilities in a project team.

Identifying documentation that will be produced at the different stages and determining the sign-off conditions.

Criteria to use to determine the suitability of the methodology used to analyse the system.

LO4 **Design the system to meet user and system requirements**

Design elements for the traditional and agile methodologies.

Determining the design features for traditional and agile methodologies.

Data flow diagrams and flow charts.

Determining the tools and techniques relevant for the design of systems for database applications, web applications, games, mobile applications and other software applications.

Identifying the design documentation contents for different application types e.g. for databases, web design, games, mobile and other software applications.

Link to other units relevant for students where systems are being designed and developed.

Design sign-off.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Evaluate the strengths and weaknesses of the traditional and agile systems analysis methodologies		**LO1 & LO2**
P1 Discuss the strengths and weaknesses of the traditional and agile systems analysis methodologies.	**M1** Compare and contrast the strengths and weaknesses of the traditional and agile systems analysis methodologies.	**D1** Critically evaluate the strengths and weaknesses of the traditional and agile methodologies and feasibility study.
LO2 Produce a feasibility study for a system for a business-related problem		
P2 Produce a feasibility study for a system for a business related problem.	**M2** Evaluate the relevance of the feasibility criteria on the systems investigation for the business related problem.	
LO3 Analyse their system using a suitable methodology		**LO3 & LO4**
P3 Review a system using a suitable methodology for a business-related problem.	**M3** Analyse the effectiveness of the methodology used in providing a solution for a given business context.	**D2** Justify the choice of the methodology used in the context of the business problem.
LO4 Design the system to meet user and system requirements		
P4 Design a fully functional system to meet user and system requirements for the business related problem.	**M4** Assess the effectiveness of the system design with particular reference to the methodology used and how the design meets user and system requirements	

Recommended Resources

Textbooks

Ambler, S. and Lines, M. (2012) *Disciplined Agile Delivery (DAD): A Practitioner's Guide to Agile Software Delivery in the Enterprise*. IBM Press.

Dennis, A. and Wixom, B. (2009) *Systems Analysis and Design*. 4th Ed. International Student Version. John Wiley & Sons.

Dingsøyr, T., Tore Dybå, T. and Moe, N.B. (eds) (2010) *Agile Software Development: Current Research and Future Directions*. Springer.

Hoffer, J., George, J. and Valacich, J. (2015) *Essentials of Systems Analysis and Design*. Global Edition. Pearson.

Hoffer, J., George, J. and Valacich, J. (2013) *Modern Systems Analysis and Design*. Global Edition. Pearson Higher Ed.

Kenneth, K. and Kendall, J. (2013) *Systems Analysis and Design*. 9th Ed. Pearson.

Larman, C. (2004) *Agile and Iterative development: A Managers Guide*. Addison-Wesley Professional.

Martin, R. (2013) *Agile Software Development, Principles, Patterns, and Practice*. New International Edition. Pearson.

Journals

The Computer Journal

Journal of Systems Analysis and Software Engineering

Journal of Emerging Trends in Computing and Information Sciences

Websites

agilemodeling.com	Agile Modelling "Agile Analysis" (Article)
www.batimes.com	Resources for Business Analysts "Applying Agile Principles To Requirement Analysis" (Article)
www.sparcedge.com	SPARC "What an Agile Design Process Looks Like" (Article)
forty.co	Forty "Agile design: what we've learned" (Article)

Links

This unit links to the following related units:

Unit 6: Managing a Successful Computing Project

Unit 9: Software Development Lifecycles

Unit 35:   Network Management

Unit code	**Y/615/1679**
Unit level	**5**
Credit value	**15**

Introduction

Network Management has become one of the most sought-after skills for government institutions, commercial organisations, financial institutions as well as academic institutions as they try to run their IT networks in a more cost effective, efficient and secure way. The art of Network Management needs to be perfected by those in charge of networks for today and the future. This includes multimedia applications such as VoIP, IPTV and mobile network as well as virtualised environments.

This unit introduces students to simple network Planning, Configurations, Setup, and Management, including LAN, WAN, NAT, PAN, MAN, using a variety of tools and methods for managing Networks, including Network Monitoring, Network Security such as Snort, Firewalls & IPS, Network Protocols and standards such as SNMP, NETCONF, IEEE, MIBII, RMON, MDIB & ANS.1, as well as industry's best practices. Students will also be introduced to Virtual Networks, Network Operating Systems, Risk Management and Cloud Network Management.

Among the topics included in this unit are: Network Planning, Network Configurations, Network Setup and Network Management of LANs, PAN, MAN, WAN, NAT using several tools and methods; Network Monitoring, Network Security, Network Load Balancing, Network Protocols and Standards, Best Practices, Virtualisation, Network Operating Systems, Network Risk Management and Cloud Network Management.

On successful completion of this unit students will be able to plan a network, configure a network, setup a network, manage a network such as a LAN, PAN, MAN, WAN as well as conduct network monitoring, Network Security, network protocols and standards. Students will also be able to apply industry best practices, manage virtualised networks, work with several operating systems vendors and well as plan and manage network risks and 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.

Learning Outcomes

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

LO1. Explore the concepts and principles of Network Management.

LO2. Plan, Design, Setup and Configure a network.

LO3. Justify the Protocols and Standards concerned with Networking and Network Management.

LO4. Use tools and methods to manage a network, including Network Security and Risk Management.

Essential Content

LO1 Explore the concepts and principles of Network Management

Describe Network Management Concepts and Principles which deals effective network management, including different technologies, protocols and activities associated with Networking Management as well as how they relate to one another. You are also required to examine the Networking Management Principles, including self-learning networks, Service Levels Agreements (SLAs) as well as topologies and security.

LO2 Plan, Design, Setup and Configure a network

Network Planning:

Plan a network based on a given scenario.

Design a network:

Design a network based on a given scenario.

Setup a network:

Setup a network based on a given scenario.

Configure a Network environment:

Conduct configurations on your network, including setting up all devices.

LO3 Justify the Protocols and Standards concerned with Networking and Network Management

Network Protocols and Standards:

Protocols: SNMP, NETCONF, RMON, TCP/IP, HTTP, DNS, DHCP, SSL, IPSec.

Standards: IEEE, ITU, ISO, OSI, IANA.

LO4 **Use tools and methods to Manage a Network including Network Security and Risk Management**

Tools and methods:

NETCONF, CISCO, SNMP, RMON.

Network Security:

IPSec, HHTPs, FTPs, DNS, Firewall, Passwords, Cryptography.

Risk Management:

Risk Identification, Risk Mitigation, Risk Avoidance, Risk Management.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the concepts and principles of Network Management		**LO1 & LO2** **D1** Provide a comprehensive network configuration by providing screenshots of your work.
P1 Investigate Network Management concepts and principles.	**M1** Evaluate the importance of Network Management.	
LO2 Plan, Design, Setup and Configure a network		
P2 Produce a comprehensive design of a network according to a given scenario.	**M2** Implement a network design according to a predefined network specification.	
LO3 Justify the Protocols and Standards concerned with Networking and Network Management		**D2** Evaluate the role and functions of SNMP and RMON.
P3 Assess the following Network Protocols and Standards: SNMP, NETCONF, RMON, TCP/IP, HTTP, DNS, DHCP, SSL, IPSec, IEEE, ITU, ISO, OSI including IANA and ICANN.	**M3** Analyse the benefits and limitations of two Protocols.	
LO4 Use tools and methods to manage a network, including Network Security and Risk Management		**D3** Critically evaluate the importance of carrying out a Risk Assessment on a network.
P4 Use tools and methods to manage a network. **P5** Implement Network Security on your network. **P6** Conduct a Risk Assessment on your network.	**M4** Justify the importance of Network Security in a network.	

Recommended Resources

Textbooks

Anderson, A. and Benedetti, R. (2009) *Head First Networking*. O'Reilly Media.

Aschermann, R. (1999) *MCSE Networking Essentials for Dummies*. Foster City, IDG Books Worldwide.

Beauchamp, K.G. and Poo, G.S. (1995) *Computer Communications* (now out of print but in library). Thompson.

Comer, D. and Droms, R. (2003) *Computer Networks and Internets*. 4th Ed. Upper Saddle River: Prentice Hall.

Fitzgerald, J. and Dennis, A. (2006) *Business Data Communications and Networking*. 9th Ed. Hoboken. John Wiley.

Hallberg, B. (2005) *Networking: A Beginner's Guide*. 4th Ed. Osborne/McGraw-Hill.

Hallberg, B. (2013) *Networking: A Beginner's Guide*. 6th Ed. McGraw-Hill Osborne.

Harrington, J.L. (1999) *Ethernet Networking Clearly Explained*. Morgan Kaufman.

Kurose, J.F. and Ross, K.W. (2001) *Computer Networking: A Top-Down Approach Featuring the Internet*. London: Addison-Wesley.

Lowe, D. (2005) *Networking All-in One Desk Reference for Dummies*. 2nd Ed. Hungry Minds Inc.

Lowe, D. (2012) *Networking All-in-One For Dummies*. 5th Ed. John Wiley & Sons.

Olifer, N. and Olifer, V. (2005) Computer Networks: Principles, Technologies and Protocols for Network Design. John Wiley and Sons Ltd.

Reid, A. (2006) *WAN Technologies CCNA 4 Companion Guide*. Cisco Press.

Spurgeon, C. and Zimmerman, J. (2014) *Ethernet: The Definitive Guide*. 2nd Ed. O'Reilly Media.

Stallings, W. (2003) *Data and Computer Communications*. 7th International Ed. Upper Saddle River: Prentice Hall.

Subramanian, M. (2000) *Network Management: An Introduction to Principles and Practice*. Addison-Wesley.

Subramanian, M. (2000) *Network Management: Principles and Practice*. Harlow: Addison-Wesley.

Tanenbaum, A. and Wetherall, D. (2013) *Computer Networks*. 5th Ed. Pearson.

Websites

www.ietf.org	Internet Engineering Task Force (General Reference)
www.itu.int	International Telecommunication Union (General Reference)
www.iso.org	International Organisation for Standardisation (General Reference)
www.tmforum.org	TeleManagement Forum (General Reference)
www.dmtf.org	Distributed Management Task Force (General Reference)

Links

This unit links to the following related units:

Unit 2: Networking

Unit 8: Computer Systems Architecture

Unit 15: Transport Network Design

Unit 17: Network Security

Unit 36: Client/Server Computing Systems

Unit 36: Client/Server Computing Systems

Unit code	**L/615/1680**
Unit level	**5**
Credit value	**15**

Introduction

The client/server system is a distributed application structure that partitions tasks or workloads between the providers of a resource or service (called servers) and service requesters (called clients). It is the basis of most internet communication. When surfing the internet, sending/receiving emails, using VoIP software and other applications, these functions work by using client/server systems.

This unit introduces students to the client/server system, an exchange mode for different applications. It consists of communication processes between clients and servers, the operation of applications based on the client/server system, and the socket programming used to code the system.

Among the topics included in this unit are: an introduction to the internet (concept, history, operation), client/server systems, various application protocols based on client/server systems, an introduction to Linux, client/server system programming, security considerations.

On successful completion of this unit students will be able to demonstrate an understanding of the concepts of servers, clients, and processes; illustrate different application protocols based on a client/server model (such as the meaning of http in a website address, POP/IMAP in email); reconstruct a client/server model in Linux systems.

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 competences.

Learning Outcomes

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

LO1. Explore the concepts of servers, clients, and processes and the differences between PPID and PID.

LO2. Analyse the communication processes between clients and servers in different application protocols with records captured from the internet.

LO3. Create a client/server model in a Linux system with User Datagram Protocol (UDP), Transmission Control Protocol (TCP) and Application Layer protocols.

Essential Content

LO1 Explore the concepts of servers, clients, and processes and the differences between PPID and PID

Introduction to the structure of Open Systems Interconnection model (OSI model) and the operation of Transmission Control Protocol/Internet Protocol (TCP/IP).

Basic concepts of client, server, process.

Introduction to the concept and function of Sockets Interface.

The communication process between servers and clients (e.g. echo server process).

Measures to ensure server security.

LO2 Analyse the communication processes between clients and servers in different application protocols with records captured from the internet

Typical internet applications.

The concept, function, communication process based on the client/server system, and applications of following protocols:

Domain Name System (DNS).

Dynamic Host Configuration Protocol (DHCP).

Remote Interactive Computing: TELNET/ Secure Shell (SSH).

Email: Simple Mail Transfer Protocol (SMTP)/ Post Office Protocol (POP)/Internet Message Access Protocol (IMAP)/ Multipurpose Internet Mail Extensions (MIME).

File Transfer and Access: File Transfer Protocol (FTP)/ Trivial File Transfer Protocol (TFTP)/ Network File System (NFS).

World Wide Web: Hypertext Transfer Protocol (HTTP).

Network Management: Simple Network Management Protocol (SNMP).

Introduction to the Wireshark:

Function, history, install Wireshark, interface, and operation.

