Higher Nationals

Computing

Specification

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

First teaching from September 2022
First Certification from September 2023

Higher National Certificate Lvl 4

Higher National Diploma Lvl 5

Undergraduate Level Qualifications

Pearson BTEC

About Pearson

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

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

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

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

Summary of changes made between previous issue and this current issue	Page number
Removed terms “black box testing”, “white box testing”, “black market” and replaced them with “functional testing”, “structural testing”, “illegal” respectively.	110, 134, 157, 246, 247, 258, 259
Unit 15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems Assessment criteria: D1 had a minor rephrase to provide more clarity on assessment.	200
Unit 31: Forensics Replaced term “Test Plan” with “forensic examination plan” on LO4, LO4 content, P7 and P8 to align with forensics terminology and provide more clarity on assessment.	322–327
Unit 45: Internet of Things Assessment criteria: P6 had a minor rephrase to provide more clarity on assessment.	427
Unit 47: Emerging Technologies Assessment criteria: M4 had a minor correction to provide more clarity on assessment.	442
Where Distinction criteria cross over to more than one Learning Outcome, it is reflected on the Learning Outcomes and Assessment Criteria tables. For Example: “LO1 and LO2”	

Earlier issues show previous changes.

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

Contents

1 Introduction

BTEC is an established brand of choice for the world's learning communities, engaging students in applied, practical, interpersonal and thinking skills for more than three decades. The BTEC suite of Pearson qualifications, Higher Nationals (HNs) are widely supported by higher education and industry as the principal vocational qualifications at Levels 4 and 5. BTEC is one of the world's most successful applied learning brands, helping students develop their practical, interpersonal and thinking skills for more than 30 years.

When developing our BTEC Higher National qualifications, we worked with a wide range of students, employers, higher education providers, colleges and subject experts to make sure the qualifications met their needs and expectations. We also work closely with professional organisations to make sure the qualifications were in line with recognised professional standards.

The Pearson BTEC Higher National qualifications are designed to reflect the increasing need for high quality professional and technical education at Levels 4 and 5. They provide students with a clear line of sight to employment and to a degree at Level 6 if they choose.

1.1 The Student Voice

Students are at the heart of what we do. That is why we consult them from the start when developing our Higher National qualifications. We involve them in writing groups, seek their feedback and take note of their opinions.

This helps us develop the best possible qualifications and learning experience for students worldwide.

1.2 Why choose Pearson BTEC Higher Nationals?

Pearson BTEC Higher National qualifications take a student-centred approach to the curriculum. There is a flexible, unit-based structure that focuses on developing the practical, interpersonal and thinking skills the student will need to succeed in employment and higher education. They represent the latest in professional standards and provide opportunities for students to develop skills and behaviours for work, for example by taking part in a group project or meeting a client brief. A student may achieve exemption from professional or vendor qualifications, or membership of selected professional organisations to help students on their journey to professional recognition or membership.

Pearson BTEC Higher Nationals are intended to keep doors open for future study if a student wishes to take their education further after completing a Higher National programme. They do this by allowing space for students to develop their higher education study skills, such as the ability to research. The study programme is clearly set out in line with the Quality Assurance Agency for Higher Education's Framework for Higher Education qualification standards at Levels 4 and 5. This means that students who want to progress to Levels 5 or 6 study should feel better prepared.

The Pearson BTEC Higher Nationals meet these requirements by providing:

- a range of general and specialist study units, both core and optional, each with a clear purpose, so there is something to suit each student's choice of programme and future progression plans
- up-to-date content, closely in line with the needs of employers, professional bodies and higher education, for a skilled future workforce
- learning outcomes mapped against professional body standards where appropriate
- support for tutors, including Authorised Assignment Briefs, curriculum planning support and assessment guidance, and
- support for students, including digital learning resources and communities, through HN Global.

1.3 HN Global

Our HN Global website provides a specially designed range of digital resources to give tutors and students the best possible experience during their BTEC Higher National programme. More information is available at: www.highernationals.com.

1.4 Qualification titles

Pearson BTEC Level 4 Higher National Certificate in Computing

Specialist pathways are given in brackets in the qualification title.

- Pearson BTEC Level 4 Higher National Certificate in Computing (General)
- Pearson BTEC Level 4 Higher National Certificate in Computing (Data Analytics)
- Pearson BTEC Level 4 Higher National Certificate in Computing (Network Engineering)
- Pearson BTEC Level 4 Higher National Certificate in Computing (Cyber Security).

Pearson BTEC Level 5 Higher National Diploma in Computing

Specialist pathways are given in brackets in the qualification title.

- Pearson BTEC Level 5 Higher National Diploma in Computing (General)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Software Engineering)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Applications Development and Testing)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Data Analytics)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Network Engineering)
- Pearson BTEC Level 5 Higher National Diploma in Computing (Cyber Security).

1.5 Qualification codes

Ofqual Regulated Qualifications Framework (RQF) Qualification numbers:

Pearson BTEC Level 4 Higher National Certificate in Computing: **603/7595/4**

Pearson BTEC Level 5 Higher National Diploma in Computing: **603/7596/6**.

1.6 Awarding institution

Pearson Education Ltd.

1.7 Key features

Pearson BTEC Higher National Computing qualifications offer:

- an exciting and informative study programme that stimulates and challenges students
- a simple and flexible structure that enables students to take the Higher National Certificate and then build on it in the Higher National Diploma, with optional units linked to their specialist area of study
- an opportunity for students to follow specialist routes of interest at both Level 4 and Level 5, gaining the knowledge and skills they need to progress to higher education or employment in their specialist area
- refreshed content that is closely aligned with professional body, vendor, employer and higher education needs.
- core competencies throughout the curriculum, to support lifelong learning skills for personal and professional development
- the opportunity for centres to offer assessments that consider cognitive skills (what students know), along with effective and applied skills (how they behave and what they can do), to support a practical and dynamic approach to learning
- unit-specific assessment and Pearson-set themes designed to encourage thorough and analytical learning, challenge students and develop skills in critical thinking, personal responsibility and decision making
- a flexible approach to assessment that supports progression to higher education or to work and which allows for different learning styles
- quality assurance measures that assure professional organisations, universities, businesses, colleges and students of the integrity and value of the qualifications, and
- a programme of learning designed to meet skills gaps in the current workforce and build today's talent to meet tomorrow's needs in an international environment.

Qualification frameworks

Pearson BTEC Higher National qualifications are recognised higher education qualifications in the UK. They are in line with 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

We are grateful to the university and further education tutors, employers, professional bodies and others who have generously shared their time and expertise to help us develop these new Pearson BTEC Higher National qualifications in Computing. Our thanks go to:

- Amazon Web Services (AWS)
- Beam Connectivity
- Bedford College
- Cisco
- CompTIA
- Fujitsu
- Imago Solutions Ltd
- Institute for Apprenticeships and Technical Education (IfATE)
- Institution of Engineering and Technology (IET)
- ISC^2
- Lockheed Martin
- National College for Digital Skills
- The Chartered Institute for IT (BCS)
- The Tech Partnership
- University of Kent
- University of Hull
- Uxbridge College
- QA Apprenticeships.

2 Programme purpose and objectives

2.1 Purpose of the Pearson BTEC Higher Nationals

The purpose of Pearson BTEC Higher Nationals is to develop students as independent-thinking professionals who can meet the demands of employers and adapt to a constantly changing world. The qualifications aim to widen access to higher education and improve the career prospects of those who take them.

2.2 Objectives of the Pearson BTEC Higher Nationals

The aims of the Pearson BTEC Higher Nationals in Computing are:

- to equip students with computing skills, knowledge and understanding in order 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, applications development and testing
- to provide insight and understanding of international computing operations and the opportunities and challenges presented by a globalised market place
- to give students knowledge and understanding of culturally diverse organisations, cross-cultural issues, diversity and values
- to give students opportunities to enter or progress in employment in computing, or to progress to higher education qualifications such as an honours degree in computing or a related area
- to provide opportunities for those students with a global outlook to aspire to international career pathways by achieving an internationally recognised professional qualification
- to provide opportunities for students to achieve vendor accredited certifications
- to allow flexibility of study and to meet local or specialist needs
- to offer a balance of employability skills and the knowledge that is essential for students with entrepreneurial, employment or academic aspirations.

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, a unit specialism which is pathway dependent and an optional unit of study; allowing for the acquisition of skills and experience across a range of occupational sectors at Level 4. The Level 4 pathway includes a general pathway and the following specialist pathways:

- Data Analytics
- Network Engineering
- Cyber Security.

The BTEC Level 4 Higher National Certificate in Computing builds underpinning core skills effectively, preparing students for further subject specialisation at Level 5. They will gain a wide range of sector knowledge that is tied to practical skills gained in research, self-study, directed study and workplace scenarios.

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 one general pathway and five specialist pathways, designed to support progression to relevant occupational areas or degree-level study.

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

- Software Engineering
- Applications Development and Testing
- Data Analytics
- Network Engineering
- Cyber Security.

The non-specialist ‘General’ pathway 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 that require the exercise of personal responsibility and decision making.

The pathways at both Level 4 and Level 5 are mapped to professional body standards and vendor-accredited certification (where appropriate) and can provide professional status and progression to direct employment.

2.5 Developing students' employability skills and academic study skills

Employability skills (sometimes referred to as transferable skills) are vital in increasing students' career prospects and they contribute to their personal development. Our BTEC Higher Nationals in Computing support students in developing the key skills, qualities and strengths that employers are looking for.

We divide employability skills into five main categories.

- **Problem-solving skills**
  These include:
  - critical thinking
  - using expert and creative solutions to solve non-routine problems
  - using systems and digital technology, and
  - generating and communicating ideas creatively.
- **Independent skills**
  These include:
  - self-management
  - adaptability and resilience
  - self-monitoring and self-development
  - self-analysis, and
  - reflection, planning and prioritising.
- **Interpersonal skills**
  These include:
  - leadership skills
  - communicating effectively
  - working with others
  - negotiating and influencing, and
  - presentation skills.

- **Commercial skills**
  These include:
  - awareness of the computing and business sector
  - IT and systems integration across the business environment
  - project management
  - programming
  - application and systems development.

Students also benefit from opportunities to carry out deeper learning; they can make connections between different study units and select areas of interest for detailed study. In this way, BTEC Higher Nationals in Computing provide a vocational context in which students can develop the knowledge and academic study skills they need to progress to university degree courses.

The academic study skills include:

- active research
- effective writing
- analytical skills
- critical thinking
- creative problem solving
- decision making
- preparing for exams, and
- using digital technology.

Appendix 3: Transferable skills mapping includes a map of transferable and academic study skills to help tutors develop students' skills. Students can also develop their academic skills through independent study modules and resources on the HN Global platform: https://hnglobal.highernationals.com/.

2.5.1 Use of Maths and English within the curriculum

Those working in the computing sector cannot just rely on their technical skills, they must ensure that **all** their skills are relevant so as to increase their 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 in these qualifications in accordance with industry requirements, examples of how these skills are developed in the BTEC Higher Nationals Curriculum are:

- 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 students' studies they will be using some level of maths in 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 that they are part of the learning activities and assessments to ensure that their skills are in line with current industry standards.

Some units in the qualification, such as Maths for Computing, Discrete Maths and Applied Analytical Models, also require maths skills. We strongly recommend that all students, as well as having a grade A* to C or 9 to 4 in GCSE Maths, complete maths diagnostic assessments before beginning a Higher National course. (See *Entry requirements and admissions* in *section 5.2*).

2.6 What could these qualifications lead to?

The Level 4 Higher National Certificate provides a solid foundation in computing, which students can build on if they decide to continue their studies. The Level 5 Higher National Diploma allows students to specialise by committing to specific career paths and progression routes to degree-level study.

Once students have achieved the Level 5 Higher National Diploma, they can develop their career in the respective sector by:

- entering employment
- continuing existing employment
- linking with the appropriate professional body
- committing to continuing professional development, or
- studying at university.

2.6.1 Progression to university

The Level 5 Higher National Diploma is recognised by higher education providers as meeting admission requirements to many computing-related courses, for example:

- BSc (Hons) Computing
- BSc (Hons) in Applied Computing
- BSc (Hons) in Business and Computing.

University recognition and articulations

We work with a range of higher education institutions around the world that accept Pearson BTEC Higher Nationals as a qualification for entry to their undergraduate degree courses; many universities allow advanced entry to the second or third year of their courses. Agreements can include transferring learning credits from one course or qualification to the other, articulation and case-by-case admission.

Students should be aware that each university sets its own admission criteria and that those criteria can change. Before applying, students should understand the course entry requirements for the subject and year in which they want to study. For more information on entry requirements, including 2+1 articulations, please visit: https://www.highernationals.com/degree-finder.

3 Preparing students for employment

3.1 Designing with employers, for employers

As a large employer and qualification-awarding organisation, Pearson understands the value of developing the skills and talent of the future workforce. We believe in, and champion, higher technical education that is relevant to employers.

We work with employers, students, professional bodies, education providers and other experts to design qualifications with the future workforce in mind. Higher National qualifications blend employability skills with academic, business and technical knowledge. They support trainees and apprentices in their higher-apprenticeship and other technical education programmes, as well as students working towards a degree. We update our programmes regularly to maintain their high quality and meet the changing needs of the workforce.

Employers contribute to our Higher Nationals in several ways:

- they are involved in every stage of designing our qualifications, from developing the structure and pathways, to selecting subjects, developing content and approving qualifications
- they help us deliver qualifications, for example through vendor accreditation, letters of support and co-badging. Our qualifications actively encourage training providers to work with employers. Work placements and work through learning are key features of BTEC Higher Nationals
- they help us review and update our qualifications to meet occupational standards and provide supporting material, such as case studies, to reflect the real world of work.

We are committed to equipping apprentices, trainees and organisations with the tools and resources they need to support high-quality, innovative technical education and Higher Apprenticeship programmes.

Including a Higher National qualification as part of a Higher Apprenticeship or technical education programme gives students:

- an internationally recognised higher-level qualification in line with the Framework for Higher Education Qualifications, and
- a stepping-stone to continue their education or training and gain a recognised degree or professional qualification.

To find out more, and to access detailed mapping to higher apprenticeship and occupational standards for your qualification, please visit the '*Apprenticeship*' pages on HN Global.

3.1.1 Employability skills and competencies for student career success

Pearson is committed to delivering learning that is rooted in the real world and to developing work-ready graduates with the professional skills and behaviours that employers need. The Pearson BTEC Higher National curriculum provides a clear line of sight to employment, depending on which specialist areas students complete. The aim is to produce students who are equipped to thrive in the changing world of work, whether they leave with an HNC or an HND qualification.

3.1.2 Developing competencies for the workplace

Core competencies developed on the specialist pathways of the programme will support students in preparing for a range of employment opportunities in their chosen sector. These core competencies collectively summarise the key capabilities that are important across the sector, covering areas of relevant expertise and technical skills that would be required in the sector to perform a job successfully, as defined in current, advertised job vacancies.

Core competencies are developed on programme in a balanced framework of cognitive (knowledge), affective (behaviours) and psychomotor (practical) learning outcomes to encourage a more vocational and practical approach to learning.

3.1.3 Professional Body recognition and exemption

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

Types of professional body agreements for Higher Nationals in Computing

There are a variety of agreements that we can have in place with professional organisations, although note that not all of these will apply to all qualifications.

- Professional accreditation: where a specific study programme prepares students to register for a regulated professional qualification. In some cases, completing the Higher National Diploma may be enough for students to receive the professional qualification
- Membership: where students are offered student membership whilst studying, or progression to membership on completion of their qualification
- Recognition: where a professional organisation recognises the value of a Higher National qualification in preparing students for the industry
- Exemption: professional organisations may also offer exemptions from units on some of their qualifications. This means that students completing these Higher National units will have covered the material required for those professional body units and can claim exemption when studying for the professional body qualification.

For the full accreditation and exemption details for this qualification, please refer to the 'Professional Recognition' pages within the Progression Hub on HN Global: https://hnglobal.highernationals.com/ or on the 'Industry Engagement' page: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/computing-2022/industry-engagement.html

We continuously work to update and add new agreements, therefore please refer to these online pages for the most up-to-date information.

3.1.4 Vendor accreditation

To see how the units in the BTEC Higher Nationals in Computing map against the vendor certificates mentioned below, please visit the **Computing subject** ***page on the HN Global site for the most up-to-date mapping and alignment:***
https://hnglobal.highernationals.com/

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.

Students will ***not*** automatically gain vendor accredited certificates as a result of studying a BTEC HNC and/or a BTEC HND. On completion of the relevant unit(s) of study, students can apply to the individual vendor to sit the appropriate exam or provide the relevant evidence to gain certification. Typically, but not always, students may need to study more than one unit to be equipped for the vendor's certification exam.

Certifications from the following vendors have been aligned to the BTEC Higher Nationals in Computing:

Cisco is the largest networking company in the world, it sponsors 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.

The Cisco Certified Network Associate (CCNA) certification has been designed to prepare students for today's associate-level job roles in IT technologies. The CCNA curriculum is one training programme and one exam, which leads to certification but that is presented in three courses that cover a broad range of fundamentals and provide integrated and comprehensive coverage of networking topics. The three CCNA courses are covered as follows:

- Introduction to Networks (ITN) covered in full
- Switching, Routing and Wireless Essentials (SRWE) covered in full
- Enterprise Networking, Security and Automation (ENSA) covered partially.

The essential principles and skills for these courses are covered through studying the relevant units. See HN Global for full mapping.

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.

Further information on how to take any of the Cisco certification exams can be found on the Cisco website: https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html

Examinations may also be available through Pearson Vue: http://www.pearsonvue.com/cisco/.

Microsoft Certifications give a professional advantage by providing globally recognised and industry-endorsed evidence of mastering skills in digital and cloud businesses. Fundamentals certifications are ideal for individuals just starting in technology or thinking about a career change.