LO3 Create a client/server model in a Linux system with User Datagram Protocol (UDP), Transmission Control Protocol (TCP) and Application Layer protocols

Introduction of Linux:

Introduction to the Linux system: concept, history, advantages and disadvantages.

Basics–Linux command, the way to compile, the debugging method.

Programming of client/server program:

Socket Programming in Linux, including socket operation, byte order operation, address formats conversion, socket option, name and address operation, secure coding.

Simple UDP client / server program: UDP-based socket API, UDP-based client, UDP-based server.

Simple TCP client / server program: TCP-based socket API, TCP-based client, TCP-based server.

Application programming, such as a DNS server/client system.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the concepts of servers, clients, and processes and the differences between PPID and PID		**LO1 & LO2**
P1 Illustrate the communication processes between servers and clients. **P2** Compare parent process and child process, PID and PPID.	**M1** Recognise parent process and child process in a communication record (such as the records obtained by Wireshark) between servers and clients. **M2** Design a model composed of parent process and child process to realise a simple function.	**D1** Design a realistic model to realise a function in real life using an Application Layer protocol.
LO2 Analyse the communication processes between clients and servers in different application protocols with records captured from the internet		
P3 Examine the concepts and functions of several Application Layer protocols. **P4** Operate Wireshark software, and recognise the different windows in the Wireshark interface.	**M3** Illustrate the communication processes of Application Layer protocols based on the client/server system. **M4** Analyse communication records captured from the internet based on Application Layer protocols.	

Pass	Merit	Distinction
LO3 Create a client/server model in a Linux system with User Datagram Protocol (UDP), Transmission Control Protocol (TCP) and Application Layer protocols		
P5 Create a UDP system in Linux. **P6** Create a TCP system in Linux.	**M5** Build a system with DNS and illustrate it by a flowchart. **M6** Implement the created DNS system in Linux.	**D2** Implement the system with some advanced functions such as breakpoint resume.

Recommended Resources

Textbooks

Comer, D. (2013) *Internetworking with TCP/IP Volume I Principles, Protocols and Architecture*. 6th Ed. Pearson.

Comer, D. (2000) *Internetworking with TCP/IP, Vol. III: Client-Server Programming and Applications*. Linux/Posix Sockets Version. 1st Ed. Pearson.

Edwards, J. and Bramante, R. (2009) *Networking Self-Teaching Guide: OSI, TCP/IP, LANs, MANs, WANs, Implementation, Management, and Maintenance*. 1st Ed. Wiley.

Johansen, A. (2015) *LINUX: The Ultimate Beginner's Guide!* CreateSpace Independent Publishing Platform.

Links

This unit links to the following related units:

Unit 2: Networking

Unit 8: Computer Systems Architecture

Unit 15: Transport Network Design

Unit 17: Network Security

Unit 35: Network Management

Unit 49: Operating Systems

Unit 37: Architecture

Unit code	**R/615/1681**
Unit level	**5**
Credit value	**15**

Introduction

The aim of this unit is to provide students with knowledge about computer systems, functionality and organisation. Systems architecture and elements of computing machines will be examined and the principles and fundamentals of how computer systems work. Computer architecture engineers work in industries such as telecoms, automotive and aerospace.

This unit introduces students to the hardware and software architecture of computer systems and low-level language program development using CPU registers to manipulate data. Students will explore how program instructions and data types can be represented, stored in a computer system and used to carry out a computing task.

Among the topics included in this unit are: computer architecture elements, CPU instruction sets, fetch-execute cycle, CPU registers, binary calculations, use of PC and stack, reading/writing to peripherals, architectural security aspects including protected memory segmentation and synchronous/asynchronous channel I/O operations, parallel machines, emerging computer architectures and security considerations.

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 the unit students will be able to:

LO1. Examine the functions of computer system components.

LO2. Discuss how data and programs can be represented within computer systems.

LO3. Demonstrate the principles of processor operations.

LO4. Investigate advanced computer architectures and performance.

Essential Content

LO1 Examine the functions of computer system components

Component functions:

Logical/physical component functions; Clock Synchronisation; Processor (CPU), buses, memory maps and IRQ; Boolean logic gates; adder circuits; analysis of how components interact to carry out the fetch-execute cycle and modify data; definition and use of CPU registers. I/O device memory.

LO2 Discuss how data and programs can be represented within computer systems

Data/program representation:

Program/data representation and storage; description, use and storage of data types integer, decimal and character; absolute/relative program location; firmware/software.

LO3 Demonstrate the principles of processor operations

Principles of processor operations:

Low-level program instruction sets; RISC; development of assembler programs (including at least 1 JMP instruction) to manipulate stored data using CPU registers; I/O memory and IRQ locations.

LO4 Investigate advanced computer architectures and performance

Advanced Architectures:

Advanced Architectures; MIMD parallelism (Flynns Taxonomy), Cache, instruction/graphics pipelining; unconventional architectures; benchmarking; functional unit mix, IRQ latency.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the functions of computer system components		**D1** Evaluate through illustration how the processor is physically connected to memory and input/output (I/O) devices using the system buses.
P1 Investigate the key computer system components and how they interact. **P2** Show how the different types of memory can be attached to a processor.	**M1** Compare the roles played by different types of memory.	
LO2 Discuss how data and programs can be represented within computer systems		**D2** Evaluate how locating a program absolutely in memory can aid ICE target system debugging.
P3 Investigate, using examples, how different types of data can be converted and stored in computer systems. **P4** Carry out Boolean logic operations.	**M2** Show how, using examples, floating point numbers can be represented in binary form. **M3** Illustrate how adder circuits are used to add binary numbers.	

Pass	Merit	Distinction
LO3 Demonstrate the principles of processor operations		**D3** Examine how the width of the data bus and address bus affect processor performance and complexity.
P5 Illustrate the use of the different processor registers in the fetch execute cycle. **P6** Illustrate, with an example, how polling and interrupts are used to allow communication between processor and peripherals.	**M4** Create a low-level program which includes decision making, branching and I/O operations. **M5** Investigate the function of an interrupt handler.	
LO4 Investigate advanced computer architectures and performance		**D4** Critically evaluate, with illustrations, computer performance improvements with MIMD architectures.
P7 State the function of DirectX API, describing its advantages and disadvantages.	**M6** Assess how instruction pipelining modifies the performance of a computer system. **M7** Evaluate how the DirectX API is used by application programmers to control graphics functions.	

Recommended Resources

Textbooks

Adamatzky, A. (2013) *Collision Based Computing*. Springer.

Blum, R. (2005) *Professional Assembly Language Programming*. John Wiley & Sons.

Gaura, E., Hibbs, D. and Newman, R. (2008) *Computer Systems Architecture*. Lexden.

Links

This unit links to the following related units:

Unit 8: Computer Systems Architecture

Unit 36: Client/Server Computing Systems

Unit 38: Database Management Systems

Unit code	**Y/615/1682**
Unit level	**5**
Credit value	**15**

Introduction

As globalisation and the 24-hour economy develop and increase, organisations must ensure that their database management systems (DBMS) are reliable, secure, efficient and able to cope with rapid change. Database management systems will continue to service the many operations of our modern world; they are becoming increasingly complex, to develop and manage, due to technological advancements and changes in the way organisations do their business in a global market.

In this unit, students will examine the structure of data, and how an efficient data design follows through into an effectively developed database management system. Students will examine the merits of different DBMS platforms, and investigate system administration and management tools of the platform.

Amongst the topics included in this unit are: examination of different database management systems, database design tools and techniques of relational database management systems, using an open source platform to develop, test and manage a client's system.

On successful completion of this unit students will be able to demonstrate their knowledge of the fundamentals of database management systems, be able to make informed choices between vendor and open source platforms for database management systems, design and develop a relational DBMS for a client using an open source platform, and carry out system administration tasks.

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:

LO1. Analyse different types of database management systems.

LO2. Design a database management system using a relational model to meet client requirements.

LO3. Develop a database management system using a suitable platform.

LO4. Demonstrate the system administration and management tools available on the chosen platform

Essential Content

LO1 Analyse different types of database management systems

Types of database management systems (DBMS) and their operating system support, e.g. MySQL, Oracle.

Data models: Entity-Relationship, relational, hierarchical, network, object-oriented, object-relational.

Examine details of DBMS based on a relational model.

Relational data structures, including: relations, attributes, domain, tuple, cardinality.

Constraints: key, domain, referential integrity.

Normalisation in developing efficient data structures.

Modelling languages: query language, data definition language (DDL), data, manipulative language (DML), relational languages.

Transaction and concurrency in DBMS.

Investigation of open source and vendor-specific systems.

Multiple platform approaches to database management.

LO2 Design a database management system using a relational model to meet client requirements

Determine user and system requirements.

Examine design tools and techniques for a relational database management system.

Physical system design.

Logical design: design for relational databases, tables, data elements, data types, keys and indexes, entity relationship modelling, data flow diagrams, flowcharts.

Mathematical relations e.g. relational algebra, relational calculus.

DBMS selection, e.g. MySQL.

Application design, including: data entry/input (verification, validation, calculated fields, masks, directed input), reports (queries, presentation of data, layouts), task automation (imports, updates, deletions), queries using multiple criteria, form values and wild cards, action queries, calculated queries, queries across multiple tables.

Hardware, software and other resource requirements.

Test plans to check correctness of data, security, functionality, accessibility and usability.

Quality, effectiveness and appropriateness of the solution: correctness of data, relationships between data, data integrity, normalisation.

Working with clients and others to improve the quality, effectiveness, security and appropriateness of solution design

LO3 **Develop a database management system using a suitable platform**

Use of an appropriate database management system and Structured Query Language (SQL) to produce a secure solution to meet client's requirements.

Creating, setting up and maintaining data tables.

Applying data validation rules.

Generating outputs e.g. user-generated queries, automated queries, reports.

Application and user interface e.g. navigation, data entry forms and sub-forms, automated functions.

Populating the database.

SQL statements to extract, manipulate and modify data.

Applying security measures to control access to data, e.g. user access levels.

Testing the database solution using different types of testing: referential integrity, functionality, security, stability.

Selection and use of appropriate test data.

Selecting suitable test users and gathering feedback from users.

Making use of testing outcomes to improve and/or refine the solution.

Reviewing the solution, criteria for use when reviewing the solution against: quality of the database, fitness for purpose, suitability against the original requirements, technology constraints, strengths and improvements, platforms and compatibility.

Optimising the solution: data types, data sizes e.g. size on disk, many tables e.g. overheads for many tables, query optimising.

LO4 **Demonstrate the system administration and management tools available on the chosen platform**

Describe core database administration tasks and tools.

Practical demonstrations of server management to include:

Setting up and managing data storage for servers and users.

Backup and recovery routines for data and applications.

Managing authorisations.

Managing security and encryption.

Importing and exporting data.

Trace database activity.

Monitoring performance and optimising performance.

Audit trails.

Managing alerts and notifications.

Database maintenance including setting up automatic routines.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse different types of database management systems		**D1** Critically evaluate different database management systems available in relation to open source and vendor-specific platforms, justifying the criteria used in the evaluation.
P1 Compare and contrast the different types of database models.	**M1** Assess how relational database models and the process of normalisation can provide reliable and efficient data structures.	
LO2 Design a database management system using a relational model to meet client requirements		**LO2 & LO3**
P2 Produce a design for a relational database management system to meet client requirements.	**M2** Analyse how the design will optimise system performance.	**D2** Critically evaluate the effectiveness of the system design and development against client and system requirements.
LO3 Develop a database management system using a suitable platform		
P3 Develop a fully functional system which meets client and system requirements, using an open source language (with an application software e.g. MySQL with front end Microsoft Access). **P4** Test the system for functionality and performance.	**M3** Implement effective features in the solution to handle concurrency, security, user authorisations and data recovery.	

Pass	Merit	Distinction
LO4 Demonstrate the system administration and management tools available on the chosen platform		
P5 Demonstrate the tools available in the system to monitor and optimise system performance, and examine the audit logs. **P6** Demonstrate the tools available in the system to manage security and authorisations.	**M4** Assess the effectiveness of the system administration and management tools available on the platform identifying any shortcomings of the tools.	**D3** Analyse any future improvements that may be required to ensure the continued effectiveness of the database system.

Recommended Resources

Textbooks

Connolly, T. and Begg, C. (2014) *Database systems: A practical guide to design, implementation and management*. 3rd Ed. Addison-Wesley.

Elmasri, R. and Navathe, S. (2011) *Fundamentals of Database Systems*. 6th Ed. Addison-Wesley.

Hoffer, J. (2008) *Modern Database Management*. Pearson Education.
Jeffrey A., Ramesh, V. and Topi Heikki, T. (2012) *Modern Database Management*. Pearson Education.

Silberschatz, A., Korth, H.F. and Sudarshan, S. (2011) *Database System Concepts*. 6th Ed. McGraw-Hill Edition.

Plus others linked specifically to the version of the software used for a given platform.

Journals

International Journal of Database Management Systems

Journal of Database Management

The Computer Journal

Journal of Emerging Trends in Computing and Information Sciences

Links

This unit links to the following related units:

Unit 4: Database Design & Development

Unit 7: Strategic Information Systems

Unit 39: 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:

LO1. Examine the strategies employed and the impact of E-Commerce on business organisations.

LO2. Analyse the hardware, software, web-based and database technologies involved in setting up a secure E-Commerce site.

LO3. Design an E-Commerce strategy based on a given end user requirement or specification.

LO4. 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
LO1 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.
LO2 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.
LO3 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.	

Pass	Merit	Distinction
LO4 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 requirement or 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 4: Database Design & Development

Unit 14: Business Intelligence Systems

Unit 38: Database Management Systems

Unit 40:   User Experience and Interface Design

Unit code	**H/615/1684**
Unit level	**5**
Credit value	**15**

Introduction

User Experience (UX) and User Interface (UI) Design is the process by which software applications and user interactions can be designed to be simple, accessible, effective and attractive for the end user. The objective of UX and UI Design is to create user interactions and software application experiences that are appropriate for specific platforms or devices and provide desirable end user outcomes utilising insight and understanding about the practical, emotional and experiential motivations and values of the end user. UX and UI Design explores the motivations and desires of the end user and seeks to design user's interactions that best satisfy those motivations and desires in a concise manner.

This unit introduces students to the role, basic concepts and benefits of UX and UI Design in the development process of software applications. The aim of the unit is to enhance the student's understanding of the methodology, terminology and benefits of UX and UI Design in the development of software applications.

Among the topics included in this unit are: classification and terminology of UX and UI Design techniques, the relationship between UX and UI Design, how UX and UI Design relates to the rest of the software development lifecycle, understand a user's emotions, desires and attitudes about using a particular feature, product, system, platform or software application, modes of interaction, human-computer interaction models, usability, accessibility, aesthetics, design thinking, value proposition design, user journey mapping and gathering meaningful insights from users feedback and research.

On successful completion of this unit students will be able to explain the basic concepts of UX and UI Design. Plan, build and measure the success of an appropriate UI Design. Design an interface and experience with a specific end user in mind. Conduct testing to gather meaningful feedback to evaluate the success or failure of a user interface. 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:

LO1.   Research what aspects of User Experience and Interface Design are necessary and appropriate to satisfy end user emotions, desires and attitudes when using a user interface concept.

LO2.   Plan an appropriate User Experience map and Interface Design for a User Interface concept with a specific target end user in mind and also outline the tests you mean to conduct.

LO3.   Build a User Interface concept and test it with users to see if it satisfies their emotions, desires and attitudes as planned.

LO4.   Evaluate user feedback, test results and insights gained from end users interacting with your User Interface concept to determine success or failure and steps to improve in future versions.

Essential Content

LO1 Research what aspects of User Experience and Interface Design are necessary and appropriate to satisfy end user emotions, desires and attitudes when using a user interface concept

Identify formats, characteristics and appropriateness of UX and UI Design

Present an overview of UX and UI Design, how they are produced and their appropriate use in software development.

Identify what UX and UI Design is by researching the role, purpose, terminology and methodology of UX and UI Design.

Recognise the various forms of UX and UI Design by researching the history of, current trends and use in the product development lifecycle.

Recognise the use of appropriate UX and UI Design patterns.

Define the characteristics of UX and UI Designs by investigating how they can be used to satisfy end user emotions, desires and attitudes.

Recognise specific forms, patterns and trends of UX and UI Design:

Research, debate and agree current functionality, patterns and trends in UX and UI Design.

Identify various forms of UX and UI Design.

Define the advantages and disadvantages of using UX and UI Design.

Define standard tools available for use in UX and UI Design:

Identify standard tools available to create UX and UI Designs.

The advantages and disadvantages of UX and UI Design tools.

How UX and UI Design tools can be used to capture end user feedback.

Appropriateness of various tools for different end user testing outcomes.

LO2 Plan an appropriate User Experience map and Interface Design for a User Interface concept with a specific target end user in mind and also outline the tests you mean to conduct

Identify a specific end user and an appropriate UX and UI Design to test with this user type:

Choose a specific end user to conduct tests against.

Evaluate the benefits, features, advantages and disadvantages of different UX and UI Design methodologies for various end user testing outcomes.

Review different end user categorisations, classifications and behaviour modelling techniques.

Select the most appropriate form of UX and UI Design to achieve desired end user testing and outcomes.

Describe a plan to use appropriate UX and UI Design methodology and tools to conduct end user testing:

Apply end user classification and behaviour modelling to select an appropriate UX and UI Design methodology.

Outline the end user characteristics, desired testing criteria and results your UX and UI Design addresses.

Select an appropriate form of UX and UI Design necessary to achieve desired results.

Use your selected end user, appropriate UX and UI Design methodology and desired testing criteria to create a plan for a UI concept.

LO3 Build a User Interface concept and test it with users to see if it satisfies their emotions, desires and attitudes as planned

Utilise appropriate tools to develop a UX and UI Design:

Employ an appropriate set of tools to develop your plan into a UI.

Run end user experiments and examine feedback.

Reconcile and evaluate end user feedback and build a new iteration of your user interface modified with the most important feedback and enhancements.

Make multiple iterations of your user interface and modify each iteration with enhancements gathered from user feedback and experimentation.

LO4 Evaluate user feedback, test results and insights gained from end users interacting with your User Interface concept to determine success or failure and steps to improve in future versions

Asses the success of your UX and UI Design:

Assemble and appraise end use feedback from multiple iterations of your user interface.

Undertake a critical review and compare your final user interface and your test results with the original plan.

Evaluate the advantages, disadvantages, strengths and weaknesses of your UX and UI Design methodology.

Critique the overall success of your UI and discuss your UX insights.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Research what aspects of User Experience and Interface Design are necessary and appropriate to satisfy end user emotions, desires and attitudes when using a user interface concept		
P1 Recognise specific forms of User Experience and Interface Design and end user testing requirements. **P2** Assess standard tools available for use in User Experience and Interface Design.	**M1** Analyse the impact of common User Experience and Interface Design methodology in the software development life cycle. **M2** Review specific forms of User Experience and Interface Design and advantages and disadvantages of end user testing requirements for appropriateness to different testing outcomes.	**D1** Evaluate specific forms of User Experience and Interface Design and justify their use in a User Interface concept.

Pass	Merit	Distinction
LO2 Plan an appropriate User Experience map and Interface Design for a User Interface concept with a specific target end user in mind and also outline the tests you mean to conduct		**LO2 & LO3** **D2** Make multiple iterations of your User Interface concept and modify each iteration with enhancements gathered from user feedback and experimentation.
P3 Review different end user categorisations, classifications and behaviour modelling techniques. **P4** Appraise a specific end user and an appropriate User Experience and Interface Design methodology to test with this user type.	**M3** Apply end user classification and behaviour modelling to select an appropriate Interface Design methodology. **M4** Devise a plan to use appropriate User Interface Design methodology and tools to conduct end user testing.	
LO3 Build a User Interface concept and test it with users to see if it satisfies their emotions, desires and attitudes as planned		
P5 Examine appropriate tools to develop a user interface. **P6** Run end user experiments and examine feedback.	**M5** Employ an appropriate set of tools to develop your plan into a user interface. **M6** Reconcile and evaluate end user feedback and build a new iteration of your user interface modified with the most important feedback and enhancements.	
LO4 Evaluate user feedback, test results and insights gained from end users interacting with your User Interface concept to determine success or failure and steps to improve in future versions		
P7 Evaluate end use feedback from multiple iterations of your user interface. **P8** Suggest steps to improve in future versions of your UI.	**M7** Undertake a critical review and compare your final user interface and your test results with the original plan.	**D3** Critically evaluate the overall success of your User Interface concept and discusses your insight using prototyping.

Recommended Resources

Textbooks

Hanington, B. (2013) *Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions*. Rockport Publishers.

Kalbach, J. (2015) *Mapping Experiences: A Complete Guide to Creating Value through Journeys, Blueprints, and Diagrams*. 1st Ed. O'Reilly Media.

Lidwell, W. (2010) *Universal Principles of Design, Revised and Updated: 125 Ways to Enhance Usability, Influence Perception, Increase Appeal, Make Better Design Decisions, and Teach through Design*. 2nd Ed. Rockport Publishers.

Tidwell, J. (2011) *Designing Interfaces.* 2nd Ed. O'Reilly Media.

Links

This unit links to the following related units:

Unit 10: Website Design & Development

Unit 28: Prototyping

Unit 41: Analytic Architecture Design

Unit code	**T/615/1687**
Unit level	**5**
Credit value	**15**

Introduction

Aircraft, trains and other high-tech machines improve our quality of life – none of these could function without automatic systems. The ability to analyse and design an automatic system is a vital subject. Architecture Analysis & Design Language (AADL) is designed for the specification, analysis, automated integration and code generation of real-time performance-critical (timing, safety, schedulability, fault tolerant, security, etc.) distributed computer systems.

This unit introduces students to the AADL. It provides an introduction to the language and AADL specifications, which is defined in the Society of Automotive Engineers (SAE) standard. The SAE AADL standard provides formal modelling concepts for the description and analysis of application systems architecture in terms of distinct components and their interactions. Within the AADL, a component is characterised by its identity, possible interfaces with other components, distinguishing properties, subcomponents and their interactions. The AADL is a useful tool to model and analyse the existing systems, but also design and integrate new systems.

Among the topics included in this unit are: AADL overview, system models and specification, security, components (software components, execution platform components), structure and instantiation, mode and flow, and properties.

On successful completion of this unit students will be able to describe the abstractions that support the specification of component interactions; present the specification of alternative operational states of a system; describe the use of the AADL flows concept and present examples of the specification of abstract flows throughout a system; describe the constructs for organising an AADL specification. It includes examples of AADL architectural pattern sets.

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:

LO1.   Explore detailed and problem-oriented material and gain a conceptual overview of the AADL abstractions.

LO2.   Illustrate the software component and execution platform component abstractions, and provide example declarations for these components.

LO3.   Analyse the specification of composite systems and their instances, and describe the abstractions that support the specification of component interactions.

LO4.   Show the specification of alternative operational states of a system by AADL flow concepts, and describe modes mode transitions, and examples of specification.

Essential Content

LO1 Explore detailed and problem-oriented material and gain a conceptual overview of the AADL abstractions

AADL overview (concept, history, applications).

Abstractions:
Basic component of AADL, utilisation of AADL.

System models and specification:
Introduction to architectural analysis and AADL architecture.

LO2 Illustrate the software component and execution platform component abstractions, and provide example declarations for these components

Software components:
Introduction to the AADL software component, the way to describe data, subprogram and thread, different representations of software component.

Execution platform component:
Introduction to the AADL hardware component, the way to describe Processor, Memory, Bus and Device, different representations of software component.

LO3 Analyse the specification of composite systems and their instances, and describe the abstractions that support the specification of component interactions

System abstraction:
Textual and graphical representations of system.

System instance:
The way to create system instance and implementation.

Component interactions:
Introduction to the connection between interface elements, implement the port and the access in the system design.

Subcomponent:

Introduction to implementation of the subcomponents in system, and the access of data in difference subcomponents.

Software components:

Implementation of software components in system design.

Execution platform components:

Implementation of execution platform components in system design.

LO4 **Show the specification of alternative operational states of a system by AADL flow concepts, and describe modes mode transitions, and examples of specification**

Modes and Flow; Properties; Structure and Instantiation.

Model specifications:

Basic introduction to the modes and the representations of modes.

Model configurations:

Thread with control system, modes in calls sequences.

Flow declarations:

Introduction basic flow concept and element.

Flow paths:

Flow paths of different components in flow design, including secure features.

Property declarations:

Idea of property and declarations about the property.

System abstraction.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore detailed and problem-oriented material and gain a conceptual overview of the AADL abstractions		
P1 Interpret the basic concept of elements and the methods of AADL, and analyse an example using AADL. **P2** List the advantages and disadvantages of using AADL.	**M1** Design and build a system using AADL to realise a specific function. **M2** Distinguish the different AADL representations.	**LO1 & LO2** **D1** Critically analyse components, physical design and logical elements.
LO2 Illustrate the software component and execution platform component abstractions, and provide example declarations for these components		
P3 Present a software component using different representations. **P4** Distinguish the software components and execution platform components in a system.	**M3** Declare components under AADL specification. **M4** Implement different components in a system.	