A few standalone units have been aligned to Microsoft certifications. These are indicated in the unit introduction. Mapping details are available on HN Global under the subject page: https://hnglobal.highernationals.com/. For students to be in a position to achieve these certifications, the units must be delivered with Microsoft Azure technology. The certifications aligned are:

- Microsoft Certified: Azure Fundamentals
- Microsoft Certified: Azure AI Fundamentals.

In addition, Microsoft Office Specialist (MOS) certifications allow demonstration of the skills needed to get the most out of Microsoft Office. There is a range of certifications available, which includes Microsoft Word, Microsoft Excel, and Microsoft PowerPoint. An MOS Certification validates expertise in Microsoft technology. Passing a first Microsoft Certification exam automatically makes the student a member of the Microsoft Certified Professional (MCP) community, with access to all of the benefits provided through the MCP.

All of the units in the BTEC Higher Nationals in Computing give students the opportunity to develop high-level Microsoft Office skills, thereby allowing students to be sufficiently prepared to take the MOS exams.

Further information on how to take any of the Microsoft certification exams can be found on the Microsoft learning website: https://www.microsoft.com/en-us/learning/.

Examinations may also be available through Pearson Vue: https://home.pearsonvue.com/Clients/Microsoft.aspx.

Huawei Certification provides leading talent certification standards across four key domains: telecoms networks, IT, smart devices and cloud services. Huawei offers three levels of certification: Huawei Certified ICT Associate (HCIA), Huawei Certified ICT Professional (HCIP), and Huawei Certified ICT Expert (HCIE)

The Huawei Certified ICT Associate (HCIA) offers foundational training and certification with small- and medium-sized enterprise network deployment and O&M capabilities and is the basis of progression to professional (HCIP) and expert (HCIE) status. The mapping in this qualification is at HCIA level.

For students to be in a position to achieve Huawei certification, the relevant units must incorporate the use of Huawei technologies.

Further information on how to take any of the Huawei certification exams can be found on the Huawei website: https://e.huawei.com/en/talent/portal/#/

Examinations may also be available through Pearson Vue:
https://home.pearsonvue.com/Clients/Huawei.aspx.

Oracle is a leading database software company and has developed technologies into the entire technology stack. The Oracle Certification Program certifies students 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.

Further information on how to take any of the Oracle certification exams can be found on the Oracle website: https://education.oracle.com/Certification

Examinations may also be available through Pearson Vue:
http://www.pearsonvue.com/oracle/

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

Further information on how to take any of the CompTIA certification exams can be found on the CompTIA website: https://www.comptia.org/

Examinations may also be available through Pearson Vue: http://www.pearsonvue.com/comptia/.

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/).

4 Centre support

4.1 Support for setting up your course and preparing to teach

You can access a wide range of resources and support to help you deliver our Pearson BTEC Higher Nationals with confidence. You will find a list of resources to support teaching, learning, assessment and professional development on HN Global.

4.2 This document

This specification gives you details of the administration of the qualifications and information on the units included.

4.3 HN Global

HN Global is a dedicated online learning platform for all Pearson BTEC Higher National students and delivery centres. You can find various free resources to support staff delivering a Pearson BTEC Higher National programme and to guide students on their learning journey. The global forum connects students and tutors and provides the opportunity to discuss common themes and share good practice. HN Global also provides access to the following.

The learning zone includes student study materials such as core textbooks, study skills modules, a 'Progression hub' featuring opportunities to develop employability skills and an e-library and subject materials.

The tutor resources section hosts a wealth of delivery materials, reading lists, blended learning resources, video guidance on assessment, and professional development opportunities. Staff can also access the QA Hub for templates and more Centre support.

Short courses provide support for curriculum planning, developing schemes of work and developing students' academic skills.

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

4.4 Authorised Assignment Briefs

We provide a booklet of Authorised Assignment Briefs (AABs) for a sample of units. These AABs have been developed to support centres with their assessment strategy for the delivery of a sample of units, as well as providing guidance and inspiration for effective planning and design of future assignment briefs.

They can be used in the following ways:

1. AABs ***can be modified and customised*** to meet localisation
2. AABs ***can be used off the shelf by centres if they meet your specific requirements***, following internal verification. They have been written to assess students' knowledge, understanding and skills specifically relevant to the unit Learning Outcomes but they have not been contextualised to meet local need and international diversity. Centres will still need to select and provide a relevant organisation.

In both cases ***the Assignment Brief should still be internally verified and made available for standards verification.***

AABs offer a range of real and simulated assessment activities, for example group work, to encourage cooperation and social skills or a solution-focused case study to develop cognitive skills. The assessment grids for each unit explain the specific requirements for assessing these skills. All assignments must be moderated in line with the internal verification process.

The *Tutor Resources* section on HN Global offers a wide range of resources and guidance documents to help you plan and design assessments effectively. Please see the *Authorised Assignment Brief booklet* on the subject page at: https://hnglobal.highernationals.com/

4.5 Assignment checking service

This is a free service for BTEC centres to make sure that assignments enable students to produce suitable evidence across the required Learning Outcomes.

It is especially useful for programme teams that are relatively new to BTEC and want to check that their assignments are fully meeting a unit's requirements. Please see: https://qualifications.pearson.com/en/support/Services/assignment-checking-service.html

4.6 Pearson English

Pearson provides a full range of support for English learning, including diagnostics, qualifications and learning resources. Please see: www.pearson.com/english.

The Pearson English Portal also offers a variety of digital resources. The portal encourages users to get involved, improves teaching and results, and increases the learning experience.

5 Planning your programme

5.1 Delivering the Higher Nationals

As a large employer and qualification-awarding organisation, Pearson understands the value of developing the skills and talent of the future workforce. We believe in, and champion, higher technical education that is relevant to employers.

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

Assess your students very carefully to make sure that they take the right qualification and the right pathways and optional units. This will allow them to progress to the next stage in their learning or employment journey. You should also check the qualification structures and unit combinations carefully when giving students advice.

Make sure that your students have access to a full range of information and advice to help them choose the right qualification and units. When students are recruited, you need to give them accurate information on the title and focus of the qualification for which they are studying. Centres must provide a programme specification for approvals but it is also essential that centres produce:

- a staff handbook to support full- and part-time members of your team, and
- a student handbook to guide students through the course requirements so they know what is expected of them and understand their rights.

You can find more information in the *BTEC Higher Nationals Centre Guide to Quality Assurance and Assessment* available on our website: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html.

5.1.1 Centre approval

We need to approve all centres before they can offer our qualifications. This is to make sure that your Centre is ready to assess students and that we can provide the support you need.

For more information about becoming a Centre and gaining approval to run our qualifications, please visit 'UK Centre approvals for schools and colleges' on our website: https://qualifications.pearson.com/en/forms/-uk-centre-approval-for-schools-and-colleges.html.

5.1.2 Tutor knowledge

We do not set any requirements for tutors, but we do recommend that centres assess the overall skills and knowledge of the teaching team to make sure they are relevant, up to date and at the correct level.

5.1.3 Resources

As part of your Centre approval, you will need to show that the right resources and workspaces are available to deliver Pearson BTEC Higher Nationals. Some units need specific resources. This is clearly explained in the unit descriptions.

5.1.4 Delivering learning

With our approval, you can deliver our Pearson BTEC Higher Nationals using a mixture of learning options that meets your students' needs. We recommend you offer full-time, part-time, blended learning and distance learning.

If you are delivering distance learning, please see the *Pearson Distance Learning Self-Assessment Policy* at: https://qualifications.pearson.com/en/support/support-topics/understanding-our-qualifications/policies-for-centres-learners-and-employees.html.

5.1.5 Support from Pearson

For each programme with active registrations, we will provide an External Examiner to help you plan and review assessments. You will also be able to access training events and support from a dedicated team of Pearson Higher National subject leads. Please see: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals.html.

5.2 Entry requirements and admissions

Pearson does not set formal entry requirements for our qualifications but as a Centre, you are responsible for making sure that the students you recruit have a reasonable chance of success on the programme.

Students who have recently been in education are **likely** to need:

- 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) in subjects such as maths and English
- other related Level 3 qualifications
- an Access to Higher Education Diploma from an approved further education institution
- relevant work experience, or
- an international equivalent to the above qualifications.

Our Recognition of Prior Learning policy means that students' previous learning and experience can be taken into account and they may be awarded certain qualifications or units of a qualification based on that learning or experience. Please see *Section 9 Recognition of prior learning and attainment* for more information.

5.2.1 English language requirements

Pearson's mission is to help people make more of their lives through learning. To assist centres in recruiting students who have the skills to benefit from undertaking a Higher National programme of study, we provide the following clarification regarding the English language **admission requirements** when offering places to applicants.

All centres delivering Pearson BTEC Higher National qualifications in English must ensure that each applicant can demonstrate their capability to learn and be assessed at the relevant level in English.

Students applying for a Pearson BTEC Higher National qualification that is taught and assessed completely in English will need a certain level of English language skills. Before accepting students onto a programme, you must make sure that those who are non-native English speakers and who have not carried out their final two years of schooling in English can demonstrate ability at a standard equivalent to:

- **Common European Framework of Reference (CEFR) level B2**
- **PTE Academic 51**, or
- **IELTS 5.5** (reading and writing must be at 5.5).

Students who have completed a Pearson BTEC Higher National qualification delivered partly or completely in another language but which was assessed in English will need to demonstrate ability in English to the standard above but at the **end** of the programme.

It is up to you to decide what proof of ability students will need to provide.

5.3 Access to study

This section focuses on the administration you will need to carry out when delivering our Pearson BTEC Higher National qualifications. It will be most relevant to quality controllers, Programme Leaders and examinations officers.

Our qualifications should:

- be available to everyone able to reach the required standards
- be free from any barriers that restrict access and progress, and
- provide equal opportunities for all those who want to access the qualifications.

For more information, please see our *Equality, diversity and inclusion policy* at: http://qualifications.pearson.com/

Please use your integrity when recruiting students to our Pearson BTEC Higher National programmes.

- Make sure that students applying have the information and advice they need about the qualification to be sure it meets their needs
- Check each student's qualifications and experience to make sure they have the potential to achieve the qualification
- For students with disabilities and specific needs, consider the support available to the during teaching and assessment. For more guidance, please see *section 5.6.2 Reasonable adjustments to* assessment.

5.4 Student registration and entry

All students should be registered on the qualification they are studying and suitable arrangements need to be made for internal and external verification. For information on making registrations, please see the information manual available in the support section of our website at: https://qualifications.pearson.com/en/support.html.

Students can be formally assessed only for a qualification on which they are registered. If a student changes the qualification they want to study for (for example if they decide to choose a different specialist pathway), you must transfer their registration to the new pathway. We cannot sample a student's work unless they are registered on the correct pathway.

5.5 Access to assessments

Assessments need to be managed carefully so that all students are treated fairly and that results and certificates are published without delay.

Our equality policy requires that:

- all students have an equal opportunity to access our qualifications and assessments, and
- 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 by law (for example race, sexuality or religious belief) are not disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for taking a qualification, and
- this achievement can be compared fairly to the achievement of their peers.

For more information on access arrangements, please visit the Joint Council for Qualifications (JCQ) website at: http://www.jcq.org.uk/.

5.6 Administrative arrangements for internal assessment

5.6.1 Records

You are required to retain records of assessment for each student. Records should include assessments taken, decisions reached and any adjustments or appeals. Further information on quality and assessment can be found in our UK and international guides, available in the support section on our website: https://qualifications.pearson.com/en/support.html. 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.

5.6.2 Reasonable adjustments to assessment

A reasonable adjustment is one that is made before a student takes an assessment, to ensure that they have fair access to demonstrate the requirements of the assessments.

You are able to make adjustments to internal assessments to take account of the needs of individual students. In most cases, this can be achieved through a defined time extension or by adjusting the format of evidence. We can advise you if you are uncertain as to whether an adjustment is fair and reasonable. You need to plan for time to make adjustments, if necessary.

Further details on how to make adjustments for students are available on the support section of our website: https://qualifications.pearson.com/en/support/support-topics/exams/special-requirements/reasonable-adjustment.html.

5.6.3 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 JCQ Guide to Special Considerations policy, which can be found on the JCQ website: https://www.jcq.org.uk/.

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.

5.6.4 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 are available in the support section of our website: https://qualifications.pearson.com/en/support.html.

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

5.7 Dealing with malpractice in assessment

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

Pearson does not tolerate actual or attempted actions of malpractice by learners, Centre staff or centres in connection with Pearson qualifications. Pearson may impose penalties and/or sanctions on learners, Centre staff or centres where malpractice or attempted malpractice has been proven.

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

Centres are required to take steps to prevent malpractice and to investigate instances of suspected malpractice. Learners must be given information that explains what malpractice is for internal assessment and how suspected incidents will be dealt with by the Centre. The *Centre guidance: Dealing with malpractice and maladministration* document gives full information on the actions we expect you to take.

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

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

5.7.1 Learner malpractice

The head of centre is required to report incidents of suspected learner malpractice that occur during Pearson qualifications. We ask centres to complete JCQ Form M1 (www.jcq.org.uk/malpractice) and email it with any accompanying documents (signed statements from the learner, invigilator, copies of evidence, etc.) to the Investigations Processing team at candidatemalpractice@pearson.com. The responsibility for determining appropriate sanctions or penalties to be imposed on learners lies with Pearson.

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.

Failure to report malpractice constitutes staff or Centre malpractice.

5.7.2 Teacher/centre malpractice

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

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

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

5.7.3 Sanctions and appeals

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

- mark reduction for affected external assessments
- disqualification from the qualification
- debarment from registration for Pearson qualifications for a period of time.

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

- working with centres to create an improvement action plan
- requiring staff members to receive further training
- placing temporary suspensions on certification of students
- placing temporary suspensions on registration of students
- debarring staff members or the Centre from delivering Pearson qualifications
- suspending or withdrawing Centre approval status.

The Centre will be notified if any of these apply.

Pearson has established procedures for considering appeals against penalties and sanctions arising from malpractice. Appeals against a decision made by Pearson will normally be accepted only from the head of centre (on behalf of 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 the *JCQ Appeals* booklet available at: https://www.jcq.org.uk/exams-office/appeals.

6 Programme structure

6.1 Units, credits and total qualification time (TQT)

The 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 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 a HND student to have achieved at least 90 credits at Level 4 before progressing to Level 5 units. This allows them to submit the remaining 30 credits at Level 4 while continuing with their Level 5 study.

If a HND student does not complete the full qualification, they may be awarded a HNC if they have gained enough credits.

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

- Core and specialist units are mandatory
- Specialist units provide a specific occupational focus to the qualification in line with professional body standards
- Optional units provide greater depth and breadth of study and can be localised.

Each unit usually carries 15 credits. Units are designed around the amount of time it will take for a student to complete them and receive a qualification. This is known as the total qualification time (TQT). TQT includes guided learning activities, directed learning activities and assessment. Each 15-credit unit has a TQT of 150 hours – 60 guided learning hours (GLH) and 90 hours of independent learning hours (ILH). (More information about guided and independent learning is given below.)

- The total qualification time for Higher National Certificate (HNC) = 1,200 hours
- The total qualification time for Higher National Diploma (HND) = 2,400 hours.

Examples of activities that can contribute to TQT include:

- guided learning
- independent and unsupervised research and learning
- unsupervised creation of a portfolio of work experience
- unsupervised e-learning
- unsupervised e-assessments
- unsupervised coursework
- watching a recorded podcast or webinar
- unsupervised work-based learning.

Guided learning hours

These are the hours where a tutor is present to give specific guidance towards the learning aim being studied. Guided learning hours include lectures, tutorials and supervised study in, for example, open learning centres and learning workshops. They also include supervised assessment activities such as invigilated exams, observed assessments and observed work-based practice.

- The total guided learning hours for Higher National Certificate (HNC) = 480 hours
- The total guided learning hours for Higher National Diploma (HND) = 960 hours.

Some examples of activities that can contribute to guided learning include:

- classroom-based learning supervised by a tutor
- work-based learning supervised by a tutor
- a live webinar or telephone tutorial with a tutor
- live e-learning supervised by a tutor, and
- all forms of assessment guided or supervised at the time by a tutor or other education or training provider. This includes where the assessment is competence-based and turned into a learning opportunity.

Independent learning hours

These are the hours where a student is learning without the direct guidance of a member of Centre staff. They are critical to the student’s ability to develop knowledge and skills, as well as providing them with the opportunity to develop key transferable skills such as self-discipline, time management and self-motivation.

Some examples of activities that can contribute to independent learning include:

- self-directed research and investigation
- reading set texts or other sources of information
- watching subject-related videos as part of investigation and research
- reviewing recordings of scheduled sessions or notes from those sessions
- peer activities, such as group meetings and online discussions, where students explore their learning together
- reviewing and recording thoughts on their own learning.
- The total independent learning hours for Higher National Certificate (HNC) = 720 hours
- The total independent learning hours for Higher National Diploma (HND) = 1,440 hours.

6.2 Programme structures

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 required
- the specialist units required
- the optional units available, and
- the maximum credit value in units that can be Centre commissioned.

When combining units for a Pearson BTEC Higher National qualification, it is up to the Centre to make sure the correct combinations are followed.

6.2.1 Pearson BTEC Level 4 Higher National Certificate in Computing

- Requires at least 120 credits = 8 units, each with a value of 15 credits
- 6 core units, 1 mandatory specialist unit and 1 optional unit
- Total qualification time = 1,200 hours
- Total guided learning hours = 480 hours
- All units are at Level 4.

Pearson BTEC Level 4 Higher National Certificate in Computing (General)		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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**7: Software Development Lifecycles**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below)			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Note: The General pathway is the prerequisite pathway for students who wish to progress to the Level 5 General, Software Engineering or Application Development pathways.

Pearson BTEC Level 4 Higher National Certificate in Computing (Data Analytics)		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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**8: Data Analytics**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Note: The Data Analytics pathway is the prerequisite pathway for students who wish to progress to the Level 5 Data Analytics pathway.

Pearson BTEC Level 4 Higher National Certificate in Computing (Network Engineering)		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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**9: Computer Systems Architecture**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13 Website Design and Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence AI) & Intelligent Systems**	15	4

Note: The Network Engineering pathway is the prerequisite pathway for students who wish to progress to the Level 5 Network Engineering pathway.