Pass	Merit	Distinction
LO3 Analyse the specification of composite systems and their instances, and describe the abstractions that support the specification of component interactions		
P5 Design a system that consists of various types of elements. **P6** Discuss the advantages and weak points of the system designed in P5.	**M5** Present the design logic and the relationships between components in the design process. **M6** Illustrate data interaction processes between components and analyse the data communication in the whole system.	**LO3 & 4** **D2** Evaluate the system designed, critiquing the flow methods and selection of elements used.
LO4 Show the specification of alternative operational states of a system by AADL flow concepts, and describe modes mode transitions, and examples of specification		
P7 Design system in flow and modes format. **P8** Recognise different flows and identify the operating process.	**M7** Provide relevant information in design process of flow, such as basic ideas, selection of elements. **M8** Present the contracture of organising an AADL specification.	

Recommended Resources

Textbooks

Feiler, P., Lewis, B., Vestal, S. and Colbert, E. (2005) *An Overview of the SAE Architecture Analysis & Design Language (AADL) Standard: A Basis for Model-Based Architecture-Driven Embedded Systems Engineering*. 1st Ed. Springer.

Gluch, D. and Feiler, P. (2012) *Model-Based Engineering with AADL: An Introduction to the SAE Architecture Analysis & Design Language*. 1st Ed. Addison-Wesley Professional.

Kordon, F., Hugues, J., Canals, A. and Dohet, A. (2013) *Embedded Systems: Analysis and Modeling with SysML, UML and AADL*. 1st Ed. Wiley-ISTE.

Links

This unit links to the following related units:

Unit 20: Advanced Programming

Unit 42:   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:

LO1. Examine risk-based testing and requirements.

LO2. Create a customised risk-based test strategy, plans and techniques for a given specification.

LO3. Demonstrate a risk-based Test Plan, producing associated outcomes.

LO4. 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		**LO1 & LO2**
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.	

Pass	Merit	Distinction
LO3 Demonstrate a risk-based Test Plan, producing associated outcomes		**D2** Assess the importance of a suitable build environment to support a risk-based test strategy.
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.	
LO4 Evaluate a risk-based Test Plan and its associated outcomes		**D3** Examine how test risk heuristics are identified, evaluated and monitored in a risk based test strategy, providing justification.
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.	

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 9: Software Development Lifecycles

Unit 43: 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:

LO1. Analyse what aspects of IoT are necessary and appropriate when designing software applications.

LO2. Outline a plan for an appropriate IoT application using common architecture, frameworks, tools, hardware and APIs.

LO3. Develop an IoT application using any combination of hardware, software, data, platforms and services.

LO4. 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 use 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			**D1** Evaluate specific forms of IoT architecture and justify their use 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.		
LO2 Outline a plan for an appropriate IoT application using common architecture, frameworks, tools, hardware and APIs			**LO2 & LO3** **D2** Make multiple iterations of your IoT application and modify each iteration with enhancements gathered from user feedback and experimentation.
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.		
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
LO4 Evaluate your IoT application and the problems it might encounter when integrating into the wider IoT ecosystem		
P7 Review your IoT application detailing the problems it solves. **P8** Assess the potential impacts of your IoT application on people, business and society and the end user. **P9** Investigate the potential problems your IoT application might encounter when integrating into the wider system.	**M6** Undertake a critical review and compare your final application with the original plan.	**D3** Critically evaluate the overall success of your application.

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 29: Application Program Interfaces

Unit 45: Emerging Technologies

Unit 44: Robotics

Unit code	**F/615/1692**
Unit level	**5**
Credit value	**15**

Introduction

Robots are becoming much more widely used, with applications ranging from agriculture through to manufacturing, including an increasing interest in autonomous systems. These are mechanical devices produced in various forms, including human form. Robots can move by themselves, and their motion can be modelled, planned, sensed, actuated and controlled by programming.

This unit is designed to explore robotic systems, both historically and as an area of rapid contemporary development. The student will be introduced to the different types and applications of robotic systems and will be encouraged to discuss and reflect on the implications of using robots

Topics included in this unit are an introduction to robotic systems, types of robots, industrial robots, automation system components, developing a solution, sensors, and sensor-based robots, ethical considerations, safety, social and economic impacts.

On successful completion of this unit, students will gain experience in building a robot and be exposed to a wide range of practical applications of robotic systems. 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:

LO1. Explore different robotic systems commonly used in industry, taking into account different configurations and the advantages and disadvantages of these.

LO2. Build a robot and appraise this from the perspectives of cost-benefit impact.

LO3. Evaluate the operation and application of a range of sensors (e.g. vision, tactile) and how they can apply to a mobile or static robotic system.

LO4. Evaluate the relevance of biologically inspired robotic systems and how these can benefit both the understanding of biological systems and the design of individual or groups of robots.

Essential Content

LO1 Explore different robotic systems commonly used in industry, taking into account different configurations and the advantages and disadvantages of these

Introduction to robotics:

Types and applications of robotics, why robots are important.

Industrial robotics:

Applications of robotics to industries, including medical, surgical and rehabilitation robotics.

Advantages and disadvantages, safety, security, social and economic impacts, and ethical issues of robots.

LO2 Build a robot and appraise this from the perspectives of cost-benefit impact

Components and instruction to build:

Classification of types of robot; identification of manipulator components and terminology; joints classification, compactor, digital millimeter, robot-line followings, battery, register, LEDs, DC motor, etc.

LO3 Evaluate the operation and application of a range of sensors (e.g. vision, tactile) and how they can apply to a mobile or static robotic system

Sensors:

Range of sensors, their components and compatibilities.

Tactile sensors:

Construction of tactile, and touch sensors, interpretation of sensory information, use of sensory data to determine kinematic information.

Vision systems:

Computer vision, perception, optical flow, road car and quad-copter navigation.

LO4 **Evaluate the relevance of biologically inspired robotic systems and how these can benefit both the understanding of biological systems and the design of individual or groups of robots**

Biologically inspired robotics:

Types of biologically inspired robotics, humanoid robots, bio-inspired morphologies, reactive and deliberative control, learning behaviours; multi-robot and swarm systems.

Reflection:

How does the robot help to understand biological systems? How do biological systems help to design a robot?

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore different robotic systems commonly used in industry, taking into account different configurations and the advantages and disadvantages of these		**LO1 & LO2** **D1** Critically evaluate the social and ethical impact of using these robots.
P1 Analyse the types of robots and their use in industry. **P2** Discuss the advantages and disadvantages of using these robots.	**M1** Choose an industry and critically evaluate the use of robotics in that industry and the benefits of using them.	
LO2 Build a robot and appraise this from the perspectives of cost-benefit impact		
P3 Assess all the components which are used to build a simple robot. **P4** Build a fully functional simple robot.	**M2** Discuss the construction process and explain the cost-benefit impact.	

Pass	Merit	Distinction
LO3 Evaluate the operation and application of a range of sensors (e.g. vision, tactile) and how they can apply to a mobile or static robotic system		**LO3 & LO4**
P5 Evaluate a range of sensors and their use. **P6** Embed a sensory system for the robot built in P4, to enhance the robots intelligence.	**M3** Critically analyse the construction process and explain the benefit of this upgrade.	**D2** Evaluate the impact of the chosen biologically inspired techniques used in the robot and detail the behavioural changes of the robot.
LO4 Evaluate the relevance of biologically inspired robotic systems and how these can benefit both the understanding of biological systems and the design of individual or groups of robots		
P7 Evaluate the range of biologically inspired techniques which can be embedded within a robot. **P8** Discuss how a biologically inspired robot can be used to study the understanding of the biological system.	**M4** Choose a biologically inspired technique and analyse how the robot behaves after embedding the technique in the robot.	

Recommended Resources

Textbooks

Backstop Media and Waldron, R. (2015) *JavaScript Robotics: Building NodeBots with Johnny-Five, Raspberry Pi, Arduino, and BeagleBone*. Maker Media.

Band, T., Mihelj, M., Lenarcic, J., Stanovnik, A. and Munih, M. (2010) *Robotics*. Springer, London.

Ceceri, K. (2015) *Making Simple Robots*. Make Publications.

Cook, D. (2015) *Robot Building for Beginners*. 3rd Ed. Apress.

Corke, P. (2011) *Robotics: Vision and control*. Springer. Berlin.

Donat, W. (2014) *Make a Raspberry Pi-Controlled Robot: Building a Rover with Python, Linux, Motors, and Sensors*. Maker Media.

Grimmett, R. (2014) *Arduino Robotic Projects*. Packt Publishing.

Grimmett, R. (2015) *Raspberry Pi Robotics Essentials*. Packt Publishing.

Grimmett, R. (2015) *Raspberry Pi Robotics Projects*. 2nd Ed. Packt Publishing.

Siciliano, B., Sciavicco L., Villani L. and Oriolo G. (2010) *Robotics: Modelling, planning and control*. Springer. London.

Links

This unit links to the following related units:

Unit 26: Machine Learning

Unit 27: Artificial Intelligence

Unit 45:   Emerging Technologies

Unit code	**R/615/1695**
Unit level	**5**
Credit value	**15**

Introduction

Emerging Technologies have the ability to disrupt industries, radically change the progress and thinking of humankind, affect society at large and solve huge problems. Computing underpins many Emerging Technologies and allows rapid development and sharing of ideas, products and scientific understanding to occur across multiple fields in shorter and shorter timeframes. The objective and effect of Emerging Technologies is usually to change the status quo. This change might be to solve problems, increase performance, improve efficiency, or create entirely new scientific fields and novel technologies by converging different systems, technology, thinking or disciplines together. Emerging Technologies explore a variety of changing technologies that display radical novelty, have the potential for significant commercial or social impact, fast growth, scalability and affect the future in uncertain ways.

This unit introduces students to the role, benefits, disadvantages and potential outcomes Emerging Technologies have in the development of software applications. The aim of the unit is to enhance the student's understanding of the current state, terminology, advantages, disadvantages, potential impact and benefits of Emerging Technologies on the development of software applications.

Among the topics included in this unit are: classification and terminology of Emerging Technologies, review the most promising and impactful Emerging Technologies, trends of convergence, the impact of computers in the development of Emerging Technologies, the hardware, software, data, platforms and services used to enable development of Emerging Technologies, understand the scale, scope, advantages and disadvantages Emerging Technologies may have on humankind.

On successful completion of this unit students will be able to explain some of the most promising and impactful Emerging Technologies. Have an awareness of the impact, advantages and disadvantages Emerging Technologies may have on humankind. Understand the impact Emerging Technologies will have on the development of software applications.

As a result they will develop skills such as communication literacy, design thinking, team working, critical thinking, analysis, reasoning, interpretation and 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:

LO1. Assess what Emerging Technologies are necessary and appropriate when designing software applications for the future.

LO2. Research state-of-the-art Emerging Technologies and choose one you believe will have significant impact in the future.

LO3. Discuss the current state and future impact of your chosen Emerging Technology.

LO4. Evaluate the political, economic and social factors which play a role in the competition between Emerging Technologies and their success or failure in the future.

Essential Content

LO1 Assess what Emerging Technologies are necessary and appropriate when designing software applications for the future

Evaluate formats, characteristics and trends of Emerging Technologies:

Present an overview of Emerging Technologies and their appropriate use in software development.

Assess what Emerging Technology is by researching its role, purpose and terminology.

Recognise the various forms of Emerging Technology by researching its history and current trends.

Define the characteristics of Emerging Technology by investigating how they can be used and how they differ from and converge with developed technology.

Recognise specific Emerging Technologies:

Research, debate and agree current trends in Emerging Technology.

Assess various forms of Emerging Technology, focusing on their relevance to software development and computing.

Define the advantages and disadvantages of Emerging Technology.

How Emerging Technologies can converge with existing technologies or replace them.

Appropriateness of using of Emerging Technology to disrupt the status quo throughout industries, markets, user adoption and established practices.

LO2 Research state-of-the-art Emerging Technologies and choose one you believe will have significant impact in the future

Investigate a specific Emerging Technology and how it will affect the status quo of an industry, end user group and the current state of technology development:

Investigate a specific Emerging Technology for discussion choosing one you believe will have the most impact to software application design and development in the future.

Choose a specific industry and end user group that will be the most influenced by this Emerging Technology.

Evaluate the benefits, features, advantages and disadvantages of this Emerging Technology.

LO3 **Discuss the current state and future impact of your chosen Emerging Technology**

Develop a report and presentation using research gathered about your chosen Emerging Technology, industry and end user:

Organise your research and findings.

Contrast the benefits, features, advantages and disadvantages of your chosen Emerging Technology.

Relate how your chosen Emerging Technologies can converge with existing technologies or replace them.

Defend your choice of Emerging Technology in relation to your belief it will have the most impact on software application design and development in the future.

Develop a report of your research and findings.

LO4 **Evaluate the political, economic and social factors which play a role in the competition between Emerging Technologies and their success or failure in the future**

Assess the success of your research:

Arrange a presentation to demonstrate your findings, gather feedback and answer questions.

Assemble and appraise your report findings and research.

Evaluate the political, economic and social factors which play a role in the competition between Emerging Technologies and their success or failure in the future.

Discuss how your chosen Emerging Technologies can converge with existing technologies or replace them.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Assess what Emerging Technologies are necessary and appropriate when designing software applications for the future		
P1 Assess formats, characteristics and trends of Emerging Technologies. **P2** Explore the advantages and disadvantages of Emerging Technology.	**M1** Evaluate the ability of Emerging Technology to disrupt the status quo throughout industries, markets, user adoption and established practices. **M2** Review various forms of Emerging Technologies, focusing on their relevance to software development and computing.	**D1** Evaluate Emerging Technologies and justify their use when designing software applications for the future.

Pass	Merit	Distinction
LO2 Research state-of-the-art Emerging Technologies and choose one you believe will have significant impact in the future		
P3 Select a specific Emerging Technology. **P4** Review a specific industry and end user group that will be the most influenced by this Emerging Technology.	**M3** Evaluate the benefits, features, advantages and disadvantages of this Emerging Technology. **M4** Show how Emerging Technologies can converge with existing technologies or replace them.	**LO2 & LO3** **D2** Defend your choice of Emerging Technology in relation to your belief it will have the most impact on software application design and development in the future.
LO3 Discuss the current state and future impact of your chosen Emerging Technology		
P5 Organise your research and findings. **P6** Contrast the benefits, features, advantages and disadvantages of your chosen Emerging Technology.	**M5** Relate how your chosen Emerging Technologies can converge with existing technologies or replace them. **M6** Develop a report of your research and findings.	
LO4 Evaluate the political, economic and social factors which play a role in the competition between Emerging Technologies and their success or failure in the future		
P7 Evaluate your report findings and research.	**M7** Arrange a presentation to demonstrate your findings, gather feedback and answer questions.	**D3** Critique the benefits, features, advantages and disadvantages of your chosen Emerging Technology.

Recommended Resources

Textbooks

Christensen, C. (2015) *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (Management of Innovation and Change).* Harvard Business Review Press.

Masters, B. (2014) *From Zero to One: Notes on Startups, or How to Build the Future*. Virgin Digital.

Schwab, K. (2016) *The Fourth Industrial Revolution.* World Economic Forum.

Links

This unit links to the following related units:

Unit 14: Business Intelligence

Unit 46: Virtual & Augmented Reality Development

Unit code	**Y/615/1696**
Unit level	**5**
Credit value	**15**

Introduction

Virtual (VR) and Augmented (AR) Reality is the process by which you can use computer software and hardware technologies to develop fully immersive, simulated virtual reality environments or augment the real world with virtual reality content. The objective of Virtual and Augmented Reality development is to design virtual environments or real world augmentations for numerous beneficial, experimental, educational or entertainment purposes. VR and AR explores the potential to work, interact, play, collaborate and communicate in expansive simulated environments or use technology to enhance the real world with some of the benefits and features of simulated virtual environments.

This unit introduces students to the role, basic concepts and benefits of VR and AR technology and how to apply them in the development of VR/AR computer applications. The aim of the unit is to enhance the student's understanding of the methodology, terminology and benefits of VR and AR software applications.

Among the topics included in this unit are: classification and terminology of VR and AR technology, the relationship between VR and AR design, how VR and AR development relates to and differs from other forms of software development, modes of interaction, human-computer interaction models, usability, accessibility, aesthetics, spatial design, 3D vision, motion tracking, understand the hardware, software, data, platforms and services available to develop VR and AR software applications.

On successful completion of this unit students will be able to explain the basic concepts of VR and AR development. Plan, build and measure the success of an appropriate VR or AR software application. Design a VR or AR software application. As a result they will develop skills such as communication, literacy, design thinking, team working, critical thinking, analysis, reasoning, interpretation and 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:

LO1. Examine what aspects of VR and AR technology are necessary and appropriate when designing VR and AR software applications.

LO2. Plan an appropriate VR or AR software application using common architecture, frameworks, tools, hardware and APIs.

LO3. Design, build and simulate a VR or AR software application using any combination of hardware, software, data, platforms and services.

LO4. Evaluate your VR or AR software application and detail the problems and limitations your application encountered and the reaction your VR or AR application generated with end users.

Essential Content

LO1 **Examine what aspects of VR and AR technology are necessary and appropriate when designing VR and AR software applications**

Identify formats, characteristics and aspects of VR/AR technology:

Present an overview of VR/AR technology and its appropriate use in software development.

Identify what AR/VR is by researching the role, purpose, terminology and methodology of this technology.

Recognise the various forms of AR/VR technology by researching its history, current trends and use in the product development lifecycle.

Define the characteristics of AR/VR by investigating how it is similar to and differs from traditional simulated and virtual environments.

Recognise specific forms of AR/VR technology:

Research, debate and agree current functionality and capabilities of AR/VR technology.

Identify various forms of AR/VR technology and end user hardware.

Identify architecture, frameworks, tools, hardware and APIs available to develop applications.

Define the advantages and disadvantages of AR/VR technology.

Define standard tools available for use in developing AR/VR applications:

Identify standard tools available to develop AR/VR applications.

The advantages and disadvantages of AR/VR tools and hardware.

Appropriateness of various tools to develop AR and VR applications.

LO2 **Plan an appropriate VR or AR software application using common architecture, frameworks, tools, hardware and APIs**

Identify an application concept to develop in AR/VR:

Evaluate the benefits, features, advantages and disadvantages of AR/VR technology to develop this application.

Review different AR/VR architecture, frameworks, tools, hardware and API techniques you could apply to develop this application.

Select the most appropriate AR/VR architecture, frameworks, tools, hardware and API techniques to include in this application.

Describe a plan to develop your AR/VR application concept:

Use your selected techniques to create an AR/VR application development plan.

LO3 **Design, build and simulate a VR or AR software application using any combination of hardware, software, data, platforms and services**

Utilise appropriate tools and techniques to develop an AR/VR application:

Employ an appropriate set of tools to develop your plan into an AR/VR application.

Run end user experiments and examine feedback.

Reconcile and evaluate end user feedback and determine advantages and disadvantages of your chosen AR/VR techniques.

LO4 **Evaluate your VR or AR software application and detail the problems and limitations your application encountered and the reaction your VR or AR application generated with end users**

Assemble and appraise end use feedback from your AR/VR application:

Undertake a critical review and compare your final application with the original plan.

Evaluate the advantages, disadvantages, strengths and weaknesses of your AR/VR techniques.

Critique the overall success of your application. Was it successful? How did users react to it?

Discusses your insight using AR/VR Technology.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine what aspects of VR and AR technology are necessary and appropriate when designing VR and AR software applications		
P1 Explore the necessary aspects of AR/VR technology **P2** Review the appropriateness of the standard architecture, frameworks, tools, hardware and APIs available for use in AR/VR development.	**M1** Justify the impact of common AR/VR architecture, frameworks, tools, hardware and APIs in the software development lifecycle.	**LO1 & LO2** **D1** Evaluate the benefits, features, advantages and disadvantages of AR/VR technology to develop this application. In addition, critique the architecture and techniques that have been used.
LO2 Plan an appropriate VR or AR software application using common architecture, frameworks, tools, hardware and APIs		
P3 Investigate architecture, frameworks, tools, hardware and API techniques you could apply to develop this application.	**M2** Select the most appropriate AR/VR architecture, frameworks, tools, hardware and API techniques to include in an application to solve this problem. **M3** Use your selected techniques to create an AR/VR application development plan.	

Pass	Merit	Distinction
LO3 Design, build and simulate a VR or AR software application using any combination of hardware, software, data, platforms and services		**D2** Make multiple iterations of your application and modify each iteration with enhancements gathered from user feedback and experimentation.
P4 Employ an appropriate set of tools to develop your plan into an application. **P5** Run end user experiments and examine feedback.	**M4** Reconcile and evaluate end user feedback. **M5** Determine the advantages and disadvantages of your chosen techniques.	
LO4 Evaluate your VR or AR software application and detail the problems and limitations your application encountered and the reaction your VR or AR application generated with end users		**D3** Critically evaluate the overall success of your software application, detailing any problems or limitations encountered.
P6 Assemble and appraise end use feedback from your AR/VR application.	**M6** Undertake a critical review and compare your final application with the original plan.	

Recommended Resources

Textbooks

Parisi, T. (2015) *Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web and Mobile*. O'Reilly Media.

Schmalstieg, D. (2016) *Augmented Reality: Principles and Practice (Usability)*. Addison-Wesley Professional.

Links

This unit links to the following related units:

Unit 29: Application Program Interfaces

Unit 43: Internet of Things

Unit 47: Games Development

Unit code   **D/615/1697**

Unit level   **5**

Credit value   **15**

Introduction

In the field of computing, games development is a multidisciplinary art form that creates worlds that blend player psychology, problem-solving and artificial intelligence with knowledge about dedicated hardware and software platforms. This level of ability can often require significant effort on the part of the student with regards to time and practice. However, as more experience is gained, the skills and abilities quickly improve. In addition, once completed it is important to know that the capabilities and flexibility of a good games developer can easily be transferred to other roles in the business sector.

This unit introduces students to games development and is designed to simulate the roles and responsibilities of a games developer working in a suitable games development studio with access to a small team of colleagues. Students are expected to discuss and review a number of original game ideas before synthesising them into a single game concept. Once defined they will need to adopt and use appropriate methods and practices to analyse, breakdown and discuss the issues – then, decide, design, create and test a functional game. Students should be free to debate, evaluate and select different design and development methodologies depending on their own judgement and consideration. On completion, and in addition to the student reviewing and reflecting on the experience, they will be expected to formally evaluate their completed game against their Games Design Document and original concept.

Among the topics included in this unit are: game design and developer documentation, problem analysis, research, system and user requirements, design methodologies and principles, development methodologies, unified modelling language (UML), software development lifecycles, games engines, hardware platforms, graphic manipulation, physics, maths for games, sound, networking, collision detection, teamwork, peer-reviews, development tools and techniques, integrated development environments, debugging, testing, software versions and quality assurance.

On successful completion of this unit students will be able to develop a Game Design Document by evaluating and synthesising game ideas into an original video game concept, select and use different design and development methodologies with tools and techniques associated with the creation of a video game, work individually and as part of a team to plan, prepare and produce a functional video game including support documentation, assess and plan improvements to a video game by evaluating its performance against its Game Design Document and original concept.

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:

LO1.   Develop a Game Design Document by evaluating and synthesising game ideas into an original video game concept.

LO2.   Use different design and development methodologies with tools and techniques associated with the creation of a video game.

LO3.   Work individually and as part of a team to plan and produce a functional video game, including support documentation.

LO4.   Evaluate the performance of a video game against its Game Design Document and original concept.

Essential Content

LO1 **Develop a Game Design Document by evaluating and synthesising game ideas into an original video game concept**

Research and compare different game genres and ideas:

Discuss and compare common game elements such as: type, story, characters, environment, levels, gameplay, loops, art, sound, user interface and controls.

Determine possible game ideas and predict the overall success of fully developing your game.

Develop a Game Design Document:

Review and discuss the value of Game Design Documents with regards to games development.

Evaluate and synthesise your game ideas into a single document that describes (in detail) your game concept.

Research and use information relating to games testing to create a suitable test plan for your game.

LO2 **Use different design and development methodologies with tools and techniques associated with the creation of a video game**

Discuss different design and development methodologies:

Present overviews on current design and development methodologies.

Debate various strengths and weaknesses commonly associated with each methodology.

Select or synthesise a design and development methodology for use with the creation of your video game.

Use appropriate tools and techniques:

Evaluate different tools and techniques available to create a video game.

Establish your development plan by debating the advantages and disadvantages of your preferred or selected tools and techniques.

LO3 Work individually and as part of a team to plan and produce a functional video game, including support documentation

Work as a small team to plan and prepare your functional video game:

Peer-review and debate your development plan and Games Design Document by effectively communicating and defending your ideas and reasoning.

Discuss differences with regards to the possible strengths and weakness of each Game Design Document and development plan.

Modify your design document or plans to reflect any new insights or considerations.

Prepare and produce a functional video game:

Use your Game Design Document with your development plan to produce a functional video game.

Create and quality check appropriate support documents for your video game.

LO4 Evaluate the performance of a video game against its Game Design Document and original concept

Assess the performance of a video game:

Analyse factors that influence the performance of a video game with regard to its system requirements.

Undertake a critical review of the performance and development of your video game against all identified factors and any adopted design and development methodologies.

Measure the overall success of the video game against your original prediction and identify any new areas of personal insight.

Plan improvements to a video game:

Evaluate the overall strengths and weaknesses of your video game against its Game Design Document and original concept.

Discuss and plan in detail possible revisions (including implementation) with regard to improving your video game's performance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Develop a Game Design Document by evaluating and synthesising game ideas into an original video game concept		
P1 Explore different game-based ideas, blending them into an original video game concept. **P2** Examine any areas of risk related to the successful completion of your video game.	**M1** Analyse and combine common game design elements (such as type, story, characters, environment, levels, gameplay, loops, art, sound, user interface and controls) with your original video game concept to create a suitable Game Design Document.	**D1** Evaluate common game design elements and justify their use when designing a suitable Game Design Document.