Pearson BTEC Level 4 Higher National Certificate in Computing (Cyber Security)		**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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**10: Cyber Security**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design and Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence AI) & Intelligent Systems**	15	4

Note: The Security pathway is the prerequisite pathway for students who wish to progress to the Level 5 Cyber Security pathway.

6.2.2 Pearson BTEC Level 5 Higher National Diploma in Computing

- Requires 240 credits, of which 120 credits are at Level 5 (7 units) and 120 credits are at Level 4 (8 units)
- Total qualification time = 2, 400 hours
- Total guided learning hours = 960 hours
- Mix of core, specialist and optional units, totalling 240 credits
- Optional units are selected to make up the remaining credit value
- **Specialist units can also be selected as optional units** for the General pathway, and for any of the specialist pathways
- **Only one specialist unit is permitted to be used as optional from any given specialist pathway.**

In order to ensure that BTEC Higher National Diploma students have the skills required to achieve on specialist pathways, we 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 14: Maths for Computing* at Level 4.

Students studying the BTEC Higher National Diploma (Cyber Security) are required to study *Unit 30: Applied Cryptography in the Cloud*, before they study *Unit 32: Information Security Management*.

Pearson BTEC Level 5 Higher National Diploma in Computing (General)		**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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**7: Software Development Lifecycles**	15	4
Plus, **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Level 5 Units			
Core Unit Mandatory	**16: Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**17: Business Process Support**	15	5
Plus, 75 credits from **FIVE** optional units selected from those listed below. The combination of units selected **must not** replicate one of the specialist pathways. Certification claims will be ineligible if a barred combination of units is selected. It is advised that units are chosen from across the Optional and Specialist Groups in order to deliver a comprehensive general computing qualification.			

Level 5 Optional Units			
Optional Unit	**33: Applied Analytical Models**	15	5
Optional Unit	**34: Analytical Methods**	15	5
Optional Unit	**35: Systems Analysis & Design**	15	5
Optional Unit	**36 User Experience & Interface Design**	15	5
Optional Unit	**37: Architecture**	15	5
Optional Unit	**38: Analytic Architecture Design**	15	5
Optional Unit	**39: Network Management**	15	5
Optional Unit	**40: Client/Server Computing Systems**	15	5
Optional Unit	**41: Database Management Systems**	15	5
Optional Unit	**42: Game Design Theory**	15	5
Optional Unit	**43: Games Development**	15	5
Optional Unit	**44: Games Engine & Scripting**	15	5
Optional Unit	**45: Internet of Things**	15	5
Optional Unit	**46: Robotics**	15	5
Optional Unit	**47: Emerging Technologies**	15	5
Optional Unit	**48: Virtual & Augmented Reality Development**	15	5
Optional Unit	**49: Systems Integration**	15	5
Optional Unit	**50: Operating Systems**	15	5
Optional Unit	**51: E-Commerce & Strategy**	15	5
Optional Unit	**52: Digital Sustainability**	15	5
Optional Unit	**53: Digital Technology as a Catalyst for Change**	15	5
Optional Unit	**54: Prototyping**	15	5

Specialist Level 5 Units			
Group A: Software Engineering			
Optional Unit	**18: Discrete Maths**	15	5
Optional Unit	**19: Data Structures & Algorithms**	15	5
Optional Unit	**20: Applied Programming and Design Principle**	15	5
Group B: Application Development and Testing			
Optional Unit	**21: Application Program Interfaces**	15	5
Optional Unit	**22: Application Development**	15	5
Optional Unit	**23: Risk Analysis & Systems Testing**	15	5
Group C: Data Analytics			
Optional Unit	**24: Advanced Programming for Data Analysis**	15	5
Optional Unit	**25: Machine Learning**	15	5
Optional Unit	**26: Big Data Analytics and Visualisation**	15	5
Group D: Network Engineering			
Optional Unit	**27: Transport Network Design**	15	5
Optional Unit	**28: Cloud Computing**	15	5
Optional Unit	**29: Network Security**	15	5
Group E: Cyber Security			
Optional Unit	**30: Applied Cryptography in the Cloud**	15	5
Optional Unit	**31: Forensics**	15	5
Optional Unit	**32: Information Security Management**	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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**7: Software Development Lifecycles**	15	4
Plus, **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Level 5 Units			
Core Unit Mandatory	**16: Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**17: Business Process Support**	15	5
Specialist Unit Mandatory	**18: Discrete Maths**	15	5
Specialist Unit Mandatory	**19: Data Structures & Algorithms**	15	5
Specialist Unit Mandatory	**20: Applied Programming and Design Principles**	15	5
Plus, 30 credits from **TWO** Level 5 units from the list below. The combination of units selected **must not** replicate one of the specialist pathways. Certification claims will be ineligible if a barred combination of units is selected.			

Level 5 Optional Units			
Optional Unit	**33: Applied Analytical Models**	15	5
Optional Unit	**34: Analytical Methods**	15	5
Optional Unit	**35: Systems Analysis & Design**	15	5
Optional Unit	**36: User Experience and Interface Design**	15	5
Optional Unit	**37: Architecture**	15	5
Optional Unit	**38: Analytic Architecture Design**	15	5
Optional Unit	**39: Network Management**	15	5
Optional Unit	**40: Client/Server Computing Systems**	15	5
Optional Unit	**41: Database Management Systems**	15	5
Optional Unit	**42: Game Design Theory**	15	5
Optional Unit	**43: Games Development**	15	5
Optional Unit	**44: Games Engine & Scripting**	15	5
Optional Unit	**45: Internet of Things**	15	5
Optional Unit	**46: Robotics**	15	5
Optional Unit	**47: Emerging Technologies**	15	5
Optional Unit	**48: Virtual & Augmented Reality Development**	15	5
Optional Unit	**49: Systems Integration**	15	5
Optional Unit	**50: Operating Systems**	15	5
Optional Unit	**51: E-Commerce & Strategy**	15	5
Optional Unit	**52: Digital Sustainability**	15	5
Optional Unit	**53: Digital Technology as a Catalyst for Change**	15	5
Optional Unit	**54: Prototyping**	15	5

Specialist Level 5 Units			
Group B: Application Development and Testing			
Optional Unit	**21: Application Program Interfaces**	15	5
Optional Unit	**22: Application Development**	15	5
Optional Unit	**23: Risk Analysis & Systems Testing**	15	5
Group C: Data Analytics			
Optional Unit	**24: Advanced Programming for Data Analysis**	15	5
Optional Unit	**25: Machine Learning**	15	5
Optional Unit	**26: Big Data Analytics and Visualisation**	15	5
Group D: Network Engineering			
Optional Unit	**27: Transport Network Design**	15	5
Optional Unit	**28: Cloud Computing**	15	5
Optional Unit	**29: Network Security**	15	5
Group E: Cyber Security			
Optional Unit	**30: Applied Cryptography in the Cloud**	15	5
Optional Unit	**31: Forensics**	15	5
Optional Unit	**32: Information Security Management**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Applications Development and Testing)		**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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**7: Software Development Lifecycles**	15	4
Plus, **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Core Unit Mandatory	**16: Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**17: Business Process Support**	15	5
Specialist Unit Mandatory	**21: Application Program Interfaces**	15	5
Specialist Unit Mandatory	**22: Application Development**	15	5
Specialist Unit Mandatory	**23: Risk Analysis & Systems Testing**	15	5
Plus, 30 credits from **TWO** Level 5 units from the list below. The combination of units selected **must not** replicate one of the specialist pathways. Certification claims will be ineligible if a barred combination of units is selected.			

Level 5 Optional Units			
Optional Unit	**33: Applied Analytical Models**	15	5
Optional Unit	**34: Analytical Methods**	15	5
Optional Unit	**35: Systems Analysis & Design**	15	5
Optional Unit	**36: User Experience and Interface Design**	15	5
Optional Unit	**37: Architecture**	15	5
Optional Unit	**38: Analytic Architecture Design**	15	5
Optional Unit	**39: Network Management**	15	5
Optional Unit	**40: Client/Server Computing Systems**	15	5
Optional Unit	**41: Database Management Systems**	15	5
Optional Unit	**42: Game Design Theory**	15	5
Optional Unit	**43: Games Development**	15	5
Optional Unit	**44: Games Engine & Scripting**	15	5
Optional Unit	**45: Internet of Things**	15	5
Optional Unit	**46: Robotics**	15	5
Optional Unit	**47: Emerging Technologies**	15	5
Optional Unit	**48: Virtual & Augmented Reality Development**	15	5
Optional Unit	**49: Systems Integration**	15	5
Optional Unit	**50: Operating Systems**	15	5
Optional Unit	**51: E-Commerce & Strategy**	15	5
Optional Unit	**52: Digital Sustainability**	15	5
Optional Unit	**53: Digital Technology as a Catalyst for Change**	15	5
Optional Unit	**54: Prototyping**	15	5

Specialist Level 5 Units			
Group A: Software Engineering			
Optional Unit	**18: Discrete Maths**	15	5
Optional Unit	**19: Data Structures & Algorithms**	15	5
Optional Unit	**20: Applied Programming and Design Principle**	15	5
Group C: Data Analytics			
Optional Unit	**24: Advanced Programming for Data Analysis**	15	5
Optional Unit	**25: Machine Learning**	15	5
Optional Unit	**26: Big Data Analytics and Visualisation**	15	5
Group D: Network Engineering			
Optional Unit	**27: Transport Network Design**	15	5
Optional Unit	**28: Cloud Computing**	15	5
Optional Unit	**29: Network Security**	15	5
Group E: Cyber Security			
Optional Unit	**30: Applied Cryptography in the Cloud**	15	5
Optional Unit	**31: Forensics**	15	5
Optional Unit	**32: Information Security Management**	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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**8: Data Analytics**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Level 5 Units:			
Core Unit Mandatory	**16: Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**17: Business Process Support**	15	5
Specialist Unit Mandatory	**24: Advanced Programming for Data Analysis**	15	5
Specialist Unit Mandatory	**25: Machine Learning**	15	5
Specialist Unit Mandatory	**26: Big Data Analytics and Visualisation**	15	5
Plus 30 credits from **TWO** Level 5 units from the list below. The combination of units selected **must not** replicate one of the specialist pathways. Certification claims will be ineligible if a barred combination of units is selected.			

Level 5 Optional Units			
Optional Unit	**33: Applied Analytical Models**	15	5
Optional Unit	**34: Analytical Methods**	15	5
Optional Unit	**35: Systems Analysis & Design**	15	5
Optional Unit	**36: User Experience and Interface Design**	15	5
Optional Unit	**37: Architecture**	15	5
Optional Unit	**38: Analytic Architecture Design**	15	5
Optional Unit	**39: Network Management**	15	5
Optional Unit	**40: Client/Server Computing Systems**	15	5
Optional Unit	**41: Database Management Systems**	15	5
Optional Unit	**42: Game Design Theory**	15	5
Optional Unit	**43: Games Development**	15	5
Optional Unit	**44: Games Engine & Scripting**	15	5
Optional Unit	**45: Internet of Things**	15	5
Optional Unit	**46: Robotics**	15	5
Optional Unit	**47: Emerging Technologies**	15	5
Optional Unit	**48: Virtual & Augmented Reality Development**	15	5
Optional Unit	**49: Systems Integration**	15	5
Optional Unit	**50: Operating Systems**	15	5
Optional Unit	**51: E-Commerce & Strategy**	15	5
Optional Unit	**52: Digital Sustainability**	15	5
Optional Unit	**53: Digital Technology as a Catalyst for Change**	15	5
Optional Unit	**54: Prototyping**	15	5

Specialist Level 5 Units			
Group A: Software Engineering			
Optional Unit	**18: Discrete Maths**	15	5
Optional Unit	**19: Data Structures & Algorithms**	15	5
Optional Unit	**20: Applied Programming and Design Principles**	15	5
Group B: Application Development			
Optional Unit	**21: Application Program Interfaces**	15	5
Optional Unit	**22: Application Development**	15	5
Optional Unit	**23: Risk Analysis & Systems Testing**	15	5
Group D: Network Engineering			
Optional Unit	**27: Transport Network Design**	15	5
Optional Unit	**28: Cloud Computing**	15	5
Optional Unit	**29: Network Security**	15	5
Group E: Security			
Optional Unit	**30: Applied Cryptography in the Cloud**	15	5
Optional Unit	**31: Forensics**	15	5
Optional Unit	**32: Information Security Management**	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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**9: Computer Systems Architecture**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems**	15	4

Level 5 Units:			
Core Unit Mandatory	**16: Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**17: Business Process Support**	15	5
Specialist Unit Mandatory	**27: Transport Network Design**	15	5
Specialist Unit Mandatory	**28: Cloud Computing**	15	5
Specialist Unit Mandatory	**29: Network Security**	15	5
Plus 30 credits from **TWO** Level 5 units from the list below. The combination of units selected **must not** replicate one of the specialist pathways. Certification claims will be ineligible if a barred combination of units is selected.			

Level 5 Optional Units			
Optional Unit	**33: Applied Analytical Models**	15	5
Optional Unit	**34: Analytical Methods**	15	5
Optional Unit	**35: Systems Analysis & Design**	15	5
Optional Unit	**36: User Experience and Interface Design**	15	5
Optional Unit	**37: Architecture**	15	5
Optional Unit	**38: Analytic Architecture Design**	15	5
Optional Unit	**39: Network Management**	15	5
Optional Unit	**40: Client/Server Computing Systems**	15	5
Optional Unit	**41: Database Management Systems**	15	5
Optional Unit	**42: Game Design Theory**	15	5
Optional Unit	**43: Games Development**	15	5
Optional Unit	**44: Games Engine & Scripting**	15	5
Optional Unit	**45: Internet of Things**	15	5
Optional Unit	**46: Robotics**	15	5
Optional Unit	**47: Emerging Technologies**	15	5
Optional Unit	**48: Virtual & Augmented Reality Development**	15	5
Optional Unit	**49: Systems Integration**	15	5
Optional Unit	**50: Operating Systems**	15	5
Optional Unit	**51: E-Commerce & Strategy**	15	5
Optional Unit	**52: Digital Sustainability**	15	5
Optional Unit	**53: Digital Technology as a Catalyst for Change**	15	5
Optional Unit	**54: Prototyping**	15	5

Specialist Level 5 Units			
Group A: Software Engineering			
Optional Unit	**18: Discrete Maths**	15	5
Optional Unit	**19: Data Structures & Algorithms**	15	5
Optional Unit	**20: Applied Programming and Design Principles**	15	5
Group B: Application Development			
Optional Unit	**21: Application Program Interfaces)**	15	5
Optional Unit	**22: Application Development**	15	5
Optional Unit	**23: Risk Analysis & Systems Testing**	15	5
Group C: Data Analytics			
Optional Unit	**24: Advanced Programming for Data Analysis**	15	5
Optional Unit	**25: Machine Learning**	15	5
Optional Unit	**26: Big Data Analytics and Visualisation**	15	5
Group E: Security			
Optional Unit	**30: Applied Cryptography in the Cloud**	15	5
Optional Unit	**31: Forensics**	15	5
Optional Unit	**32: Information Security Management**	15	5

Pearson BTEC Level 5 Higher National Diploma in Computing (Cyber 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: Planning a Computing Project (Pearson-set)**	15	4
Specialist Unit Mandatory	**10: Cyber Security**	15	4
Plus **ONE** 15-credit unit from the Level 4 Optional Unit Bank (see below).			
Optional Unit	**11: Strategic Information Systems**	15	4
Optional Unit	**12: Management in the Digital Economy**	15	4
Optional Unit	**13: Website Design & Development**	15	4
Optional Unit	**14: Maths for Computing**	15	4
Optional Unit	**15: Fundamentals of Artificial Intelligence AI) & Intelligent Systems**	15	4

Level 5 Units:			
Core Unit Mandatory	**16: Computing Research Project (Pearson-set)**	30	5
Core Unit Mandatory	**17: Business Process Support**	15	5
Specialist Unit Mandatory	**30: Applied Cryptography in the Cloud**	15	5
Specialist Unit Mandatory	**31: Forensics**	15	5
Specialist Unit Mandatory	**32: Information Security Management**	15	5
Plus 30 credits from **TWO** Level 5 units from the list below. The combination of units selected **must not** replicate one of the specialist pathways. Certification claims will be ineligible if a barred combination of units is selected.			

Level 5 Optional Units			
Optional Unit	**33: Applied Analytical Models**	15	5
Optional Unit	**34: Analytical Methods**	15	5
Optional Unit	**35: Systems Analysis & Design**	15	5
Optional Unit	**36: User Experience and Interface Design**	15	5
Optional Unit	**37: Architecture**	15	5
Optional Unit	**38: Analytic Architecture Design**	15	5
Optional Unit	**39: Network Management**	15	5
Optional Unit	**40: Client/Server Computing Systems**	15	5
Optional Unit	**41: Database Management Systems**	15	5
Optional Unit	**42: Game Design Theory**	15	5
Optional Unit	**43: Games Development**	15	5
Optional Unit	**44: Games Engine & Scripting**	15	5
Optional Unit	**45: Internet of Things**	15	5
Optional Unit	**46: Robotics**	15	5
Optional Unit	**47: Emerging Technologies**	15	5
Optional Unit	**48: Virtual & Augmented Reality Development**	15	5
Optional Unit	**49: Systems Integration**	15	5
Optional Unit	**50: Operating Systems**	15	5
Optional Unit	**51: E-Commerce & Strategy**	15	5
Optional Unit	**52: Digital Sustainability**	15	5
Optional Unit	**53: Digital Technology as a Catalyst for Change**	15	5
Optional Unit	**54: Prototyping**	15	5

Specialist Level 5 Units			
Group A: Software Engineering			
Optional Unit	**18: Discrete Maths**	15	5
Optional Unit	**19: Data Structures & Algorithms**	15	5
Optional Unit	**20: Applied Programming and Design Principles**	15	5
Group B: Application Development			
Optional Unit	**21: Application Program Interfaces**	15	5
Optional Unit	**22: Application Development**	15	5
Optional Unit	**23: Risk Analysis & Systems Testing**	15	5
Group C: Data Analytics			
Optional Unit	**24: Advanced Programming for Data Analysis**	15	5
Optional Unit	**25: Machine Learning**	15	5
Optional Unit	**26: Big Data Analytics and Visualisation**	15	5
Group D: Network Engineering			
Optional Unit	**27: Transport Network Design**	15	5
Optional Unit	**28: Cloud Computing**	15	5
Optional Unit	**29: Network Security**	15	5

6.2.3 Meeting local needs

When developing our Pearson BTEC Higher National qualifications, we consulted centres, employers and professional organisations. We designed the units to meet the skill needs of the sector and to cover the full range of employment opportunities it offers. You should make full use of the choices available to you in the specialist pathways to meet the needs of your students and local skills and training needs.

If you find the units that we offer do not meet a certain need, you can apply to import units from other RQF Pearson BTEC Higher National qualifications through the Meeting Local Needs (MLN) process. You will need to justify your reasons for using these other units from other RQF Pearson BTEC Higher National specifications. Your application must be in before 31 January of the calendar year in which you want to use the units. For more information please visit: http://qualifications.pearson.com or contact your Pearson regional contact.

There are some restrictions on importing units from other RQF Pearson BTEC Higher National qualifications:

- for the RQF Pearson BTEC HNC qualification, you cannot import units worth more than 30 credits
- for the RQF Pearson BTEC HND qualification, you cannot import units worth more 60 credits (30 at Level 4 and 30 at Level 5)
- you cannot use MLN units to replace compulsory units in any qualification
- you must still follow the qualification's rules of combination.

6.2.4 Commissioning new units for Pearson BTEC Higher Nationals

If MLN does not provide enough flexibility in terms of qualification structure, you can ask us to develop new units to meet your needs. You will need to fill in an application form explaining the reasons for your request. You must apply a full year ahead of the year in which you want to deliver the new unit.

If we agree to your application, we will develop the new unit in consultation with you.

We would be pleased to discuss your ideas for commissioning new units. For more information, please see *Custom Designed Higher Nationals* on our website at: http://qualifications.pearson.com.

6.3 Pearson-set units

Pearson-set units form part of the core units. Each year, Pearson will decide on a theme and (for Level 4) a set of topics related to that theme. At Level 5, students must work with their tutors to define their own topic related to the theme.

It is a formal requirement that you must:

- apply the theme to Level 4 and Level 5 units and select a topic at Level 4, and
- develop an assignment, to be internally assessed, to involve students in work related to the theme.

Example

Theme: "Digital Wellbeing is about fashioning and sustaining a healthy relationship with technology. As technology plays a big part in our lives, we find ourselves spending an increasing amount of time online and on our devices. Our wellbeing is dependent upon our mental and physical health and thereby our digital wellbeing is influenced by our online interactions and the amount of time we spend on our devices."

Level 4 topics

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

You will find full support in the *Pearson-set Assignment Guidance* for the units, and the theme and topic release documentation, which will be provided for each level. These documents can be found on HN Global: https://hnglobal.highernationals.com/.

The Pearson-set unit provides a common framework for centres to develop work that allows us to:

- compare information across the sector, and
- identify and share best practice in higher education teaching and learning.

We will share the best practice results with all centres.
For more information on assessing Pearson-set units, please see *Section 7 Assessment*.

6.4 Unit descriptor example

The unit descriptor is how we define the individual units of study that make up a Higher National qualification. Students will complete the units included in the programme you offer at your Centre.

You can use any of the unit descriptors listed in *Section 11*. We have described each part of the unit as follows.

Unit title	A general statement of what the unit will cover.
Unit code	The Ofqual unit code.
Unit type	There are three-unit types. • Core (mandatory to all pathways) • Specialist (mandatory to specific pathways) • Optional (available to most pathways).
Unit level	All our Pearson BTEC Higher National units are at Levels 4 or 5.
Credit value	The credit value relates to the total qualification time (TQT) and unit learning hours (ULH). It is easy to calculate: • 1 credit = 10 ULH, so • 15 credits = 150 ULH. To complete a Higher National Certificate or Diploma, students must achieve all of the credits required.
Introduction	Some general notes on the unit: • setting the scene • stating the purpose, and • outlining the topics and skills gained through the unit.
Learning Outcomes	These clearly explain what students will be able to do after completing the unit. There are usually 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	Tutors can refer to this table when grading assignments. The table connects the unit's Learning Outcomes with the student's work. Assignments can be graded at 'Pass' (P), 'Merit' (M) and 'Distinction' (D), depending on the quality of the student's work.
Recommended Resources	Lists the resources that students should use to support their study for the unit. It includes books, journals and online material. The programme tutor may also suggest resources, particularly for local information.

Web resources − referencing

Some units have web resources as part of their recommended resources list. Hyperlinking to these resources directly can cause problems, as their locations and addresses may change. To avoid this problem, students and tutors should reference web resources as follows.

[1] A link to the main page of the website

[2] The title of the site

[3] The section of the website where the resource can be found

[4] The type of resource it is, for example:

- research
- general reference
- tutorials
- training
- e-books
- report
- wiki
- article
- datasets
- development tool
- discussion forum.

Examples

Web

[1] baeldung.com	[2] Baeldung –
	[3] A Solid Guide to SOLID Principles
	[4] (General reference)
[1] tutorialspoint.com	[2] tutorialspoint
	[3] Software Testing Dictionary
	[4] (General reference)

7 Assessment

Pearson BTEC Higher Nationals are assessed using a combination of:

- Centre-developed internal assignments that are set and assessed by centres, and
- Pearson-set assignments, which are set by centres in line with our guidelines and graded by centres.

Pearson-set units are mandatory and target particular industry-specific skills. The number and value of these units are dependent on qualification size.

- For the HNC, centres will assess one compulsory Pearson-set unit targeted at particular skills. This is a Level 4 core unit carrying 15 credits.
- For the HND, centres will assess two compulsory Pearson-set units targeted at particular skills:
  - one Level 4 core unit carrying 15 credits
  - one Level 5 core unit carrying 15 credits.

All other units are assessed through internal assignments set by the Centre.

7.1 Principles of internal assessment

This section summarises the main features of internal assessment and explains how you can offer it effectively. Full details are given in the *BTEC Higher Nationals Centre Guide to Quality Assurance and Assessment*, available on the enhanced Quality Assurance section of our website at: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html. All your assessment team will need to refer to this document.

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

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

7.1.1 Assessment through assignments

For internally assessed units, assessment takes the form of an assignment carried out after the unit (or part of the unit if several assignments are used) has been delivered. An assignment may take a variety of forms, including practical and written. It is a distinct activity completed independently by students (alone or in a team). It is separate from teaching, practice, exploration and other activities that students complete with direction from tutors.

Students should receive each assignment as an Assignment Brief with a hand-out date, a completion date and clear requirements for the evidence they must provide. There may also be specific practical activities, which the student must complete under tutor observation as part of the assignment. Assignments can be divided into separate parts and may require several forms of evidence. A valid assignment will enable a clear and formal assessment grade based on the assessment criteria.

7.1.2 Using unit-based criteria

You must base your assessment decisions for Pearson BTEC Higher Nationals on the specific criteria we have provided for each unit and grade level. We have based these criteria on a framework to make sure that standards are consistent in the qualification and across the whole range of qualifications. We have developed each unit to assess the student's understanding, practical skills and the vocational qualities necessary for the qualification.

The assessment criteria for a unit are based on a hierarchy. For example, if a Merit criterion requires the student to show 'analysis' and the related Pass criterion requires the student to 'explain', then to gain a Merit the 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.

Assessors must show how they have reached their decisions using the criteria in the assessment records. When a student has completed all the assessments for a unit, the assessment team can give a grade for the unit. This grade is based on the highest level the student is judged to have met for all the criteria.

- To achieve a Pass, a student must have met all the Pass criteria for the Learning Outcomes, demonstrating that they have covered the unit content and achieved Level 4 or 5 of the national framework
- To achieve a Merit, a student must have met all the Merit criteria (and the Pass criteria) through high performance in each Learning Outcome
- To achieve a Distinction, a student must have met all the Distinction criteria (and the Pass and Merit criteria), demonstrating outstanding performance across the whole unit.

A Pass cannot be awarded just because the student has completed all the assignments. Students must meet all of the Pass criteria. If they do not, their grade should be reported as 'unclassified'.

7.1.3 The assessment team

You will need an effective team for internal assessment. There are three key roles involved, each with different responsibilities. These roles are listed below.

- The **Programme Leader** is responsible for the programme, its assessment and internal monitoring to meet our requirements. They must register with us each year. They are also responsible for:
  - record keeping
  - liaising with the standards verifier
  - acting as an Assessor
  - supporting the rest of the assessment team
  - making sure that the team has the information it needs about our assessment requirements
  - organising training, and
  - using our guidance and support materials.
- **Internal Verifiers** oversee all assessment activity with the Programme Leader. They check that assignments and assessment decisions are valid and meet our requirements. All Internal Verifiers will follow the same standards and procedures as instructed by your Programme Leader. Internal Verifiers are usually also assessors, but they do not verify their own assessments
- **Assessors** set assignments or use assignments to assess students to national standards. Before taking any assessment decisions, they are trained by the Programme Leader to all work to the same standards and procedures. They also work with the Programme Leader and Internal Verifiers to make sure the assessment is planned and carried out in line with our requirements
- Our external examiner will sample student work across your assessors. They will also want to see evidence of how you have verified assignments and assess your decisions.

Full information is provided in the *BTEC Higher Nationals Centre Guide to Quality Assurance and Assessment*, available in the enhanced Quality Assurance section of our website: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html.

7.1.4 Effective organisation

Internal assessment needs to be well organised so that you can track student progress and so that we can make sure your assessments are in line with national standards. It is particularly important that you manage the overall assignment programme and deadlines to make sure that all your students can complete their assignments on time.

When developing an overall plan for delivering and assessing your 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.

We support you in this through:

- assessment and feedback guidance documents available on HN Global, and
- training materials and sample templates for curriculum planning.

Please see also *BTEC Higher Nationals Centre Guide to Quality Assurance and Assessment*, available in the enhanced Quality Assurance section of our website: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html.

7.1.5 Preparing students

You need to make sure that your students understand their responsibilities for assessment and the centre's arrangements. From induction onwards, you will want to make sure that students are motivated to work consistently and independently to achieve their qualifications. They need to understand:

- how assignments are used
- the importance of meeting assignment submission deadlines, and
- that all the work submitted for assessment must be their own.

To support them, you should provide a guide that explains:

- how you use assignments for assessment
- how assignments relate to the teaching programme
- how to use and reference source materials, including how to avoid plagiarism, and
- your centre's approach to assessments, for example how students must submit assignments, what happens if they submit late work, how they can request an extended deadline in special circumstances.

7.2 Making valid assessment decisions

7.2.1 Authentic student work

An Assessor must assess only student work that is authentic – in other words, the student's own independent work. Students must sign a declaration for each assessment to confirm that it is their own work. This declaration must confirm that:

- any evidence submitted for the assignment is the student's own, and
- the student understands that if this is not the case, they may face penalties for malpractice.

Assessors must make sure that evidence is authentic by setting valid assignments and supervising students during the assessment period. Assessors must also take care not to provide direct input, instructions or specific feedback that may influence the student's work and final grade.

You can use Pearson templates or your own templates to document authentication.

If your Assessor suspects that a student's evidence is not authentic, they must take action in line with our policies for malpractice. (See *Section 5.7* for more information.)

7.2.2 Making assessment decisions using criteria

Assessors must use our criteria to make assessment decisions. They can judge the evidence from a student using all the relevant criteria at the same time, but they must be satisfied that there is enough detailed evidence for each criterion required. For example, including a concluding section may not be enough evidence to meet the criterion requiring 'evaluation'.

Assessors should use the information and support available to help them reach their decisions. This includes:

- examples of moderated assessed work, and
- their Programme Leader and assessment team's experience.

7.2.3 Dealing with late assignments

For assessment to be fair, it is important that students are all assessed in the same way and that some students are not given an advantage by having extra time or the opportunity to learn from others. You should develop and publish your own regulations on late assignments and circumstances where you may agree to an extension.

Students must understand your policy on completing assignments by the deadlines you give them. You may agree to extend a deadline for a genuine reason such as illness in line with your Centre policies (see also *Section 5.6 Administrative arrangements for internal assessment*).

You can apply a penalty to assignments that are submitted late. To do this, you should:

- assess the assignment normally
- apply the penalty or cap to the grade awarded
- tell the student their uncapped grade to recognise the learning they have achieved and provide genuine assessment feedback
- record both the uncapped and capped grades, and
- have both grades verified by a suitable Assessment Board, taking into account any genuine reasons for the assignment being late.

Please see also *BTEC Higher Nationals Centre Guide for Quality Assurance and Assessment*, which can be found on our website: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html.

7.2.4 Providing assessment decisions and feedback

Once your assessment team has completed the assessment process for an assignment, they will provide a formal assessment decision. This should be recorded formally and reported to the student. The information given to the student:

- must show the formal decision and how it has been reached, including how assessment criteria have been met
- may show why they have not demonstrated achievement against assessment criteria
- must not provide feedback on how to improve evidence, and
- may provide feedback on how to improve in the future.

7.2.5 The opportunity to resubmit an assignment

If a student's assignment does not pass after the first assessment, they must have the opportunity to resubmit the assignment for reassessment.

- Students can have the assignment reassessed once only
- If coursework, project- or portfolio-based assignments need to be reassessed, this will usually involve carrying out the original activity again
- For examinations, reassessment will involve completing a new activity
- The grade for a reassessed assignment will be capped at a Pass
- Assignments already graded at a pass or higher cannot be reassessed.

7.2.6 Repeat units

If a student fails to achieve a Pass for a unit following reassessment, your Assessment Board may agree that they can repeat the unit. In this case:

- the student must pay the unit fee and study the unit again, with full attendance
- the grade for the unit (if successfully completed) will be capped at a Pass.

Students can repeat a unit once only.

7.2.7 Assessment boards

It is a formal Pearson requirement that centres must have an Assessment Board for all your Pearson BTEC Higher National programmes. The main purpose of an Assessment Board is to make recommendations on:

- the grades achieved by students in the units
- extenuating circumstances
- cases of cheating and plagiarism
- students progressing to the next stage of the programme
- the awards to be made to students, and
- students resubmitting assignments and repeating units.

Assessment boards may also monitor academic standards. The main board meetings normally take place at the end of the session but if your Centre operates on a semester system, there may be meetings at the end of the first semester. There may also be separate meetings to deal with referrals.

If you do not have an Assessment Board, our external examiner will discuss this with your quality nominee and Programme Leader. Assessment Board reports and minutes provide valuable evidence of your Quality Assurance processes.

7.3 Planning and record keeping

For internal processes to be effective, your assessment team needs to be well organised and keep effective records. We will work closely with you to make sure you are meeting national standards. This process gives stakeholders confidence in your assessment approach.

Your Programme Leader must have an assessment plan, produced as a spreadsheet. This plan should include:

- the time required to train the assessment team and make sure they are working to the same standards and procedures
- the time available for teaching and carrying out assessments, including when students may complete assessments and when Quality Assurance will take place
- the completion dates for different assignments

- who is acting as Internal Verifier for each assignment and the date by which the assignment needs to be verified
- a procedure for Internal Verifiers to sample assessors' decisions that covers all assignments, assessors and a range of students
- a process to assess and verify students' work so that they receive formal decisions quickly, and
- a system for scheduling resubmissions.

The Programme Leader must also keep records of all assessments carried out. The key records are:

- checking of Assignment Briefs
- student declarations
- Assessor decisions on assignments, with feedback given to students, and
- confirmation of assessment decisions.

Examples of records and more information are available in the *BTEC Higher Nationals Centre Guide to Quality Assurance and Assessment*, available on the enhanced Quality Assurance process section of our website at: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html.

7.4 Calculating the final qualification grade

7.4.1 Conditions for the award

Conditions for awarding our HNC

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

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

Conditions for awarding our HND

To achieve our 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, and
- achieved at least a Pass in 105 credits at Level 4.

7.4.2 Compensation

Compensation for the HNC

- Students who have attempted but not achieved a Pass in one of their Level 4, 15-credit units can still be awarded an HNC as long as they have completed and passed the remaining units.

Compensation for the HND

- Students who have attempted but not achieved a Pass in one of their Level 4, 15-credit units and one of their Level 5, 15-credit units can still be awarded an HND as long as they have completed and passed the remaining units at both levels as per rules of combination of the required qualification.

7.4.3 Calculating the overall qualification grade

A student's overall qualification grade is based on their performance in all units. They are awarded a Pass, Merit or Distinction using the points gained through all 120 credits, at Level 4 for the HNC or Level 5 for the HND. The overall qualification grade is calculated in the same way for the HNC and the HND. For HND, the overall qualification grade is based on student performance in Level 5 units only.

Students must have attempted all units in a valid combination for each qualification. The conditions of award and compensation arrangements will apply as explained above. If a student has been granted compensation for a unit attempted but not achieved, that unit will appear as unclassified (a 'U' grade) on the notification of performance provided with their 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 +

7.4.4 Modelled student outcomes

Pearson BTEC Level 4 Higher National Certificate

				Student 1		Student 2		Student 3		Student 4		Student 5	
	Credits	Level	Grade point	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points
Core 1	15	4	4	P	60	P	60	P	60	D	120	D	120
Core 2	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 3	15	4	4	P	60	P	60	P	60	D	120	M	90
Core 4	15	4	4	P	60	P	60	M	90	M	90	M	90
Core 5	15	4	6	M	90	P	60	M	90	M	90	M	90
Core 6	15	4	6	M	90	P	60	M	90	M	90	M	90
Opt 1	15	4	6	M	90	M	90	D	120	D	120	D	120
Opt 2	15	4	6	M	90	M	90	D	120	D	120	D	120
Total	120				600		540		690		870		810
Grade					M		P		M		D		M

Optional (Opt)

The table above is provided as general examples of using unit grades to calculate qualification grades. They do not reflect the specifics of this qualification.