Pass	Merit	Distinction
LO2 Use different design and development methodologies with tools and techniques associated with the creation of a video game		
P3 Research the use of different design and development methodologies, tools and techniques and determine which have been selected for the development of this video game.	**M2** Compare the differences between the various design and development methodologies, tools and techniques researched and justify your preferred selection.	**LO2 & LO3** **D2** Evaluate any new insights, ideas or potential improvements to your concept, methodology or use of tools and justify the reasons why you have chosen to include (or not to include) them as part of this development.
LO3 Work individually and as part of a team to plan and produce a functional video game, including support documentation		
P4 Create a formal presentation that effectively reviews your video game concept together with your preferred design and development methodologies and selected tools and techniques. Use this presentation as part of a peer-review and document any feedback given. **P5** Develop a functional video game based on a specified game concept.	**M3** Interpret your peer-review feedback and identify opportunities not previously considered. **M4** Develop a functional video game based on a specific Game Design Document with supportive evidence of using the preferred design and development methodologies and selected tools and techniques.	
LO4 Evaluate the performance of a video game against its Game Design Document and original concept		
P6 Evaluate the performance of your video game against your original concept.	**M5** Critically analyse the factors that influence the performance of a video game and use them to undertake a critical review of the design, development, game elements and testing stages of your video game. Conclude your review by reflectively discussing your previously identified risks.	**D3** Critically evaluate the strengths and weaknesses of your video game and fully justify opportunities for improvement and further development.

Recommended Resources

Textbooks

Gibson, J. (2014) *Introduction to Game Design, Prototyping, and Development.* New Jersey: Pearson Education.

Gregory, J. (2014) *Game Engine Architecture*. United States: Taylor.

Madhav, S. (2013) *Game Programming Algorithms and Techniques*. USA: Addison-Wesley.

Nystrom, R. (2014) *Game Programming Patterns*. USA: Genever Benning.

Rogers, S. (2014) *Level Up! The Guide to Great Video Game Design*. UK: John Wiley and Sons Ltd.

Schell, J. (2014) *The Art of Game Design: A Book of Lenses*. USA: A K Peters/CRC Press.

Links

This unit links to the following related units:

Unit 9: Software Development Lifecycles

Unit 31: Games Engine & Scripting

Unit 32: Game Design Theory

Unit 48: Systems Integration

Unit code	**H/615/1698**
Unit level	**5**
Credit value	**15**

Introduction

Large organisations and businesses are composed of different functional areas, such as finance, HR, customer management, engineering services, product manufacturing, storage and warehousing. These functional areas carry out different operations in order to fulfil the goals of the business and often use a variety of different IT systems (e.g. stock control, accounts, HR, etc.) from a range of different suppliers and vendors to service their needs. The success of any large business or enterprise in achieving its goals depends on the ability of IT systems to effectively communicate with each other. However, IT systems from different vendors or suppliers often use different hardware and/or software platforms and services, thus creating the need for systems integration.

This unit introduces students to enterprise business requirements, and the need and purpose of systems integration to support organisational goals. Students are expected to gather and review business objectives with the aim of developing a systems specification document. As part of a feasibility analysis, students are expected to evaluate factors and issues affecting the successful completion of integration, including describing and documenting the functional architecture and design of a system. Students are also expected to explore hardware and software technologies used to connect systems and subsystems and establish an integration methodology to design and implement an integrated solution. In addition, students will investigate and compare different cloud service models and evaluate different deployment methods and consider their effect on systems integration.

Among the topics included in this unit are: enterprise business objectives, purpose and operation of systems integration, systems specification documents, feasibility analysis, risk assessments, architectural development, hardware and software technologies for systems integration, operational configuration, systems integration design framework, design, development and deployment of a systems integration solution, quality assurance, cloud services as a systems integration provision, cloud service models 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 different hardware and software systems with regard to connectivity, communication and data transfer, prepare a suitable integrated solution based on a set of business requirements and compare a range of cloud computing providers and evaluate their services.

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:

LO1. Analyse systems integration requirements with regards to business objectives.

LO2. Investigate different hardware and software systems with regards to connectivity, communication and data transfer.

LO3. Prepare a suitable integrated solution based on a set of business requirements.

LO4. Compare a range of cloud computing providers and evaluate their services.

Essential Content

LO1 Analyse systems integration requirements with regards to business objectives

Identifying business objectives:

Introduce and outline the purpose and operation of 'systems integration'.

Gathering and reviewing business objectives, including interpreting business needs from different functional areas and departments.

Developing a systems specification document, including establishing and ensuring requirements can be met.

Feasibility analysis:

Using risk assessments to evaluate issues threatening the successful completion of integrating systems, including identifying any reasonable steps necessary to prevent or mitigate issues.

Architectural development; describe and document the functional architecture and design of the system and specify all technical requirements and capabilities.

LO2 Investigate different hardware and software systems with regards to connectivity, communication and data transfer

Exploring hardware and software technologies:

Research and evaluate hardware and software servers, technologies, platforms and services.

Connecting systems and subsystems, including custom software services and development.

Establish a systems integration methodology:

Operational configuration: exploring requirements, information needs and facilitating data transfer and communication.

Identifying and tracking issues for problem resolution and fault detection, including diagnosing type and location.

Implementing a design framework: using top-down and bottom-up methodologies.

LO3 Prepare a suitable integrated solution based on a set of business requirements

Establishing a strategic approach:

Analyse functional architecture and technical capabilities against a specification document to determine the probability of successfully developing (and deploying) an effective integrated solution.

Establishing a management strategy.

System design, development and deployment:

Designing, developing and monitoring an integrated system.

Quality Assurance, including deploying and testing an integrated system.

Evaluating system functionality: documentation, maintenance and upgrades.

LO4 Compare a range of cloud computing providers and evaluate their services

Investigating and comparing cloud service models:

Introduce and discuss IaaS (Infrastructure as a Service).

Review and debate PaaS (Platform as a Service).

Research and discuss: SaaS (Software as a Service).

Investigating and comparing deployment models:

Research and discuss private, public and hybrid clouds.

Evaluating issues: security, privacy and constraints.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse systems integration requirements with regards to business objectives		
P1 Discuss the objectives and effect of 'Systems Integration' with regards to business operations and management. **P2** Prepare a suitable 'Systems Specification' and 'Risk Assessment' document for a set of specific business objectives.	**M1** Evaluate the processes involved in 'System Integration' and review the purpose and impact of assessing risk. **M2** Provide a detailed 'Systems Specification' and 'Risk Assessment' document.	**LO1 & LO2** **D1** Critically evaluate your detailed 'System Specification' and 'Risk Assessment' document, including justification on how each of the specified business objectives has been met.
LO2 Investigate different hardware and software systems with regards to connectivity, communication and data transfer		
P3 Discuss a range of hardware and software systems, technologies, platforms and services that would be suitable for use with a given 'Systems Specification' document. **P4** Determine the purpose of top-down and bottom-up methodologies and how they relate to 'Systems Integration'.	**M3** Provide a detailed and evaluated review of your selected systems, platforms, technologies and services and include details on system and service connectivity.	

Pass	Merit	Distinction
LO3 Prepare a suitable integrated solution based on a set of business requirements		
P5 Create an 'Integrated Systems' solution to a set of specific business objectives using existing 'Systems Specification and Risk Assessment' documents, including illustrated design diagrams and details on information flow. **P6** Create a systems deployment and test plan suitable for use with your 'Integrated Systems' solution.	**M4** Provide a detailed and evaluated 'Integrated Systems' solution, including fully annotated diagrams, details on information flow, risk, redundant systems, backups, security, connectivity, deployment, testing and a full review of the solution's functionality compared to the 'Systems Specification' document.	**LO3 & LO4** **D2** Critically evaluate the impact of cloud services on 'Systems Integration' and discuss the implications of 'IaaS', 'PaaS' and 'SaaS' and how they could be used to help organisations improve their performance.
LO4 Compare a range of cloud computing providers and evaluate their services.		
P7 Discuss the differences between 'IaaS, 'PaaS' and 'SaaS' services and compare the 'private', 'public' and 'hybrid' deployment models offered by cloud computing providers.	**M5** Review a range of cloud computing providers and compare the services offered.	

Recommended Resources

Textbooks

Erl, T., Mahmood, Z. and Puttini, R. (2014) *Cloud Computing: Concepts, Technology & Architecture*. USA: Prentice Hall

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 16: Cloud Computing

Unit 49:   Operating Systems

Unit code	**R/615/1700**
Unit level	**5**
Credit value	**15**

Introduction

Although many computer users do not interact directly with systems software and hardware, it is important that computing students have the opportunity to learn about these underlying systems.

MS-DOS, Windows, UNIX, Linux, Android, OS2, MacOS are just a few examples of different types of both modern and legacy Operating Systems. The foundations of most, if not all of them, is MS-DOS (Microsoft Disk Operating System). Way back in the 1980s this was used as the first Operating System for Personal Computers (PCs). In the 1990s, MS-DOS was transformed to a GUI (Graphic User Interface) WSWIG (What You See Is What You Get) Operating System through the release of Windows 3.11/Windows for Workgroups. That has led to several iterations of the Windows Operating System.

This unit introduces students to different operating systems such as DOS, Windows, UNIX and Linux. The topics covered are the tasks of operating systems such as controlling and allocating memory, prioritising system requests, controlling input and output devices, facilitating data networking and managing files, including security and protection.

Among the topics included in this unit are: the history and evolution of Operating Systems; the definition of an Operating System; why Operating Systems are needed; how Operating Systems started and developed; Operating Systems management roles; management of memory, processes, processors, devices and files; security and protection: user security, device, application and process protection; inter-process communication; comparison of Operating Systems; distributed and networked systems; concurrent systems; multi-user systems; graphical interface systems; and practical application of Operating Systems: user interface commands of major Operating Systems; installations and extensions of Operating Systems.

On successful completion of this unit students will be able to competently operate any given Operating System and undertake routine maintenance of Operating System as well as their optimisation. 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:

LO1. Investigate different Operating Systems, their functions and user interfaces.

LO2. Explore the processes managed by an Operating System.

LO3. Demonstrate the use of DOS, Windows, UNIX and Linux.

LO4. Analyse appropriate techniques and technologies used in distributed and concurrent systems.

Essential Content

LO1 Investigate different Operating Systems, their functions and user interfaces

The history of Operating Systems:

Discuss the history of Operating Systems from Legacy Operating Systems to current Operating Systems, tracking its development from Batch files to the modern Operating Systems.

History and evolution of operating systems:

Discuss what is meant by an Operating System; why do we need Operating Systems? How did Operating Systems start and develop throughout the ages? What constitutes an Operating System?

LO2 Explore the processes managed by an Operating System

Operating Systems Management:

Discuss in detail how Memory Management is conducted in an Operating System.

Discuss how job scheduling is handled by an Operating System. Discuss how Process Scheduling happens in in Operating Systems. How does concurrent processing happen in an Operating System. Discuss how device management is accomplished by an Operating System. File Management is a crucial element for an Operating System, discuss how this is performed by an Operating System.

LO3 Demonstrate the use of DOS, Windows, UNIX and Linux

Commands for manipulating:

Interaction with different Operating Systems requires knowledge of certain commands and knowledge of manipulating them. You are required to research several MS-DOS, Windows, UNIX and Linux commands.

Consider how secure different Operating Systems are. In addition, also make reference to different environments and the conditions of use.

LO4 Analyse appropriate techniques and technologies used in distributed and concurrent systems

Critical evaluation of an Operating System environment:

Operating Systems can be used for a number of domains. Your task is to evaluate different Operating Systems' environments, including Distributed Operating Systems as well as Concurrent Operating Systems, etc.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate different Operating Systems, their functions and user interfaces		**LO1, LO2 & LO3**
P1 Explore what an Operating System is. **P2** Research the evolution of Operating Systems.	**M1** Discuss the importance of Operating Systems.	**D1** Critically evaluate the functionality, interface design and processes of a range of operating systems.
LO2 Explore the processes managed by an Operating System		
P3 Research the process of Memory Management in an Operating System. **P4** Investigate the process of job scheduling.	**M2** Analyse, with the aid of a diagram, the importance of Resource Management in an Operating System to aid its efficiency.	
LO3 Demonstrate the use of DOS, Windows, UNIX and Linux		
P5 With an aid of screenshots, prove the use of MS-DOS and Windows. **P6** With an aid of screenshots, prove the use of UNIX and Linux and MacOS.	**M3** Justify the security of each operating system discussed in P5 and P6.	
LO4 Analyse appropriate techniques and technologies used in distributed and concurrent systems		
P7 Discuss distributed Operating Systems. **P8** Discuss Concurrent Operating Systems.	**M4** Justify which techniques and technologies you would use in a Distributed Operating system.	**D2** Critically evaluate your work and make some recommendations about current Operating Systems and future advancements.