Pearson BTEC Level 5 Higher National Diploma

				Student 1		Student 2		Student 3		Student 4		Student 5	
	Credits	Level	Grade point	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points	Grade	Unit points
Core 1	15	4	0	P	0	P	0	P	0	D	0	P	0
Core 2	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 3	15	4	0	P	0	P	0	P	0	D	0	M	0
Core 4	15	4	0	P	0	P	0	M	0	M	0	M	0
Core 5	15	4	0	M	0	P	0	M	0	M	0	P	0
Core 6	15	4	0	M	0	P	0	M	0	D	0	U	0
Opt 1	15	4	0	M	0	P	0	D	0	D	0	D	0
Opt 2	15	4	0	M	0	P	0	D	0	D	0	D	0
Core 7	30	5	6	M	180	M	180	M	180	P	120	D	240
Core 8	15	5	6	M	90	M	90	M	90	P	60	D	120
Opt 3	15	5	6	M	90	M	90	D	120	P	60	D	120
Opt 4	15	5	6	M	90	P	60	D	120	P	60	D	120
Opt 5	15	5	6	M	90	P	60	D	120	M	90	M	90
Opt 6	15	5	6	M	90	P	60	M	90	M	90	P	60
Opt 7	15	5	6	M	90	P	60	M	90	M	90	M	90
Total	240				720		600		810		570		840
Grade					M		M		M		P		D

Optional (Opt)

The table above is provided as general examples of using unit grades to calculate qualification grades. They do not reflect the specifics of this qualification.

8 Quality assurance

The Quality Assurance system for all Pearson BTEC Higher National programmes is linked to Level 4 and Level 5 of the Quality Assurance Agency (QAA) Framework for Higher Education Qualifications (FHEQ). This means that centres have effective Quality Assurance processes to review their programme delivery. It also means that assessment grades are in line with national standards.

The Quality Assurance process for centres offering our Pearson BTEC Higher National programmes has five main features.

1 The approval process
2 Monitoring internal systems
3 Independent review of assessments
4 Annual programme monitoring report
5 Annual student survey.

8.1 The approval process

If you want to deliver our programmes at your Centre, you must apply first through the existing Centre approval process and then through the programme approval process. We can consider your application by:

- carrying out a desk-based review, or
- visiting your Centre.

You will need to provide evidence that your Centre:

- has the human and physical resources needed to deliver and assess the programme effectively
- understands the rules of independent assessment and agrees to follow them
- has a strong internal assessment system supported by 'fit for purpose' assessment documentation, and
- has a system to internally verify assessment decisions so that they are consistent across all assessors and sites.

Your application must be supported by the head of the Centre (your principal or chief executive). It must include a declaration that you will operate the programmes strictly and in line with our requirements.

If your Centre is already approved and you want to renew approval, you may be able to use our automatic approval process.

We may withdraw qualification or Centre approval if we believe you can no longer quality assure your programme delivery or assessment standards.

8.2 Centre and qualification approval

As part of the approval process, your Centre must meet the conditions listed below before offering the qualification.

- You must have suitable physical resources (for example equipment, IT, learning materials, teaching rooms) to support delivery and assessment of the qualifications
- You must provide the specific resources required for individual units
- Staff involved in the assessment process must have relevant skills or experience
- You must have systems to provide continuing professional development for staff delivering the qualification
- You must have suitable Health and Safety policies for students and staff using equipment
- You must deliver the qualification in line with current equality legislation.

In this way, we can provide qualifications that meet the needs and expectations of students worldwide.

8.3 Monitoring internal systems

You will need to demonstrate that you continue to meet our Centre approval criteria over time and across all Higher National programmes. This involves providing evidence to our external examiners for review.

Our examiners will check that:

- your systems and the way you use them remain suitable for supporting the programmes
- you apply student registration and appeals policies consistently, and
- you have effective internal examination and standardisation processes.

In some cases, you may present evidence of your operation within a recognised code of practice such as that of the Quality Assurance Agency for Higher Education. However, we may still want to confirm independently that these arrangements are operating to our standards.

If our examiners identify problems with your internal systems, we will take steps to help you correct them.

8.4 Independent review of assessments

The external examiner will review your internal assessments for all Pearson BTEC Higher National programmes benchmarked to Levels 4 and 5 of the Quality Assurance Agency (QAA) Framework for Higher Education Qualifications. They will either:

- confirm that your internal assessments meet national standards and allow certification
- provide actions to improve the quality of your assessments before allowing certification.

8.5 Annual programme monitoring report (APMR)

This annual review form gives you the opportunity to analyse and reflect on the most recent teaching year. It also provides us with information to help us improve the Quality Assurance of the Pearson BTEC Higher National programmes. An overview report is produced to outline the findings of the APMR each year. You can access it at: HigherNationals.com at http://monitoring-report.highernationals.com.

8.6 Annual student survey

Pearson will conduct an annual survey of Pearson BTEC Higher National students. This provides us with a snapshot of every Higher National student’s experience as part of the Quality Assurance process. Each Centre with enough students taking part in the survey will get its own report about their results. You can access the report via HN Global at: http://hnglobal.highernationals.com.

8.7 Continuing quality assurance and standards verification

Each year we update our *BTEC Higher Nationals Centre Guide to Quality Assurance and Assessment*, available in the enhanced Quality Assurance section of our website at: https://qualifications.pearson.com/en/qualifications/btec-higher-nationals/about/quality-assurance-process.html. The guide contains detailed guidance on the quality processes you should follow.

Our key principles of quality assurance

- A Centre delivering Pearson BTEC Higher National programmes must be approved by us and must have our approval for the programmes or groups of programmes it is delivering
- As part of gaining our approval, the Centre agrees to always follow our terms and conditions for delivering programmes effectively and assessment Quality Assurance

- We provide approved centres with a range of materials and opportunities for reviewing internal materials through our assessment-checking service. This service demonstrates the processes required for effective assessment and provides examples of effective standards. You must use these materials and services to make sure that all staff delivering Pearson BTEC Higher National qualifications keep up to date with the guidance on assessment
- You must follow agreed processes for:
  - making sure that assessors and verifiers all work to the same standards and procedures
  - planning, monitoring and recording assessment processes, and
  - dealing with special circumstances, appeals and malpractice.
- We will work in partnership with you to help you achieve quality-assured assessment
- We will help you follow best practice and use suitable technology to support Quality Assurance processes
- We will try to make sure our Quality-Assurance processes do not create unnecessary administrative work for you
- We will monitor and support you in achieving effective assessment and Quality Assurance.

We will do this by:

- making sure that you complete a suitable declaration at the time of approval
- carrying out approval visits to your Centre
- making sure that you have a well-trained, effective team of assessors and verifiers
- sampling and verifying your assessments, assessed student work and other relevant documents, and
- reviewing your strategy for assessing and quality-assuring your BTEC programmes.

As an approved Centre, you must advertise your certification only with our permission and in line with our reporting requirements.

If you do not have and maintain a strong approach to Quality Assurance, you will not be able to apply for certification for any of Pearson BTEC Higher National qualifications.

If you do not follow our recommendations for improving your Quality Assurance, we may withdraw approval for you to deliver our qualifications.

9 Recognition of Prior Learning and attainment

Recognising prior learning (RPL) is a way of awarding credit if a student can demonstrate that they meet the assessment requirements for a unit through knowledge, understanding or skills they already have. As long as the assessment requirements are met, RPL can be used to accredit a unit, units or a whole qualification.

RPL provides a route for recognising the achievements of continuous learning from a range of activities using any valid assessment procedure. We encourage you to recognise students' previous achievements and experiences at work, at home, in leisure and in the classroom. Evidence of learning must be valid and reliable.

For full guidance on RPL, please see *Recognition of prior learning policy and process* in the support section of our website at: https://qualifications.pearson.com/en/support/support-topics/understanding-our-qualifications/policies-for-centres-learners-and-employees.html.

10 Equality and diversity

Equality and fairness are central to our work. The design of these qualifications embeds 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, and
- raising ambitions and supporting achievement for people with different needs and backgrounds.

Creating an inclusive learning environment means anticipating students' varying needs and trying to make sure that all students have equal access to educational opportunities. This involves providing access for people who have differing individual needs and removing unnecessary barriers to learning. Qualification design must be inclusive so that students with and without disabilities have equal access to learning opportunities.

Our equality policy requires that:

- all students have an equal opportunity to access our qualifications and assessments, and
- our qualifications are 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 by law (for example race, sexuality, religious belief) are not disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for taking a qualification, and
- this achievement can be compared fairly to the achievement of their peers.

Our qualifications should:

- be available to everyone capable of reaching the required standards
- be free from any barriers that restrict access and progress, and
- offer equal opportunities for all those who want to access them.

Please see our *Equality, diversity and inclusion policy* in the support section of our website at: https://qualifications.pearson.com/en/support.html.

Please use your integrity when recruiting students to our Pearson BTEC Higher National programmes.

- Make sure they have the information and advice they need about the qualification to be sure it meets their needs
- Check each student's qualifications and experience to make sure they have the potential to achieve the qualification
- For students with disabilities and specific needs, consider the support available to them and any other support they may need during teaching and assessment.

Please see our policy documents on students with particular needs.

Access to qualifications for students with disabilities or specific needs

Students can be assessed in a recognised regional sign language.

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 *Guidance for reasonable adjustments and special consideration in vocational internally assessed units*. Please see the support section of our website for both documents: https://qualifications.pearson.com/en/support.html.

11 Units

Unit 1: Programming

Unit code	**H/618/7388**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Programming involves describing processes and procedures that are derived from algorithms. The ability to program is what sets apart a developer and an end user. Typically, the role of the developer is to instruct a device (such as a computer) to carry out instructions; the instructions are known as source code and are 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 along with an introduction to algorithms and the characteristics of programming paradigms. Among the topics included in this unit are: introduction to algorithms, procedural, object-orientated and event-driven programming, security considerations, the integrated development environment and the debugging process.

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

Learning Outcomes

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

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), data structures, e.g. arrays, stacks, queues, methods (including input/output), control structures, iteration, scope, parameter passing, classes, inheritance and events.

Key components of an IDE, with a brief explanation of 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:

Develop simple applications that implement basic algorithms, including the features of a suitable language and IDE.

Create logical and maintainable codes.

Consideration of security concerns and how they could be solved.

Build, manage and deploy code to the relevant environment to solve the identified problems.

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.

Use of debugging the process to help developers fix vulnerabilities, defects and bugs in code.

Apply structured techniques to problem solving, debugging code and consider structure of programmes to identify and resolve issues.

Understand coding standards and their 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		**D1** Evaluate the implementation of an algorithm in a suitable language and the relationship between the written algorithm and the code variant.
P1 Define an algorithm and outline the process in building an application. **P2** Determine the steps taken from writing code to execution.	**M1** Analyse the process of writing code, including the potential challenges faced.	
LO2 Explain the characteristics of procedural, object-orientated and event-driven programming		**D2** Critically evaluate the source code of an application that implements the procedural, object-orientated and event-driven paradigms, in terms of the code structure and characteristics.
P3 Discuss what procedural, object-orientated and event-driven paradigms are; their characteristics and the relationship between them.	**M2** Compare the procedural, object-orientated and event-driven paradigms used in given source code of an application.	
LO3 Implement basic algorithms in code using an IDE		**D3** Evaluate the use of an IDE for development of applications contrasted with not using an IDE.
P4 Write a program that implements an algorithm using an IDE.	**M3** Enhance the algorithm written, using the features of the IDE to manage the development process.	
LO4 Determine the debugging process and explain the importance of a coding standard		**D4** Evaluate the role and purpose of a coding standard and why it is necessary in a team as well as for the individual.
P5 Explain the debugging process and the debugging facilities available in the IDE. **P6** Explain the coding standard you have used in your code.	**M4** Examine how the debugging process can be used to help develop more secure, robust applications.	

Recommended Resources

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

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

Textbooks

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

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

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

Links

This unit links to the following related units:

Unit 19: Data Structures & Algorithms

Unit 20: Applied Programming and Design Principles

Unit 54: Prototyping.

Unit 2: Networking

Unit code M/618/7393

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 any time, anywhere, using many applications like email, audio and video transmission, including the World Wide Web, and this has opened the floodgates to availability of information.

The aim of this unit is to give students a 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. Students will also explore the protocol methodologies related to IP data networks.

On successful completion of this unit, students will have gained the knowledge and skills needed 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**

Introduction to networks:

Impact of networks on daily lives, the basic requirements of a reliable network, employment opportunities in the networking field, network common network attacks, network trends, e.g. bring your own device (BYOD).

Role of networks:

Purpose, benefits, resource implications, communications, e.g. transmission mediums, 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:

Network representation logical, e.g. ethernet, Token Ring; physical, e.g. star, ring, bus, mesh, tree.

Protocols:

Purpose of protocols; adherence, routed protocols, e.g. IPv4 (addressing, subnetting, VLSM), IPv6 (addressing); global unicast, multicast, link local, unique local, EUI 64, auto configuration, ICMP, FTP, HTTP, SMTP, POP3, SSL; management of protocols for addressing.

Wireless networks:

Explore the use and evolution and industry developments in mobile/cellular networks, including key technologies; standards for communications (3G, 4G, 5G); process of accessing and connecting to NB-IoT, GPRS and Wi-Fi networks.

Distinguish between NB-IoT and Wi-Fi AT command sets.

LO2 **Explain networking devices and operations**

Networking devices:

Explain the operation of server, hub, routers, switches, multilayer switch (including their operating systems, e.g. CISCO IOS, etc.), firewall, Host-based Intrusion System (HIDS), repeaters, bridges, wireless devices, access point (wireless/wired), content filter, load balancer, modem, packet shaper, VPN concentrator.

Explore the basic concepts, features and key technologies of IoT gateways, including IoT gateway solutions, industrial IoT gateway positioning, edge computing, network topologies, RF mesh, Smart Home networks, acceleration, Wi-Fi coverage and intelligent services and serial data transmission (binary data).

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.

System bus and local-system architecture, e.g. memory, processor, I/O devices.

Permissions.

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.

Consider what the network will be used for (purpose) according to the scenario.

Networking services and applications:

DHCP, including static vs dynamic IP addressing, reservations, scopes, leases, options (DNS servers, Suffixes), IP helper, DHCP relay, DNS records, Dynamic DNS, static and dynamic routing between multiple subnets.

Calculate IP subnet address ranges in dotted decimal and binary.

Calculate subnet masks.

Communications:

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

Scalability:

Ability to support device growth, able to support addition of communication devices, able to cope with bandwidth use and trend changes, protocol utilisation, addressing, multiple subnets, dynamic, static routing protocols.

Selection of components:

Supporting infrastructure needs; supporting connectivity requirements.

Security:

The concept of 'secure by design' and its application to infrastructure.

Security considerations when designing a network for an identified scenario, e.g. shared data, network access, remote workers, public facing systems, internal policy.

LO4 **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.

Evidence the system meets design requirements, including security controls as required by the scenario, have been implemented.

System monitoring:

Utilisation, bandwidth needs, monitoring user productivity and security of the system. Factors affecting network performance.

Identify typical failure modes in protocols and approaches to error control.

Review network monitoring data to optimise performance and undertake root cause analysis of events and make recommendations to reduce false positives and false negatives.

Network automation:

Process of setting up software to automatically manage, configure, test, deploy, and operate network devices (physical or virtual).

Maintenance schedule:

Backups, upgrades, security, auditing.

Diagnose and resolve layer 1 problems:

Explore the E2E integrated development and testing process.

Framing, CRC, runts, giants, dropped packets, late collisions, input/output errors.

Policy review:

Bandwidth, resource availability.

Service level agreements (SLAs):

Conditions of service availability, time window for each level of service (prime time and non-prime time), responsibilities of each party, escalation procedures, and cost/service trade-offs.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Examine networking principles and their protocols</td><td rowspan="4">LO1 and LO2

D1 Evaluate the topology and protocol suite selected for a given scenario and how it demonstrates the efficient utilisation of a networking system.</td></tr>
<tr><td>P1 Discuss the benefits and constraints of different network types and standards.

P2 Explain the impact network topologies have on communication and bandwidth requirements.</td><td>M1 Assess common networking principles and how protocols enable the effectiveness of networked systems.</td></tr>
<tr><td colspan="2">LO2 Explain networking devices and operations</td></tr>
<tr><td>P3 Discuss the operating principles of networking devices and server types.

P4 Discuss the interdependence of workstation hardware and relevant networking software.</td><td>M2 Explore a range of server types and justify the selection of a server for a given scenario, regarding cost and performance optimisation.</td></tr>
<tr><td colspan="2">LO3 Design efficient networked systems</td><td rowspan="4">LO3 and LO4

D2 Critically reflect on the implemented network, including the design and decisions made to enhance the system.</td></tr>
<tr><td>P5 Design a networked system to meet a given specification.

P6 Design a maintenance schedule to support the networked system.</td><td>M3 Analyse user feedback on your designs with the aim of optimising your design and improving efficiency.</td></tr>
<tr><td colspan="2">LO4 Implement and diagnose networked systems</td></tr>
<tr><td>P7 Implement a networked system based on a prepared design.

P8 Document and analyse test results against expected results.</td><td>M4 Recommend potential enhancements for the networked systems.</td></tr>
</table>

Recommended Resources

Textbooks

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

Donahue, G. A. (2011) *Network Warrior* 2nd edn. O'Reilly Media.

Goransson, P. Black, C. et al (2016) *Software Defined Networks: A Comprehensive Approach* 2nd edn. Morgan Kaufmann.

Hallberg, B. (2005) *Networking: A Beginner's Guide*. 4th edn. 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 edn. 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 edn. (Prentice Hall).

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

Links

This unit links to the following related units:

Unit 9: Computer Systems Architecture

Unit 27: Transport Network Design

Unit 29: Network Security

Unit 39: Network Management

Unit 40: Client/Server Computing Systems.

Unit 3: Professional Practice

Unit code L/618/7398

Unit type Core

Unit level 4

Credit value 15

Introduction

In the workplace, it is essential to be effective as a communicator, critical thinker, analyser, team worker and team leader. These skills are needed on a daily basis in order to carry out designated tasks as part of a job role. The development of academic competence and the continuation of lifelong learning and continuing professional development (CPD) are 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 skills that enable tasks to be completed successfully and facilitate effective decision making. Working with others in a group environment such as an academic setting or in 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, reflective practice and working towards various goals are encouraged in the workplace through an appraisal framework. Professional development includes at higher levels of learning and the ability to demonstrate effective research skills and academic reporting skills.

This unit covers the development of communication skills and communication literacy and the use of qualitative and quantitative data to demonstrate analysis, reasoning and critical thinking. Students will carry out tasks that require working with others in a team-based scenario and planning and problem solving.

On successful completion of the unit, students will be able to demonstrate leadership skills through the dynamics of team working. Through reflective practice, they will be able to evaluate the contributions they make as an individual and those of others.

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.

Understanding of the reasons for communicating with internal and external stakeholders, e.g. responding to queries, technical support, providing instructions, raising awareness of issues.

Considerations when communicating with internal and external stakeholders, e.g. maintaining privacy and security, tone of voice, use of technical vocabulary or jargon, company image.

Consideration of issues relating to inclusion and diversity when communicating and interacting with others.

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.

Demonstrate resourcefulness and creativity when solving problems.

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 problem solving, 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 and strategy, problem-solving and short-term development projects, flexibility and adaptability, team player.

Individual responsibility when working as part of a team.

Working effectively on individual and collaborative tasks regardless of levels of supervision.

Allocation and management of tasks between members of the team, identifying team members' strengths, communicating requirements and expectations effectively.

Teams and team building:

Selecting team members e.g. specialist roles, skill and style/approach mixes.

Identification of team and work group roles.

Stages in team development, including team building, identity, loyalty, commitment to shared beliefs, professionalism.

Team health evaluation, including promoting and maintaining a safe and secure working environment, 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 responsibilities, including employment legislation, ethics, employment rights and responsibilities.

Maintaining a productive, professional and secure working environment.

Performance objectives:

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

CPD, including 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, including 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:

Plan to include current performance, future needs, opportunities and threats to career progression, aims and objectives, achievement dates, review dates, learning programme or activities, action plans, personal development plans, ongoing commitment to CPD.

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 used in the design and delivery of a training event.
P1 Demonstrate effective design and delivery of a training event for a given target audience, using different communication styles and formats. **P2** Demonstrate 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** Evaluate the overall success of the event delivered, in terms of how well critical reasoning and thinking were applied to achieve the end goal.
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 the design and delivery of the event.	**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 methodologies in the design and delivery of an event.	

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 in a team to achieve a defined goal.	**M4** Analyse team dynamics, in terms of the roles that group members play in a team and the effectiveness in terms of achieving shared goals.	**D3** Critically evaluate 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 and motivation. **P8** Review different motivational theories and the impact they can have on performance in the workplace. **P9** Produce a development plan that outlines responsibilities, performance objectives and required skills for future goals.	**M5** Justify the role of CPD and development planning in building motivation.	**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 edn. Palgrave Macmillan.

Forde, C. et al (2006) *Professional Development, Reflection and Enquiry.* Sage Publications.

Megginson, D. and Whitaker, V. (2007) *Continuing Professional Development*. 2nd edn. 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 – Japan Institute for Group Dynamics

Professional Development in Education – Taylor and Francis Online

Web

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

Links

This unit links to the following related units:

Unit 6: Planning a Computing Project (Pearson-set)

Unit 16: Computing Research Project (Pearson-set).

Unit 4: Database Design & Development

Unit code	**A/618/7400**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Organisations depend on their databases for providing information that is essential for their day-to-day operations and to help them take advantage of today's rapidly growing and maturing e-commerce opportunities. An understanding of database tools and technologies is an essential skill for designing and developing systems to support them.

As applications get increasingly more sophisticated, database systems continue to demand more complex data structures and interfaces. 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 is 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. It will also provide the practical skills needed to be able to translate that understanding into the design and creation of complex databases.

Topics covered in this unit are: examination of different design tools and techniques; examination of different development software options; consideration of 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 the 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 that it meets user and system requirements, and fully document the system by providing technical and user documentation. For practical purposes, this unit covers relational databases and related tools and techniques. A brief overview of object-oriented databases will also be covered. 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 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**

Database design:

Principles and uses of relational and non-relational databases.

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

Determining user and system requirements.

Design tools and techniques for a relational database system.

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

Designs for data integrity, data validations, data security and data controls. User interface design.

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**

Implementation:

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 and linking code to data sets.

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, dropdown lists, option buttons.

Consideration of user interface requirements looking at functionality, reliability, consistency, performance and accessibility for a range of different users.

Develop effective user interfaces linked 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.

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

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

LO3 **Test the system against user and system requirements**

Testing methodologies:

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. structural testing, functional testing; 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**

Structure and functionality documentation:

Technical and user documentation and their contents.

Technical documentation to include diagrams showing movement of data through the system and flowcharts describing how the system works.

User documentation, including how to use the system, outputs produced by the system, menu operations and other functions.

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		**LO2 and LO3**
P2 Develop the database system with evidence of user interface, output and data validations, and querying across multiple tables. **P3** Implement a query language into the relational database system.	**M2** Implement a fully-functional database system, which includes system security and database maintenance. **M3** Assess whether meaningful data has been extracted through the use of query tools to produce appropriate management information.	**D2** Evaluate the effectiveness of the database solution in relation to user and system requirements and suggest improvements.
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.	

Pass	Merit	Distinction
LO4 Produce technical and user documentation		
P5 Produce technical and user documentation.	**M5** Produce technical and user documentation for a fully-functional system, including data flow diagrams 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 edn. Apress.

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

Flejoles, R. P. (2018) *Database Theory and Application*. Arcler Press.

Karwin, B. (2017) *SQL Antipatterns: Avoiding the Pitfalls of Database Programming* Pragmatic Programmers, LLC, The.

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

Journals

The Computer Journal – Oxford Academic

International Journal of Database Management (IJDMS)

Journal of Emerging Trends in Computing and Information Sciences

Journal of Systems Analysis and Software Engineering

Systems Journal of Database Management

Web

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

Links

This unit links to the following related units:

Unit 11: Strategic Information Systems

Unit 41: Database Management Systems.

Unit 5: Security

Unit code	**D/618/7406**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

Security is one of the most important challenges modern organisations face. It 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 give students knowledge of security, the associated risks and how it has an impact on business continuity. Students will examine security measures involving access authorisation and regulation of use. They will implement contingency plans and devise security policies and procedures. The unit also introduces students to detection of threats and vulnerabilities in physical and IT security, and how to manage risks relating to organisational security.

This unit includes 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. 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 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 of unauthorised use of a system, including 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, internal and external sources of risk.

Legal restrictions on the access to data, including UK and international data laws (walled garden laws), e.g. General Data Protection Regulation (UK) (GDPR).

Organisational security, including business continuance, backup/restoration of data, audits, areas of systems to be secured, e.g. data, network, systems (hardware and software), WANs, intranets, wireless access systems, security culture and the approaches to security in the work place, operational impact of security breaches.

The concepts, main functions and features of a range of Operating Systems (OS) and their security functions and associated security features.

LO2 **Describe IT security solutions**

IT security solution evaluation:

Network security infrastructure, including evaluation of network address translation (NAT), demilitarized zone (DMZ), static and dynamic IP addresses.

Network performance: redundant array of inexpensive disks (RAID), Main/Standby, Dual LAN, web server balancing.

Data security, including asset management, image differential/incremental backups, storage area network (SAN) servers, encryption.

Data centre, including replica data centres, virtualisation, secure transport protocol, secure MPLS routing, segment routing and remote access methods/procedures for third-party access, physical mechanisms, e.g. air flow and cooling to prevent overheating.

Security vulnerability, including logs, traces, honeypots, data mining algorithms, vulnerability testing, zero-day exploits.

Educating staff and customers on IT security issues and prevention methods.

Understand how cyber security technology components are typically deployed in digital systems to provide security and functionality, including hardware and software to implement security controls.

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.

Legal mechanisms, both UK and international, including Data Protection Act 2018, Computer Misuse Act 1990 and amendments, ISO 31000 Risk Management standards.

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

Awareness of common security architectures and methodologies that incorporate hardware and software components, and sources of architecture patterns and guidance.

Assess the security culture within an organisation (the approach to security, including how user actions impact on security).

Ensure system defences are informed by the most up-to-date legislation and guidance on best practice from professional bodies.

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, third-party access, business continuity, responsibility matrix.

Reviewing and monitoring of security risk assessments and ensuring stakeholder compliance with security procedures and standards.

Collect information from various sources (e.g. log files, system monitoring tools, Secure Information and Event Management (SIEM) tools, access control systems, physical security systems) and compare to known threat and vulnerability data to determine a digital system security breach.

Using enterprise risk management (as part of system management and lifecycle) for identifying, evaluating, implementing and follow up of security risks according to ISO 31000 standards.

Understand appropriate security tools and methods, 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 and penetration testing.

Investigate organisation policy on ethical hacking and bug bounties.

Gathering and recording information on security and initiating suitable actions for remediation.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Assess risks to IT security		**LO1 and LO2**
P1 Discuss types of security risks to organisations. **P2** Assess organisational security procedures.	**M1** Analyse the benefits of implementing network monitoring systems with supporting reasons.	**D1** Evaluate a range of physical and virtual security measures that can be employed to ensure the integrity of organisational IT security.
LO2 Describe IT security solutions		
P3 Discuss the potential impact to IT security of incorrect configuration of firewall policies and third-party VPNs. **P4** Discuss, using an example for each, how implementing a DMZ, static IP and NAT in a network can improve network security.	**M2** Propose a method to assess and treat IT security risks.	
LO3 Review mechanisms to control organisational IT security		
P5 Review risk assessment procedures in an organisation. **P6** Explain data protection processes and regulations as applicable to an organisation.	**M3** Summarise an appropriate risk-management approach or ISO standard and its application in IT security. **M4** Analyse possible impacts to organisational security resulting from an IT security audit.	**D2** Recommend how IT security can be aligned with an organisational policy, detailing the security impact of any misalignment.

Pass	Merit	Distinction
LO4 Manage organisational security		
P7 Design a suitable security policy for an organisation, including the main components of an organisational disaster recovery plan. **P8** Discuss the roles of stakeholders in the organisation in implementing security audits.	**M5** Justify the security plan developed giving reasons for the elements selected**.**	**D3** Evaluate the suitability of the tools used in the organisational policy to meet business needs.

Recommended Resources

Textbooks

Alexander, D. et al. (2020) *Information Security Management Principles.* BSC.

Collins, R. (2017) *Network Security Monitoring: Basics for Beginners. A Practical Guide* CreateSpace Independent Publishing Platform.

Sanders, C. Smith, J. (2013) *Applied Network Security Monitoring: Collection, Detection, and Analysis.* Syngress.

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 edn. Auerbach Publications.

Web

www.bcs.org	BCS, The Chartered Institute for IT (General Reference)
www.bsa.org	Software Alliance (General Reference)
www.fast.org.uk	Federation Against Software Theft (General Reference)
www.ico.org.uk	Information Commissioners Office (General Reference)

Links

This unit links to the following related units:

Unit 29: Network Security

Unit 30: Applied Cryptography in the Cloud

Unit 31: Forensics

Unit 32: Information Security Management.

Unit 6: Planning a Computing Project (Pearson-set)

Unit code	**H/618/7407**
Unit type	**Core**
Unit level	**4**
Credit value	**15**

Introduction

This unit is assessed through 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.

As computing systems and technologies continually develop so do the ways in which businesses utilise technologies to support their operations and remain competitive. As a computing professional it is important to understand the ways in which technology evolves and how it can be utilised in different sectors.

The aim of this unit is to give students an opportunity to demonstrate the research skills required for developing a deeper understanding of a subject and the ability to use evidence to inform decisions. Students will undertake independent research, and investigation of a theme set by Pearson. Students will also investigate and research an industry sector as outlined in the centre-set project brief. Students will use the outcomes of their research to help them plan a computer-based project and to support recommendations for how the identified business could utilise the tools and technologies identified as part of their research.

On successful completion of this unit, students will have the confidence to engage in decision making, problem solving, research activities and project planning tasks. They will have the fundamental knowledge and skills that will enable them to investigate and examine relevant computing concepts in 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 Conduct small-scale research, information gathering and data collection to generate knowledge on an identified subject

LO2 Explore the features and business requirements of organisations in an identified sector.

LO3 Produce project plans based on research of the chosen theme for an identified organisation

LO4 Present your project recommendations and justifications of decisions made, based on research of the identified theme and sector.

Essential Content

LO1 **Conduct small-scale research, information gathering and data collection to generate knowledge on an identified subject**

Project execution phase:

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

The distinct phases that 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) used to gather data (qualitative or quantitative).

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

Analysing information and data:

Using data collection tools, such as interviews and questionnaires, and their advantages and disadvantages.

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

Sources of, and access to, data, including open and public data, administrative and sensitive data, research data.

The principles of data to govern data, including data has value, data should be reusable, data is managed according to its value, data should be fit for purpose.

Ethics, reliability and validity:

Ensure that all research is conducted, data stored, processed and used in an ethical way.

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

Ensure validity and reliability of secondary data and information used, including consideration of who wrote or collected the information or data, age of data collected, original purpose of the data collection, potential errors or variability in the data, potential bias, e.g. sample size, sample participants, questions used, interpretation of results.

LO2 **Explore the features and business requirements of organisations in an identified sector**

Features of businesses:

Types of business, their ownership and liability.

Private, e.g. sole trader, private limited company, public limited company.

Public, e.g. government department, not-for-profit, e.g. charity, voluntary.

Industry sectors, including primary, secondary, tertiary, quaternary.

How an organisation may provide a specific product(s) or service within a sector.

How some organisations provide both products and services.

The concept of diversification to aid business success.

Operational areas of businesses:

The operational areas of a business ('business functions') and how they support the organisation's purpose, e.g. human resources, research and development, sales, marketing, purchasing, production and quality, finance, customer service, IT, administration.

Stakeholders:

Internal stakeholders, e.g. management, employees, shareholders.

External stakeholders, e.g. suppliers, customers, government agencies, communities.

How stakeholders influence business processes and decisions.

The impact of stakeholders on an organisation's success.

Challenges to the success of a business:

Legislation and industry standards relevant to the organisation and sector.

Change management, including planned change, e.g. expansion, diversification, changes in legislation, system upgrades.

Unplanned change, e.g. response to a security breach, disaster response and recovery.

Communication of need for change to stakeholders.

Management of stakeholders before during and after change, e.g. training, target setting, support

Method of implementation of change, e.g. parallel running, direct change over, phased changeover.

Documenting the change process, testing changes to the system and business.

Security and privacy concerns relevant to the organisation and sector.

LO3 **Produce project plans based on research of the chosen theme for an identified organisation**

Project planning and initiation:

The role of a business or systems analyst and the activities they undertake as part of initiation of a project.

Analysing the features and requirements of an identified organisation to establish their requirements.

Recommend potential solutions to identified business needs, including carrying out a cost/benefit analysis, defining business objectives, scope and purpose of the project.

Comprehensive project plans, including defining functional and non-functional requirements of the system, stakeholder requirements and expectations, carrying out impact analysis, prioritising requirements, describing the deliverables to be produced, timescales and time management, costs, change management planning, risk and challenges analysis.

Success criteria to be used, e.g. Key Performance Indicators (KPIs), performance metrics, quality metrics, and business targets.

Use of an identified project management methodology, e.g. Waterfall, Agile, Rapid Application Development (RAD).

Consider approaches to continuous integration, version and source control.

Tools:

Tools for effective project planning, resource planning and allocation, and work breakdown structure, including Project Initiation Documents (PID), bar and Gantt charts, Critical Path Analysis (CPA), risk matrix.

LO4 **Present your project recommendations and justifications of decisions made based on research of the identified theme and sector**

Presenting and communicating project recommendations:

Presenting to different technical and non-technical stakeholders, e.g. emphasis on operational or strategic information, technical terminology used, levels of detail given and simplifying concepts.

Consider the methods and mediums to be used, including written or verbal, report, online or presentation.

Understand how project research and intended audience will influence on method and medium.

Justification of decisions made:

Justification of recommendations, including use of key points from cost/benefit analysis, deliverables, success criteria, impact analysis.

Justifications of planning, including chosen development methodology, work and resource allocation, key deadlines and timescales.

Rationale for decisions made in the recommended solution and project plan, including use of research and data for the identified technology and business sector, analysis of evidence and business requirements, contextual factors specific to the identified organisation.

Reflection on the quality of research:

Quality of secondary and primary data used to inform planning and make decisions.

Awareness that some studies may result in generalised findings and how this can impact on the quality of decisions and the accuracy of conclusions made.

Evaluate the quality of the data and information used to inform project initiation plans, e.g. sample size, sample characteristics, user experience during collection, domain context.

Reach conclusions as to the likely accuracy and reliability of assertions made.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Conduct small-scale research, information gathering and data collection to generate knowledge on an identified subject</td><td rowspan="4">LO1 and LO2

D1 Interpret findings to generate knowledge on how the research theme supports business requirements in the identified sector.</td></tr>
<tr><td>P1 Demonstrate qualitative and quantitative research methods to generate relevant primary data for an identified theme.

P2 Examine secondary sources to collect relevant secondary data and information for an identified theme.</td><td>M1 Analyse data and information from primary and secondary sources to generate knowledge on an identified theme.</td></tr>
<tr><td colspan="2">LO2 Explore the features and business requirements of organisations in an identified sector</td></tr>
<tr><td>P3 Discuss the features and operational areas of a businesses in an identified sector.