Recommended Resources

Textbooks

Davis, W.S. and Rajkumar, T.M. (2004) *Operating Systems: A Systematic View*. 3rd Ed. Harlow, Addison-Wesley.

McHoes, A.M. and Flynn, I.M. (2007) *Understanding Operating Systems*. 5th Ed. Course Technology.

Nutt, G.J. and Clegg, N. (2003) *Operating Systems*. International Edition. Harlow, Addison-Wesley.

O'Gorman, J. (2000) *Operating Systems (Grassroots)*. Basingstoke. Palgrave Macmillan.

Ritchie, C. (2002) *Operating Systems*, 4th Ed. London, Thomson Learning.

Silberschatz, A. and Galvin, P. (1998) *Operating System Concepts*. Harlow. Addison-Wesley.

Stallings, W. (2001) *Operating Systems: Internals and Design Principles*. London. Prentice Hall.

Tanenbaum, A.S. (2001) *Modern Operating Systems*. Upper Saddle River. Prentice Hall.

Woodhull, A.S. and Tanenbaum, A.S. (2006) *Operating Systems: Design and Implementation*. 3rd Ed. Upper Saddle River. Prentice Hall.

Links

This unit links to the following related units:

Unit 36: Client/Server Computing Systems

11 Appendices

Appendix 1: Professional Body Memberships

Qualification	Membership/Specialist Group
Higher National Certificate in Computing	Student Membership
Higher National Diploma in Computing	Student Membership Associate Membership (on completion) Business Information Systems Specialist Group
Higher National Diploma in Computing (Network Engineering)	Student Membership Associate Membership (on completion) Distributed and Scalable Computing Specialist Group
Higher National Diploma in Computing (Software Engineering)	Student Membership Associate Membership (on completion) Advanced Programming Specialist Group Open Source Specialist Group Software Testing Specialist Group
Higher National Diploma in Computing (Systems Data & Analysis)	Student Membership Associate Membership (on completion) Data Management Specialist Group Information Risk Management and Assurance Specialist Group
Higher National Diploma in Computing (Security)	Student Membership Associate Membership (on completion) Cybercrime Forensics Specialist Group Information Security Specialist Group
Higher National Diploma in Computing (Intelligent Systems)	Student Membership Associate Membership (on completion) Artificial Intelligence Specialist Group Cybernetic Machine Specialist Group

Qualification	Membership/Specialist Group
Higher National Diploma in Computing (Applications Development)	Student Membership Associate Membership (on completion)
Higher National Diploma in Computing (All Pathways)	Project Management Specialist Group Quality Specialist Group Requirements engineering Specialist Group

Appendix 2: Vendor Accredited Certifications

CompTIA	
Server+	Unit 36: Client/Server Computing Systems
	Unit 48: Systems Integration
Linux+	Unit 36: Client/Server Computing Systems
	Unit 49: Operating Systems
Network+	Unit 2: Networking
	Unit 35: Network Management
Security+	Unit 5: Security
	Unit 17: Network Security
	Unit 23: Cryptography
	Unit 24: Forensics
Cloud+	Unit 16: Cloud Computing
A+	Unit 8: Computer Systems Architecture
CISCO	
IT Essentials	Unit 8: Computer Systems Architecture
CCNA Routing & Switching	Unit 2: Networking
	Unit 8: Computer Systems Architecture
	Unit 15: Transport Network Design
	Unit 35: Network Management

CCNA Security	Unit 2: Networking
	Unit 8: Computer Systems Architecture
	Unit 15: Transport Network Design
	Unit 17: Network Security
	Unit 35: Network Management
Microsoft	
Microsoft Office Specialist (MOS) certification	Throughout
Oracle	
Java SE 8 Fundamentals	Unit 1: Programming
	Unit 20: Advanced Programming
Introduction to SQL	Unit 4: Database Design & Development
	Unit 19: Data Structures & Algorithms
	Unit 38: Database Management Systems
Oracle Database 12c Administration	Unit 8: Computer Systems Architecture
	Unit 19: Data Structures & Algorithms
	Unit 38: Database Management Systems

AXELOS	
Prince2 Foundation Qualification	Unit 13: Computing Research Project
Cyber Resilience Qualification (RESILIA)	Unit 5: Security
	Unit 17: Network Security
	Unit 23: Cryptography
	Unit 24: Forensics

Appendix 3: SFIA Skill Levels

SFIA LEVEL 3 SKILLS

Skill	Description	
Information security	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.	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.
Analytics	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.	Undertakes analytical activities and delivers analysis outputs, in accordance with customer needs and conforming to agreed standards.

Skill	Description	
Information content publishing	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.	Specifies and creates content management processes to meet the needs of users. Selects appropriate platforms for publishing, applying the concept of customer journey. Uses content publishing systems and publishing content across different channels, including mobile and social media. Takes account of the implications of copyright, data protection and other legal issues associated with publishing. Contributes to achievement of search engine optimisation.
Research	The advancement of knowledge by data gathering, innovation, experimentation, evaluation and dissemination, carried out in pursuit of a predetermined set of research goals.	Within given research goals, builds on and refines appropriate outline ideas for research, i.e. evaluation, development, demonstration and implementation. Uses available resources to gain an up-to-date knowledge of any relevant field. Reports on work carried out and may contribute sections of material of publication quality.
Data management	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.	Applies ethical and robust techniques in the transformation of data from one format/medium to another, in line with organisational policies and procedures and being sensitive to risks around the use of information.

Skill	Description	
Portfolio, programme and project support	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.	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.
Business analysis	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.	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.

Skill	Description	
Requirements definition and management	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.	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.
Business modelling	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 around the representation of processes, roles, data, organisation and time. Models may be used to represent a subject at varying levels of detail and decomposition.	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.

Skill	Description	
Data analysis	The investigation, evaluation, interpretation and classification of data, in order to define and clarify information structures which describe the relationships between real world entities. Such structures facilitate the development of software systems, links between systems or retrieval activities.	Applies data analysis, data modelling, and quality assurance techniques, based upon 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.
Systems design	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.	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 all work using required standards, methods and tools, including prototyping tools where appropriate.
Database design	The specification, design and maintenance of mechanisms for storage and access to both structured and unstructured information, in support of business information needs.	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.

Skill	Description	
Programming/software development	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.	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.
Safety engineering	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.	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.
Information content authoring	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.	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.

Skill	Description	
Testing	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. 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.	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. Analyses and reports test activities and results. Identifies and reports issues and risks associated with own work.
User experience analysis	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	Identifies and engages with users/ stakeholders, defines relevant characteristics (e.g. 'personas') and describes users goals and tasks (e.g. as 'user stories'). Describes the environment within which the system will be used. Identifies and describes requirements of users with special needs (e.g. resulting from physical disabilities).

Skill	Description	
User experience design	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.	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.
User experience evaluation	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.	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.

Skill	Description	
Systems integration	The incremental and logical integration and testing of components and/or subsystems and their interfaces in order to create operational services.	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.
Porting/software configuration	The configuration of software products into new or existing software environments/platforms.	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.
Systems installation/ decommissioning	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.	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.

Skill	Description	
		Reviews change requests. Maintains accurate records of user requests, contact details and outcomes. Contributes to the development of installation procedures and standards.
Service level management	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.	Monitors service delivery performance metrics and liaises with managers and customers to ensure that service level agreements are not breached without the stakeholders being given the opportunity of planning for a deterioration in service.
Configuration management	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.	Applies tools, techniques and processes to track, log and correct information related to CIs, ensuring protection of assets and components from unauthorised change, diversion and inappropriate use.

Skill	Description	
Change management	The management of change to the service infrastructure including service assets, configuration items and associated documentation. 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.	Develops, documents and implements changes based on requests for change. Applies change control procedures.
Release and deployment	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.	Uses the tools and techniques for specific areas of release and deployment activities. 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.
System software	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.	Uses system management software and tools to collect agreed performance statistics. Carries out agreed system software maintenance tasks.
Security administration	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.	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.

Skill	Description	
Application support	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.	Identifies and resolves issues with applications, following agreed procedures. Uses application management software and tools to collect agreed performance statistics. Carries out agreed applications maintenance tasks.
IT Infrastructure	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.	Carries out agreed operational procedures, including network configuration, installation and maintenance. Uses network management tools to collect and report on network load and performance statistics. Contributes to the implementation of maintenance and installation work. Uses standard procedures and tools to carry out defined system backups, restoring data where necessary. Identifies operational problems and contributes to their resolution.

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 (e.g. using replication software to allow resilience). Identifies operational problems and contributes to their resolution (e.g. 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	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.	Performs routine assessments of knowledge and experience using specified methods and according to specified standards.
Learning delivery	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, on-line virtual environments, self-assessment, peer-assisted learning, simulation, and other current methods).	Delivers learning activities to a variety of audiences.
Quality assurance	The process of ensuring that the agreed quality standards within an organisation are adhered to and that best practice is promulgated throughout the organisation.	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.
Quality standards	The development, maintenance, control and distribution of quality standards.	Controls, updates and distributes new and revised quality standards.
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.	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.

Skill	Description	
Sourcing	The provision of policy, internal standards and advice on the procurement or commissioning of externally supplied and internally developed products and services. 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. The identification and management of suppliers to ensure successful delivery of products and services required by the business.	Prepares pre-qualification questionnaires and tender invitations in response to business cases. Recognises the difference between open source and proprietary systems options. Produces detailed evaluation criteria for more complex tenders and assists in evaluation of tenders. Acts as the routine contact point between organisation and supplier. Collects and reports on supplier performance data.
Customer service support	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.	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.

Skill	Description	
Sales support	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.	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.
Product management	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.	Carries out research and performance monitoring activities for specified products. Develops marketing collateral content and evaluates results and feedback from marketing campaigns.

SFIA LEVEL 4 SKILLS

Skill	Description	
Information management	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.	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.
Information security	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.	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.
Analytics	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.	Applies a variety of analytical and visualisation techniques, in consultation with experts if appropriate, and with sensitivity to the limitations of the techniques.

Skill	Description	
Information content publishing	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.	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.
Technical specialism	The development and exploitation of expertise in any specific area of information or communications technology, technique, method, product or application area.	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.
Research	The advancement of knowledge by data gathering, innovation, experimentation, evaluation and dissemination, carried out in pursuit of a predetermined set of research goals.	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.

Skill	Description	
Financial management	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.	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.
Business risk management	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.	Investigates and reports on hazards and potential risk events within a specific function or business area.

Skill	Description	
Sustainability strategy	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. Evaluation and inclusion, as appropriate, of political, legislative, economic, social and technological factors. Identification of major external standards, practices or schemes to be adopted. Consultation with identified relevant parties, either internal or external. Obtaining agreement to the strategy and the commitment to act upon it.	Assesses and reports on how different tactical decisions affect organisational sustainability. Evaluates factors and risks (political, legislative, technological, economic, and social) that impact on operational processes and strategic direction.
Emerging technology monitoring	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. The promotion of emerging technology awareness among staff and business management.	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. Contributes to briefings and presentations about their relevance and potential value to the organisation.

Skill	Description	
Continuity management	The provision of service continuity planning and support. This includes the identification of information systems which 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.	Provides input to the service continuity planning process and implements resulting plans.
Data management	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.	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.

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	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.	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.
Business analysis	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.	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.

Skill	Description	
Requirements definition and management	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.	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 base-line on which delivery of a solution can commence. Manages requests for and the application of changes to base-lined requirements. Identifies the impact on business requirements of interim (e.g. migration) scenarios as well as the required end position.
Business process testing	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.	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.

Skill	Description	
Business modelling	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 around the representation of processes, roles, data, organisation and time. Models may be used to represent a subject at varying levels of detail and decomposition.	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.
Sustainability assessment	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.	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.

Skill	Description	
Data analysis	The investigation, evaluation, interpretation and classification of data, in order to define and clarify information structures which describe the relationships between real world entities. Such structures facilitate the development of software systems, links between systems or retrieval activities.	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.
Systems design	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.	Recommends/Designs structures and tools for systems which 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.

Skill	Description	
Database design	The specification, design and maintenance of mechanisms for storage and access to both structured and unstructured information, in support of business information needs.	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.
Programming/software development	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.	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.
Safety engineering	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.	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.

Skill	Description	
Sustainability engineering	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.	Investigates and recommends components and subsystems that meet sustainability criteria and levels.

Skill	Description	
Information content authoring	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.	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 (e.g. 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.
Testing	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.	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.

Skill	Description	
	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.	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.
User experience analysis	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	Analyses qualitative data (e.g. from site visits) and presents the data in ways that can be used to drive design (e.g. 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 use experience (e.g. in the form of scenarios of use), resolving potential conflicts between user requirements, (e.g. between accuracy and speed). Specifies measurable criteria for the required usability of the system.

Skill	Description	
User experience design	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.	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.

Skill	Description	
User experience evaluation	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.	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.
		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.	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.