P4 Discuss the role of stakeholders and their impact on the success of a business.</td><td>M2 Analyse the challenges to the success of a business in an identified sector.</td></tr>
</table>

Pass	Merit	Distinction
LO3 Produce project plans based on research of the chosen theme for an identified organisation		**LO3 and LO4**
P5 Devise comprehensive project plans for a chosen scenario, including a work and resource allocation breakdown using appropriate tools.	**M3** Produce comprehensive project plans that effectively consider aims, objectives and risks/benefits for an identified organization.	**D2** Evaluate the project planning recommendations made in relation to the needs of the identified organisation and the accuracy and reliability of the research carried out.
LO4 Present your project recommendations and justifications of decisions made, based on research of the identified theme and sector		
P6 Communicate appropriate project recommendations for technical and non-technical audiences. **P7** Present arguments for the planning decisions made when developing the project plans. **P8** Discuss accuracy and reliability of the different research methods applied.	**M4** Assess the extent to which the project recommendations meet the needs of the identified organisation, including fully-supported rationales for planning decisions made.	

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 edn. 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* edn. UK: Routledge.

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

Journals

International Journal of Quantitative and Qualitative Research (IJQQRM) – EA Journala

Qualitative Research Journal (QRJ) – Sage Journals

Web

www.apm.org.uk	Association for Project Management (General Reference)
www.gov.uk/government/publications	Department of Business Innovations and Skills, *Guidelines for managing projects – How to organise, plan and control projects*. (Report)
www.hesa.ac.uk	Higher Education Statistics Agency (HESA) – data collection and analysis for higher education
www.ons.gov.uk	Office for National Statistics (ONS) (General Reference)
www.pmi.org.uk	Project Management Institute UK (General Reference)

Links

This unit links to the following related units:

Unit 3: Professional Practice

Unit 16: Computing Research Project (Pearson-set)

Unit 17: Business Process Support

Unit 35: Systems Analysis & Design.

Unit 7: Software Development Lifecycles

Unit code	**K/618/7408**
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 give students the knowledge and skills needed to understand software development lifecycles so that they can demonstrate their knowledge by implementing a software development lifecycle with a suitable methodology.

The unit introduces students to lifecycle decision making at different stages of the software development process. They will examine various lifecycle models and learn to appreciate their particular characteristics in order to understand for which project environments they are most appropriate. Theoretical understanding will be translated into practical skills through an actual software development lifecycle project. 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.

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:

Describe different software development lifecycles.

Understand and use different lifecycle models, including predictive (Waterfall, Prototyping, RAD), adaptive (Spiral, Agile, DSDM), sequential and iterative software development models.

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

Testing and integration, including relationship between test activities and software development activities, levels of testing, building test environments, developing test harnesses, functional and structural testing, incremental testing, system testing, acceptance test and integration approaches, changeover strategies, trials and Go-Live prerequisites.

Understand the role and utilisation of analysis artefacts:

The creation of analysis artefacts in a software development project, e.g. software requirements specification, use case or user stories, user profiles, workflow model, wireframes, logical data model, data dictionary etc.

The purpose and activities of the gap analysis process.

Roles and responsibilities in a large-scale software project development lifecycle:

Identify the different individuals in a project, e.g. project manager, business analyst, systems analyst, programmer, DevOps engineer, testing engineer etc.

Contributions, including quality assurance, common core skills, tools and behaviours.

Explore how the psychology and mindset of testing differs to that development mindset and their possible influence on the overall success of a software project.

LO2 **Explain the importance of a feasibility study**

Requirement gathering:

Requirement gathering techniques, including how to categorise, validate and prioritise, e.g. MosCow method, functional requirements, non-functional requirements, users and constraints.

Interviews, observation, investigation.

Importance of feasibility study:

Feasibility criteria considerations, e.g. legal, social, economic, technical, timescales, organisational constraints.

Components of feasibility study, including purpose, structure, intended audience, outcomes.

The purpose of process modelling and the importance of an organisational view of business processes.

Key drivers for change, including performance and efficiency, legacy systems upgrade, automation, elimination of human error.

LO3 **Undertake a software development lifecycle**

Carry out software development lifecycle:

Follow company, team or client approaches to continuous integration, version and source control.

Apply an appropriate software development approach according to the relevant paradigm, e.g. object oriented, event driven or procedural.

Identify stakeholder requirements.

Scope of project, including inputs, outputs, processes and process descriptors, consideration of alternate solutions and security considerations, required quality assurance and testing.

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

Create simple software designs to effectively communicate understanding of the program.

Follow agreed software designs and technical and functional specifications.

Follow organisational policies and procedures relating to the tasks being undertaken, e.g. the storage and treatment of GDPR sensitive data.

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

Use of appropriate systems analysis terminology and tools, including data stores and entities, data flows, process representation techniques relationships (1:1, 1:M and M:M).

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

Techniques and documents for documenting business requirements and processes relevant to selected methodology, e.g. Context Diagrams, Data Flow Diagrams (DFDs), Entity Relationship Diagrams (ERDs), Business Systems Options (BSOs), Technical Systems Options (TSOs) and requirements traceability.

Analyse documented requirements to remove duplication, conflict and overlap.

Quality considerations, e.g. Total Quality Management (TQM).

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

Evaluate suitability of software behavioural design 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.

Understand the characteristics of software architecture that impact on software testing in the development lifecycle.

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 software lifecycle models.	**M1** Discuss using 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.	**D3** Evaluate the process of undertaking a systems investigation with regard 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 of use for both.	**D4** Present justifications of how data-driven software can improve the reliability and effectiveness of software.

Recommended Resources

Textbooks

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 edn. Addison-Wesley.

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

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

Web

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: Planning a Computing Project (Pearson-set)

Unit 16: Computing Research Project (Pearson-set)

Unit 22: Application Development

Unit 35: Systems Analysis & Design

Unit 42: Game Design Theory

Unit 43: Games Development

Unit 54: Prototyping.

Unit 8: Data Analytics

Unit code	**F/618/7415**
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 terms 'data analytics' and 'business analytics' are used interchangeably.

This unit introduces students to the theoretical foundation of data analytics and a range of data analytic processes and techniques to provide hands-on experience to enhance their 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 understand the theoretical foundation of data analytics, data analytic processes and techniques. They will also 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, Power BI, 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.

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.

Data visualisation, e.g. graphs, charts, plots.

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

Data analysis lifecycle:

Implement the stages of the data analysis lifecycle, including discovery, data preparation, model planning, model building, operationalise, communicate results.

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.

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 etc.

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

Optimisation:

Classical optimisation, linear programming techniques, non-linear programming techniques, dynamic programming.

Decision analysis:

Models, justifiable decisions and defensible decisions.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Discuss the theoretical foundation of data analytics that determine decision-making processes in management or business environments</td><td rowspan="4">LO1 and LO2
D1 Evaluate the importance of data analytical techniques to the decision-making process.</td></tr>
<tr><td>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.</td><td>M1 Investigate the three types of data analytic methods and their use in industry.</td></tr>
<tr><td colspan="2">LO2 Apply a range of descriptive analytic techniques to convert data into actionable insight using a range of statistical techniques</td></tr>
<tr><td>P3 Investigate descriptive analytic techniques and explain with appropriate examples.
P4 Apply an appropriate tool or programming language to demonstrate these descriptive analytics techniques.</td><td>M2 Show how these descriptive analytic techniques contribute to decision making.</td></tr>
</table>

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 them 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 methods with appropriate examples. **P8** Demonstrate these methods using an appropriate programming language or tool.	**M4** Describe how these prescriptive analytic methods 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 methods are used to find the best course of action in a situation.

Recommended Resources

Textbooks

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

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

Web

archive.ics.uci.edu/ml	University of California, Irvine Machine Learning Repository (Data sets) (General reference)
cran.r-project.org	The R Project for Statistical Computing R Archive Network (Development Tool)
cs.waikato.ac.nz	University of Waikato – Machine Learning Group Data Mining Software in Java (Development Tool)
lfd.uci.edu	University of California, Irvine – Laboratory for Fluorescence Dynamics (Research)
	Binaries for Python Extension Packages (Development Tool)
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 17: Business Process Support

Unit 26: Big Data Analytics and Visualisation.

Unit 9: Computer Systems Architecture

Unit code	**J/618/7416**
Unit level	**4**
Credit value	**15**

Introduction

As technology develops, it is important to have a working foundation of computer systems architecture on which to build technical knowledge. Despite hardware and software being constantly updated and seemingly becoming more complex, students with a solid, underpinned knowledge of computer systems architecture will not only be able to answer questions such as, '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 skills to many other areas.

This unit introduces students to the foundations of computer systems architecture, and the integrated hardware and software components and subsystems that enable and allow data to be input, processed and output. Students will explore the concepts of operating systems, hardware management and computer networks, and gain the practical skills needed to be able 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 and 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 in a central processing unit and the core hardware and software components associated with computer operations. Students will 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:

The four main subsystem of Von Neumann Architecture including memory, input and output systems, arithmetical & logic unit (ALU) and control unit.

The CPU.

Review memory subsystems in terms of 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), DVDs etc.), IO controllers and data transfer (speed, buffers, interrupts etc.).

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

Investigate how the control unit works (program code and 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 (ID).

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 and server/network, mobile, embedded systems, e.g. Windows 10, Windows Server 2012/2016, Linux, Unix, MacOS, IOS, Android.

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

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

Features and services:

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

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

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

Networking technology and services:

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

Layers of the TCP/IP model: application layer, transport layer, internet layer, network access layer.

7-layer OSI model, including purpose, architecture, functionality.

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

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

Connecting computer systems to a network:

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

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

Explain characteristics of cellular mobile networks.

Explore LPWA communication technology in comparison to WCT.

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

Hardware, software and networking issues and maintenance:

Different hardware- and software-related problems and the implication of choices with regard 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).

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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explain the relationships between hardware components and the subsystems used in a computer system</td><td rowspan="4">LO1 and LO2

D1 Evaluate the structure and functions of an operating system, including memory, processor, device, file, security, performance and error management with regard to functionality, operation and dependency.</td></tr>
<tr><td>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.</td><td>M1 Review the operation of the CPU and assess its dependency and performance with regard to associated systems and subsystems.</td></tr>
<tr><td colspan="2">LO2 Categorise the key features and services provided by different computer operating systems and hardware</td></tr>
<tr><td>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.</td><td>M2 Analyse the services provided by an operating system with regard to user interaction, memory management, file management and hardware support.</td></tr>
<tr><td colspan="2">LO3 Use network communication technology and the associated services to connect computer systems</td><td rowspan="2">D2 Evaluate the OSI and TCP/IP models with regard to hierarchy, layers and services, including information on the associated protocols and hardware.</td></tr>
<tr><td>P5 Explain the relationships between hardware and network addresses, including their use with regard to networking devices and components.

P6 Set up, configure and document appropriate hardware and software systems to establish computer-based network connectivity.</td><td>M3 Compare common physical and logical networking topologies and explain the differences and purposes of each.</td></tr>
</table>

Pass	Merit	Distinction
LO4 Demonstrate diagnostic and troubleshooting skills to solve hardware, software and networking related issues.		
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 regard to computer hardware and software.	**M4** Review different diagnostic and troubleshooting skills, including data gathering methods and techniques.	**D3** Assess any future improvements that may be required to ensure the continued effectiveness of a computer system.

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 27: Transport Network Design

Unit 29: Network Security

Unit 39: Network Management

Unit 40: Client/Server Computing Systems.

Unit 10: Cyber Security

Unit code M/618/5661

Unit type Core

Unit level 4

Credit value 15

Introduction

Digital technologies provide an opportunity for malicious hackers and cyberterrorists to exploit individuals, government, institutions and large organisation. Defending against cyber-attacks including insider threats is a priority within the digital technologies sector. Cybercrime techniques and attack vectors are fast-growing taking advantage of the speed, anonymity and convenience of the internet as a facilitator for malicious and criminal activity.

This unit has been designed to develop students' knowledge and understanding in relation to cyber threats and vulnerabilities, cyber defence techniques and incident response. Students will explore fundamental principles as well as leading-edge concepts, terminologies, models, and hardening methods. Students will assess the types of malicious activity and potential targets, and the role everyone has for maintaining cyber resilience.

On successful completion of the unit, students will have explored the nature of cybercrime and cyber threat actors; looked into the roles and responsibilities in relation to information assurance; assessed the threats to, and vulnerabilities in, ICT infrastructure; and investigated strategic responses to cyber security threats.

Learning Outcomes

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

LO1 Explore the nature of cybercrime and cyber threat actors

LO2 Investigate cyber security threats and hazards

LO3 Examine the effectiveness of information assurance concepts applied to ICT infrastructure

LO4 Investigate incident response methods to cyber security threats.

Essential Content

LO1 **Explore the nature of cybercrime and cyber threat actors**

Cyber security – the importance to business and society:

Business and society reliance on technology.

Why technology is a target for cybercrime.

Use of technology in business and society, e.g. email correspondence, financial transactions, networking, collaborative work documents, global modes/means of communication.

Impact of cyber security on protecting business and society.

Risks of not educating end users in security measures with regular updates to users.

Key definitions:

Cybercrime, cyber security, malicious cyber activity, hacker, malware, phishing, cyber resilience.

Cyber threat actors:

For example, cyber terrorists, government-sponsored/state-sponsored actors, organised crime/cybercriminals, 'hacktivists', insiders, internal user errors.

Targets:

For example, critical national infrastructure, mainframes, data centres, mobile phones, consumers, individuals, business, websites.

The categorisation of activity:

Active attacks attempt to alter system resources.

Passive attacks, attempts to learn or make use of information from the system without affecting the integrity of targeted systems, e.g. wiretapping.

Attacks can be initiated from inside or outside the perimeters.

Digital systems as 'target', e.g. viruses, attacks against hardware and software, malware, ransomware, hacking, distributed denial of service attacks, e.g. malware, mail bombing, pagejacking

Digital systems as a 'tool', e.g. cyber-enabled crimes, crimes against children, financial crimes, e.g. fraud, identity theft, information warfare, phishing, spam, propagation of obscene or offensive content.

LO2 **Investigate cyber security threats and hazards**

Threats and hazards:

Types of threats and hazards to a system, service, process, e.g. cybercriminals, organised crime groups, states and state-sponsored activity, terrorists, 'hacktivists', script kiddies, insiders (knowing and accidental).

Threat behaviour.

Missing data encryption.

Global threat landscape.

Individual and business fraud, extortion, trolling, racketeering, illegal sales, embezzlement, cyberstalking, cyber terrorism, industrial espionage, prostitution, gambling, suicide assistance.

Denial-of-service (DoS) and distributed denial-of-service (DDoS) attacks.

Man-in-the-middle (MitM) attacks.

Phishing and spear phishing attacks.

Drive-by attacks.

Password attacks; brute-force, factionary etc.

SQL injection attacks.

Cross-site scripting (XSS) attacks.

Eavesdropping attacks.

Advanced Persistent Threats (APTs).

Hazards and sources of potential damage, harm, adverse effect, e.g. life, political, military, organisational, critical infrastructure, economy, social group, technology, environmental, legal.

Cyber threat intelligence (CTI):

Importance of threat intelligence.

CTI types, including tactical, operational, strategic.

Evidence-based CTI.

Attribution and signs of accountability.

Risk of not acting on intelligence.

Acting on threat intelligence.

Emerging threats:

Horizon scanning, e.g. increased dependency on technology, increased use of robots, quantum technologies, low-orbiting satellites, Internet of Things (IoT), increased threats from developing countries as computer literacy increases.

LO3 **Examine the effectiveness of information assurance concepts applied to ICT infrastructure**

Information assurance and governance concepts:

Assurance, trustworthy vs trusted, user awareness of security requirements.

Achieving assurance in practice, e.g. penetration testing and contribution to assurance, extrinsic assurance methods.

Definitions and Information Architecture (IA) principles, data, information and IT governance, Information Governance (IG) roles and responsibilities.

Accountability, legal and regulatory applicability and requirements.

Recovery, IG strategic planning and best practices, IG policy development, IG business consideration and legal functions.

IG standardisation and accepted practices, IG auditing and enforcement, monitoring.

Records management and inventorying, IT and data governance frameworks.

IG in the cloud, social media and mobile devices, maintain an IG programme (challenges and opportunities).

ICT infrastructure:

ICT infrastructure, e.g. fundamental building blocks and typical architectures.

Common vulnerabilities in networks and systems.

Hardware, storage, routers/switches, application software, operating systems.

Traditional, cloud or hyper converged IT Infrastructure.

IoT, IIoT and IoMT.

LO4 **Investigate incident response methods to cyber security threats**

Standards:

International Organization for Standardisation (ISO) e.g. ISO/IEC 27001 Information Security Management, ISO/IEC 27002:2013.

Information technology security techniques, code of practice for information security controls.

Encryption standards, including AES – Advanced Encryption Standard, RSA – Rivest Shamir Adleman, 3DEA – Triple Data Encryption Algorithm, PGP – Pretty Good Privacy, common international encryption laws and policies, e.g. General Right of Encryption, Mandatory Minimum or Maximum Encryption Strength, Licensing/Regulation Requirements, Import/Export Controls, Obligations on Providers to Assist Authorities, Obligations on Individuals to Assist Authorities.

Legislation:

UK specific laws and policies, e.g. Electronic Communications Act (2000), Electronic Signatures Regulations (2002), Wassenaar Arrangement (1996), Regulation of Investigatory Powers Act (2016), International Traffic in Arms Regulations (ITAR), disclosure laws, e.g. Public Interest Disclosure Act (1998), Freedom of Information Act (2000), Data Protection Act (2018), General Data Protection Regulation (GDPR) (2016), Computer Misuse Act (1990), The Serious Crime Act (2015), Police and Justice Act (2006), Terrorism Act (2000), Human Rights Act (1998), Digital Economy Act (2017), Extradition Act (2003), Crime and Courts Act (2013) (to prevent extradition), Interception of Communication Act (1985).