Skill	Description	
Porting/software configuration	The configuration of software products into new or existing software environments/platforms.	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.
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.	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/decom missioning	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.	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.
Availability management	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.	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.

Skill	Description	
Service level management	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.	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.
Service acceptance	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).	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.

Skill	Description	
Configuration management	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.	Maintains secure configuration, applying and maintaining tools, techniques and processes to identify, track, log and maintain accurate, complete and current information.
Asset management	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.	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.

Skill	Description	
Change management	The management of change to the service infrastructure including service assets, configuration items and associated documentation. 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.	Assesses, analyses, develops, documents and implements changes based on requests for change.
Release and deployment	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.	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. Ensures release processes and procedures are maintained.
System software	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.	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.

Skill	Description	
Capacity management	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.	Monitors service component capacity and initiates actions to resolve any shortfalls according to agreed procedures. Applies techniques to control the demand upon a particular resource or service.
Security administration	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.	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.

Skill	Description	
Penetration testing	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 (e.g. the protection of specific Intellectual Property) or achieve specific adversarial objectives (e.g. establishment of a covert Command and Control infrastructure). Pen Test results provide deeper insight into the business risks of various vulnerabilities.	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.

Skill	Description	
Application support	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.	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.
IT Infrastructure	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.	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.

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	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.	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.
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.	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.
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.	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.

Skill	Description	
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.	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.
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 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.
Learning assessment and evaluation	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.	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.

Skill	Description	
Learning design and development	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. Typically involves the assimilation of information from existing sources, selection and re-presentation 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.	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.
Learning delivery	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, on-line virtual environments, self-assessment, peer-assisted learning, simulation, and other current methods).	Prepares or customises and delivers learning activities to a variety of audiences.
Performance management	The optimisation of performance of people, including determination of capabilities, integration into teams, allocation of tasks, direction, support, guidance, motivation, and management of performance.	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.

Skill	Description	
Resourcing	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.	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.
Professional development	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.	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.
Quality management	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.	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.
Quality assurance	The process of ensuring that the agreed quality standards within an organisation are adhered to and that best practice is promulgated throughout the organisation.	Investigates and documents the internal control of specified aspects of automated or partly automated processes, and assesses compliance with the relevant standard.

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	The provision of policy, internal standards and advice on the procurement or commissioning of externally supplied and internally developed products and services. 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. The identification and management of suppliers to ensure successful delivery of products and services required by the business.	Reviews business cases (requirements, potential benefits and options) and determines appropriate procurement routes, e.g., 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.
		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. Investigates, resolves or escalates problems. Implements supplier service improvement actions and programmes.

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 take appropriate steps to address non-compliance. Pro-actively 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	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.	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.
Digital marketing	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.	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.
		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.

Skill	Description	
Selling	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.	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.
Sales support	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.	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.

Skill	Description	
Product management	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.	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.

Appendix 4: Mapping of Pearson BTEC HND in 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:

FHEQ Level 5 descriptor		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 upon the external environment.
	KU3	A critical understanding of the evolving concepts, theories and models within the study of 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.

FHEQ Level 5 descriptor		Computing HND Programme Outcome
	KU7	Critical understanding of how computer-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 an 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.

FHEQ Level 5 descriptor		Computing HND Programme Outcome
	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.
	CS1	Deploy appropriate theory, practices and tools in order to analyse, specify, design and implement computing systems and software applications.
	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.
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 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 self-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:

FHEQ Level 5 descriptor		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 and 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 continuing professional development 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:

FHEQ Level 5 descriptor		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: Glossary of terms used for internally assessed units

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

Term	Definition
Analyse	Present the outcome of methodical and detailed examination either: • breaking down a theme, topic or situation in order to interpret and study the interrelationships between the parts and/or of information or data to interpret and study key trends and interrelationships. Analysis can be through activity, practice, written or verbal presentation.
Apply	Put into operation or use. Use relevant skills/knowledge/understanding appropriate to context.
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	Identify the main factors relating to two or more items/situations or aspects of a subject that is extended to explain the similarities, differences, advantages and disadvantages. This is used to show depth of knowledge through selection of characteristics.
Compose	Create or make up or form.
Communicate	Convey ideas or information to others. Create/construct skills to make or do something, for example a display or set of accounts.
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	Consider different aspects of: ● 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	Work draws on varied information, themes or concepts to consider aspects, such as: ● strengths or weaknesses ● advantages or disadvantages ● alternative actions ● relevance or significance 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.
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: • 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	Make a formal assessment of work produced. The assessment allows students to: • 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, e.g. an idea or plan, for consideration
Undertake/ Carry Out	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, e.g. 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 6: 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 present 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

Assessment technique	Description	Transferable skills development	Formative or Summative
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
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, and using maps.	Creativity Interpretation Written and oral communication Interpretation Decision-making Initiative Information and Communications Technology Literacy, etc	Summative

Assessment technique	Description	Transferable skills development	Formative or 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
Self-reflection	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.	Self-reflection Written communication Initiative Decision-making Critical thinking	Summative

Assessment technique	Description	Transferable skills development	Formative or Summative
Simulated activity	This technique is a multi-faceted activity based on realistic work situations.	Self-reflection Written communication Initiative Decision-making Critical thinking	Formative Summative
Team assessment	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.	Collaboration Teamwork Leadership Negotiation Written and oral communication	Formative Summative
Tiered knowledge	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.	Critical thinking Analysis Interpretation Decision-making Oral and written communication	Formative

Assessment technique	Description	Transferable skills development	Formative or Summative
Time-constrained assessment	This technique covers all assessment that needs to be done 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, set of instructions, giving information.	Reasoning Analysis Written communication Critical thinking, interpretation.	Summative

Appendix 7: Pearson BTEC HNC/HND 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	17
1	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	
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	
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
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			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
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
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		
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	X	
9	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	
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
11			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
13	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
14	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
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	
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	
17	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	
18			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	
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	
21	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	X	X		X	X	X	X	X	X	X	X	X	
23	X	X	X	X		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**																
Unit	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
24	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		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		X	X	
27	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
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	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	
30	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	
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	X		X	X	
32	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
33				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		X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X		X	X	
35	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	
36	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	
37	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	
38	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	
39	X	X	X	X	X	X			X						X		X	X					X	X	X				X	X	X	X	X	X		X		X				X	X	
40	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
41	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	
42	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	
43	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	
44	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	
45	X	X	X		X	X			X		X				X	X	X	X	X									X	X	X	X	X	X			X		X				X	X	
46	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	
47	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

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	17
48	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	
49	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	

Appendix 8: Transferable skills mapping

Level 5 Higher National Diploma in Computing: mapping of transferable employability and academic study skills

Skill Set	Cognitive skills							Intra-personal Skills				Interpersonal Skills		
Unit	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			
2	X	X	X		X		X	X	X	X	X			X
3		X	X	X			X	X	X	X	X	X	X	X
4	X	X	X		X	X	X	X	X	X	X			
5	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			
8	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	
11	X	X	X			X		X	X	X				
12	X	X	X		X	X		X	X	X	X			
13	X	X	X	X	X		X	X	X	X	X		X	
14		X	X	X	X		X	X		X	X			X
15	X	X	X	X	X	X	X	X	X	X	X			
16	X	X	X	X	X	X	X	X	X	X	X			
17	X	X	X	X	X			X	X	X	X		X	X

Skill Set	Cognitive skills							Intra-personal Skills				Interpersonal Skills		
Unit	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
18	X	X	X			X		X	X	X	X			
19	X	X	X	X	X	X	X	X	X	X	X		X	
20	X	X	X		X	X	X	X	X	X	X			
21	X	X	X			X	X	X	X	X	X			
22	X	X	X	X	X	X	X	X	X		X			
23		X		X	X	X			X	X	X			
24	X	X	X		X	X	X	X	X	X	X			
25	X	X	X	X	X			X	X	X	X		X	
26	X	X	X	X	X	X	X	X	X	X	X			
27	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
29	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	
31	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
33	X	X	X		X	X	X	X	X	X	X			
34	X	X	X	X	X		X	X	X	X	X	X	X	X
35	X	X	X	X	X			X	X	X	X			
36	X	X	X	X	X		X	X	X	X	X			
37	X	X	X	X	X		X	X	X	X	X			
38	X	X	X	X	X		X	X	X	X	X	X	X	
39	X	X	X	X	X		X	X	X	X	X	X	X	X

Skill Set	Cognitive skills							Intra-personal Skills				Interpersonal Skills		
Unit	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
40	X	X	X	X	X		X	X	X	X	X	X	X	X
41	X	X	X	X	X		X	X	X	X	X	X		
42	X	X	X	X	X			X	X	X	X		X	
43	X	X	X	X	X		X	X	X	X	X		X	X
44	X	X	X	X	X	X	X	X	X	X	X			
45		X	X	X	X				X	X	X			X
46	X	X	X	X	X	X	X	X	X	X	X	X	X	X
47	X	X	X	X	X		X	X	X	X	X	X	X	X
48	X	X	X		X			X	X	X	X			
49	X	X	X		X		X	X	X	X	X	X	X	

Appendix 9: Recognition of Prior Learning

QCF Pearson BTEC Level 4 Higher National Certificate in Computing unit content mapped to the Level 4 units available in the Pearson BTEC Higher National Computing programmes (RQF)

HNCs in Computing: Unit Mapping Overview

This mapping document is designed to support centres who wish to recognise student achievement in older QCF Higher Nationals within the new RQF suites. The document demonstrates where content is covered in the new suite, and where there is new content to cover to ensure full coverage of learning outcomes.

P – Partial mapping (some topics from the old unit appear in the new unit)

X – Full mapping + new (all the topics from the old unit appear in the new unit, but new unit also contains new topic(s))

N – New unit

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN programme	Level of similarity between units
1	Programming	18	P
		19	P
		20	P
		34	P
2	Networking	24	X
3	Professional Practice	3	X
		50	P
4	Database Design & Development	17	P
		21	X
5	Security	48	P
6	Managing a Successful Computing Project	4	P
		7	P
7	Strategic Information Systems	30	X
8	Computer Systems Architecture	25	P
9	Software Development Lifecycles	9	P

Unit no.	Unit title New RQF HN programme	Maps to unit number on existing QCF HN programme	Level of similarity between units
10	Website Design & Development	14	P
		36	P
11	Maths for Computing		N
12	Data Analytics		N

HNCs in Computing: Unit Mapping in Depth

The RQF Pearson BTEC Level 4 HNC Certificate in Computing mapped against the current QCF Pearson BTEC Level 4 HNC Certificate in Computing units (specification end date 31/12/17).

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
1	Programming	18	Procedural Programming	Unit 18 LO1	Unit 1 LO2
		19	Object Oriented Programming	Unit 19 LO1	Unit 1 LO2
		20	Event Driven Programming Solutions	Unit 20 LO1	Unit 1 LO2
		34	Data Structures and Algorithms	Unit 34 LO1	Unit 1 LO1
2	Networking	24	Networking Technologies	Unit 24 LO1 Unit 24 LO2 Unit 24 LO3 Unit 24 LO4	Unit 2 LO1 Unit 2 LO2 Unit 2 LO3 Unit 2 LO4
3	Professional Practice	3	Employability and Professional Development	Unit 3 LO2 Unit 3 LO4 Unit 3 LO3 Unit 3 LO1	Unit 3 LO1 Unit 3 LO2 Unit 3 LO3 Unit 3 LO4
		50	Work-based Experience	Unit 50 LO1	Unit 3 LO4
4	Database Design & Development	17	Database Design Concepts	Unit 17 LO2 Unit 17 LO3	Unit 4 LO1 Unit 4 LO2
		21	Software Applications Testing	Unit 21 LO1-4	Unit 4 LO3
5	Security	48	IT Security Management	Unit 48 LO1 Unit 48 LO3 Unit 48 LO4	Unit 5 LO1 Unit 5 LO3 Unit 5 LO4

RQF HNC Units		QCF HNC units		Mapping comments	
No	RQF unit title	No	QCF unit title	QCF LOs	RQF LOs
6	Managing a Successful Computing Project	4	Project Design Implementation and Evaluation	Unit 4 LO4 Unit 4 LO3	Unit 6 LO3 Unit 6 LO4
		7	Research Skills	Unit 7 LO2	Unit 6 LO2
7	Strategic Information Systems	30	Information Systems in Organisations	Unit 30 LO1 Unit 30 LO2 Unit 30 LO3	Unit 7 LO1 Unit 7 LO2 Unit 7 LO3
8	Computer Systems Architecture	25	Routing Concepts	Unit 25 LO4	Unit 8 LO4
9	Software Development Lifecycles	9	Systems Analysis and Design	Unit 9 LO1 Unit 9 LO2	Unit 9 LO1 Unit 9 LO2
10	Website Design & Development	14	Website Design	Unit 14 LO4	Unit 10 LO4
		36	Internet Server Management	Unit 36 LO1 Unit 36 LO2	Unit 10 LO1 Unit 10 LO1