Incident response methodology:

Preparation, Detection and Analysis, Containment, Eradication, and Recovery.

Developing a containment strategy, identifying and mitigating the hosts and systems under attack, and having a plan for recovery.

Post-incident activity.

The principles and elements of incident management.

Guidelines for incident responders and computer forensic investigations, together with legal aspects and relevant laws.

Intrusion detection and response methods.

Cryptography:

Contemporary use of cryptography, e.g. data encryption in storage, in usage and in transit (disks, network), data hashing (verification of origin, passwords, look-up tables, software verification, MD5).

Future trends in cryptography, e.g. blowfish, twofish, honey encryption, quantum key distribution.

Asymmetric and symmetric cryptography.

Organisations:

Organisations involved in preventing cyber security threats, e.g. National Cyber Security Centre (NCSC), police, National Crime Agency (NCA), National Cybercrime Unit (NCCU), Military Cyber Security Operations Centre (MCSOC), Regional Organised Crime Units (ROCUs).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the nature of cybercrime and cyber threat actors		**LO1 and LO2** **D1** Evaluate types of malicious cyber activity and the action that can be taken to neutralise cyber threat actors.
P1 Review types of malicious and/or criminal cyber activity. **P2** Investigate the potential targets of cybercrime.	**M1** Analyse the concept of digital systems as 'targets' and 'tools' as related to cyber security, giving real-world examples.	
LO2 Investigate cyber security threats and hazards		
P3 Describe security threats and hazards to a system or service or process. **P4** Investigate common attack techniques and recommend how to defend against them.	**M2** Assess the role of threat intelligence when defending against common attack techniques.	
LO3 Examine the effectiveness of information assurance concepts applied to ICT infrastructure		**LO3 and LO4** **D2** Evaluate the responses that have been implemented by different organisations in response to cyber security threats.
P5 Explore how information assurance concepts can mitigate threats and vulnerabilities in ICT infrastructure, giving examples.	**M3** Assess how information assurance could enhance the cyber resilience of ICT infrastructure.	
LO4 Investigate incident response methods to cyber security threats		
P6 Describe security standards, regulations and their consequences across at least two sectors. **P7** Investigate the types of response that have been implemented in response to cyber security threats.	**M4** Analyse the role of criminal and other law in deterring cybercrime.	

Recommended resources

Textbooks

Amoroso, E. and Amoroso, M. (2017) *From CIA to APT: An Introduction to Cyber Security.* New York: Independently published.

Gillespie, A. A. (2015) *Cybercrime.* Oxon: Routledge.

GRABOSKY, P. (2015) *Cybercrime (Keynotes Criminology & Criminal Justice).* New York: Oxford University Press.

Stevens, T. (2015) *Cyber Security and the Politics of Time.* Cambridge: Cambridge University Press.

Sutton, D. (2017) Cyber Security: A practitioner's guide. Swindon: BCS, The Chartered Institute for IT.

Web

interpol.int	Interpol crime areas, cybercrime (General Reference)
nationalcrimeagency.gov.uk	National Crime Agency – crime threats, cybercrime (General Reference)
ncsc.gov.uk	National Cyber Security Centre (General Reference)

Links

This unit links to the following related units:

Unit 5: Security

Unit 30: Applied Cryptography in the Cloud.

Unit 11: Strategic Information Systems

Unit code L/618/7417

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 increases and the 24-hour economy develops, organisations must ensure that their information systems are reliable, efficient and able to cope with rapid change.

This unit introduces students to how important information is to organisations. Students will examine how information systems can be used to support core business functions and how they enable organisations to be more productive and competitive in the global marketplace.

Students will analyse the information needs of an organisation at different levels and in different functional areas. It is important that computing professionals are able to understand how an organisation works and how it uses information so that they are able to design, implement, maintain and manage secure information systems to support its operations. The unit covers understanding organisations in terms of their information needs and the variances in different functional areas. Students will examine different information systems at the operational, tactical and strategic levels and will evaluate their effectiveness and role in terms of decision making and gaining competitive advantage.

On successful completion of this unit, students will have gained an insight into the types of systems and technologies available for effective information processing. They will have used critical analysis to examine the integrated role that each type of system and technology plays 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 Review the information requirements of organisations

LO2 Explore 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 Review the effectiveness of strategic information systems for global competitiveness

Essential Content

LO1 **Review 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, continuing professional development (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 in an organisation.

Requirements analysis:

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

LO2 **Explore 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 in 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:

Planning reports to include data required, sources of data, type of output expected, formatting and layout of data.

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.

Quality risks inherent in data and how to mitigate or resolve these.

Uses:

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

Understanding tasks, e.g. use of GDPR data, how organisations and industry have policies and procedures relating to those tasks.

LO4 **Review the effectiveness of strategic information systems for global competitiveness**

Models for strategic information systems:

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

Competitive advantage:

How 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 Review the information requirements of organisations		**D1** Evaluate the inputs, outputs and processing activities of a selected organisation.
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 different processing activities that occur within functional departments within an organisation.	
LO2 Explore the types of information systems that are used within all levels of an organisation		**D2** Differentiate between the function and purpose of information systems at different levels within 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.	
LO3 Demonstrate the use of an information system to produce management information		**D3**. Determine the constraints that an organisation can face when gathering data and information, and the importance of having data that is current, valid and accurate.
P5 Plan the design of a range of management reports for a given scenario. **P6** Produce a range of management reports using an information system for a given scenario.	**M3** Analyse how a range of reports can be used by an organisation for effective decision making and forecasting.	

Pass	Merit	Distinction
LO4 Review the effectiveness of strategic information systems for global competitiveness		
P7 Identify different models that can be applied to strategic information systems.	**M4** Justify the ways in which an organisation can obtain competitive advantage in a global market.	**D4** Evaluate how strategic information systems can contribute to the competitiveness of organisations.

Recommended Resources

Textbooks

Bradford, M. (2014) *Modern ERP. Select, Implement, and Use Today's Advanced Business Systems*. Lulu.com.

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

Stair, R. Reynolds, G. (2017) *Fundamentals of Information Systems.* 9th edn. Course Technology.

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

Journals

Information Systems Journal (Online)

The Journal of Strategic Information Systems (Online)

Web

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 41: Database Management Systems.

Unit 12: Management in the Digital Economy

Unit code H/618/5690

Unit level 4

Credit value 15

Introduction

The Internet creates a borderless economy and over the last few decades has taken shape resulting from billions of everyday connections between people, business, data and processes. As the digital economy continues to evolve, each day it destabilises traditional norms and practices in organisations, therefore requiring managers to reinvent and consider new ways of working. The way in which an organisation structures and organises its workforce will affect the culture that develops within it. Its system of shared values and beliefs will determine and shape the accepted pattern of behaviour within the organisation. This structure and culture, along with the way that managers approach the workforce and motivate their staff, will directly affect performance. The management of structure and culture in digital sector organisations is now quite different to those in other sectors.

This unit introduces students to the concept of organisational behaviour and encourages them to apply this to the digital sector, developing an awareness of how organisations in the digital economy are organised and formed. It will explore topics including structures, culture, and the impact and influence stakeholders can have on digital organisations. Students will consider the use of communication and media channels to understand different stakeholders, discover a range of digital-led management styles and leadership skills to assess those most appropriate, before applying theories of motivation to digital teams.

On successful completion of this unit, students will have discussed different types of organisational structure and culture; evaluated the impact of stakeholders in a digital sector organisation; investigated digital-led approaches to management and leadership; and assessed the relationship between motivation, organisational behaviour, performance and reflection. Students will have the opportunity to progress to a range of roles within the digital sector, which could include, for example, the role of IT Manager, Team Leader, Digital Community Manager, or working within project management.

Learning Outcomes

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

LO1 Investigate types of organisational structures and cultures in the digital economy sector

LO2 Explore the role, impact and influence of stakeholders in a digital economy organisation

LO3 Investigate digital-led approaches to management and leadership

LO4 Assess the relationship between motivation, organisational behaviour, performance and reflection in a digital team.

Essential Content

LO1 **Investigate types of organisational structures and cultures in the digital economy**

Digital economy organisations:

ICT-goods-producing and supporting infrastructure (i.e. hardware, software, telecoms) and ICT-service-producing, e-commerce and e-business (i.e. trading of goods or services).

Existing sectors increased use of digital products or services to include: government, retail, transport and logistics, financial services, manufacturing and agriculture, education, healthcare, broadcasting and media.

Supporting organisations, e.g. charities, social enterprises; and voluntary groups, e.g. third sector role in supporting delivery of services.

Key terminology and organisational structures:

Organisational terms, e.g. hierarchy, span of control, chain of command, line management, authority, delegation, empowerment, lines of communication, delayering, centralisation and decentralisation, collaboration and cross-collaboration, examples of organisational charts.

Structures including functional, product-based, geographically based, divisional, multifunctional and multidivisional, matrix, project, tall, flat, holistic, bureaucratic and post-bureaucratic, parent, strategic business units (SBUs).

Archetypes of digital teams, e.g. centralised, hybrid, independent, informal.

Organisational culture:

Types of organisational culture, e.g. forward-looking, backward-looking, innovation, customer-centric, digital transformation.

Shared drivers of organisational culture to include: behaviours (e.g. assumptions, vision, norms, values and beliefs), systems (e.g. processes, decision-making, renumeration) and symbols (e.g. observations, language, stories).

Theories, e.g. Hofstede's Cultural Dimensions (6D's), Handy's Model of Organisational Culture (power, role, task and person), Schien's Model of Organisational Culture, Lewin's Force Field Analysis for change; and digital-led trends, e.g. social connectivity, communication speed, learning, automation.

LO2 **Explore the role, impact and influence of stakeholders in a digital sector organisation**

Size and scope of organisations in the digital sector:

Differences between small, medium and large-sized organisations including objectives and goals, market share, profit share, growth and sustainability.

Global digital growth and developments of transnational, international and global organisations.

Role and community impact of stakeholders:

Examples of organisational stakeholders, e.g. employees, communities, shareholders, creditors, investors, government, customers, owners, managers, suppliers, competitors, unions, trade groups, analysts and media.

Stakeholders and responsibilities of organisation to engage with different internal and external stakeholder interests, perspectives and expectations.

Importance of corporate communication strategy alignment to support business objectives, brand loyalty and community relationships.

Stakeholder communication and media channels, e.g. corporate website, online communities and forums, publications, meetings and visits, to communicate technical information to both technical and non-technical audiences.

The relationship with stakeholders and meeting stakeholder expectations in the context of encouraging, developing and sustaining community; sharing and delivering welcomed and unwelcomed information; conflict management techniques and understanding of community management best practice relevant in the industry.

Influence of stakeholders in the digital sector:

The importance of effective communication and engagement with a range of stakeholders in relation to Business Analysis assignments.

Central government, e.g. legislation, budget and spending review, economic growth, education and social welfare.

Private and public sector, e.g. digital innovation and change (new technologies, business processes, business models, domains and people development), labour force (elimination and creation of jobs) and transparency of business habits.

Customer, clients and users, e.g. law of supply-demand, accessibility of data and content, surveillance capitalism, consumer rights and brand reputation.

LO3 **Investigate digital-led approaches to management and leadership**

Digital-led approaches to management:

Quantitative or mathematical approach (i.e. management science).

Systems approach (i.e. systems management).

Contingency or situational approach (i.e. empirical case study).

Administrative or management process (i.e. ‘traditional’ or ‘universalist’).

Human relations (i.e. social and psychological factors).

Behavioural science (i.e. interpersonal behaviour).

Decision-theory (i.e. decision-making).

IT-led management (i.e. operational and management process).

Types of management styles:

Methods used by managers to organise people, e.g. directive, authoritative, visionary, affiliative, participative, pacesetting, autocratic, consultative, servant, persuasive, democratic, chaotic, laissez-faire, paternalistic or maternalistic, transactional, results-based, transformational.

Roles and responsibilities of managers, e.g. interpersonal, informational, decisional, planning, leading, organising, commanding, coordinating, coaching, controlling, decision making, conflict resolution, managing change, delegation, contingency planning.

Identify ways that managers elicit information from stakeholders to process information, identify business needs, validate requirements and document areas of interest and influence.

Digital-led leadership skills:

Adopted roles and characteristics, i.e. digital champions, digital investors, digital pioneers, digital transformers.

Leader capabilities, i.e. cognitive transformation, behaviour transformation and emotional transformation.

LO4 Assess the relationship between motivation, organisational behaviour, performance and reflection in a digital team

Motivation and performance:

Motivational theories including content theories (e.g. Maslow, Herzberg and Alderfer), process theories (e.g. Vroom, Adams, Latham and Locke) and applications of motivational theory on management and leadership.

The use of rewards and incentives (monetary and non-monetary), effective management, performance standards (goal setting, appraisals) and staff morale on digital team's performance management.

Organisational behaviour and reflective practice:

Organisational psychology, personality and work behaviour, self and self-image, personality traits and types (e.g. Myers Briggs Type Indicator (MBTI)), group dynamics and inter-group behaviour (e.g. Belbin Team Roles).

Benefits of reflective practice on individual and organisation performance, recognition of paradigms (i.e. assumptions, frameworks, patterns of thought and behaviour, thinking and action).

Organisational learning, monitoring and evaluation.

Addressing issues of position, conflict, resistance and power relationships.

Reflective theory and models, e.g. Dewey, Schön, Gibbs' reflective cycle, Lawrence-Wilkes' REFLECT model, Rolfe et al's reflective model.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Investigate different types of organisational structures and cultures in the digital economy</td><td rowspan="4">LO1 and LO2

D1 Evaluate the structure, culture, role, impact of communication and influence of stakeholders in a digital sector organisation.</td></tr>
<tr><td>P1 Explain different types of organisational structures in the digital economy.

P2 Describe the concept of culture as it applies to digital sector organisations.</td><td>M1 Discuss the different structures and cultures used in the digital economy, providing specific examples.</td></tr>
<tr><td colspan="2">LO2 Explore the role, impact and influence of stakeholders in a digital sector organisation</td></tr>
<tr><td>P3 Explain the role of stakeholders, providing specific examples, in the digital sector.

P4 Review stakeholder communication and media channels to identify a threat or opportunity in a digital sector organisation.</td><td>M2 Analyse how different stakeholders, and choice of communication and media channels, can impact and influence a digital sector organisation.</td></tr>
<tr><td colspan="2">LO3 Investigate digital-led approaches to management and leadership</td><td rowspan="4">LO3 and LO4

D2 Assess the management approach and leadership skills, in response to motivation theory and organisational behaviour, to improve performance of a digital team.</td></tr>
<tr><td>P5 Discuss different approaches to management styles, providing specific examples.</td><td>M3 Analyse the roles, characteristics and capabilities of digital-led leaders.</td></tr>
<tr><td colspan="2">LO4 Assess the relationship between motivation, organisational behaviour, performance and reflection in a digital team</td></tr>
<tr><td>P6 Describe the relationship between motivation, organisational behaviour and reflection, on performance.</td><td>M4 Compare advantages and disadvantages, of using motivation and reflection theories, when applied to a digital team.</td></tr>
</table>

Recommended resources

Textbooks

BEAMES, C. (2019) *How to Manage Your Workforce in the Digital Age*. Online: Blurb.

GARFIELD, S.A. (2020) *Handbook of Community Management: A Guide to Leading Communities of Practice.* Berlin: Walter de Gruyter.

HILL, A. (2016) *Leadership in the Headlines: Insider insights into how leaders lead.* London: Financial Times Publishing.

HUCZYNSKI, A. and BUCHANAN, D. (2013) *Organisational Behaviour.* 8th edn. Harlow: Pearson.

MULLINS, L.J. (2016) *Management and Organisational Behaviour.* 11th edn. Harlow: Pearson.

O'BRIEN, J. (2017) *The Power of Purpose: Inspire teams, engage customers, transform business.* Online: Pearson Business.

RASKINO, M. and WALLER, G. (2015*) Digital to the Core: Remastering Leadership for Your Industry, Your Enterprise and Yourself*. Oxon: Taylor & Francis.

ROLLINSON, D. (2008) *Organisational Behaviour and Analysis: An Integrated Approach.* 4th edn. Harlow: Prentice Hall.

SCHEDLITZKI, D. and EDWARDS, G. (2014) *Studying Leadership: Traditional and Critical Approaches.* London: SAGE.

STOKES, P. et al (2016*) Organizational Management: Approaches and Solutions.* London: Kogan Page.

SZCZEPANSKA-WOSZCZYNA, K. (2020*) Management Theory, Innovation, and Organisation: A Model of Managerial Competencies*. Oxon: Taylor & Francis.

YUKI, G. and GARDENER, W.L. (2019) *Leadership in Organizations, Global Edition.* 9th edn. Online: Pearson.

Journals

Journal of Management, Online

Journal of Leadership and Organizational Studies, Online

Journal of Occupational and Organizational Psychology, Online

Web

myersbriggs.org	The Myers & Briggs Foundation (General Reference)
belbin.com	The Nine Belbin Team Roles (General Reference)

Links

This unit links to the following related units:

Unit 53: Digital Technologies as a Catalyst for Change.

Unit 13: Website Design & Development

Unit code	**Y/618/7419**
Unit level	**4**
Credit value	**15**

Introduction

Wireless, public hotspot, mobile broadband and unlimited network connections mean 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 use technology successfully to deliver high-quality and consistent User Experiences (UX) through friendly and functional User Interfaces (UI). However, as the software and hardware evolve so does the challenge of design.

This unit introduces students to the underpinning services required to host, manage and access a secure website. Students will then be introduced to and explore the methods used by designers and developers to blend back-end technologies (server-side) with front-end technologies (client-side). To help ensure that new designers are able to design and deliver a site that offers an outstanding User Experience (UX) supported by an innovative User Interface (UI), students will discuss the reasons, requirements, relationships, capabilities and features of the systems they will be using. This gives them an opportunity to explore various tools, techniques and technologies with 'good design' principles in order 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 the unit, students will be able to explain the 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, 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 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, Domain Name System (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 regard 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, e.g. integrated development environments, code repositories, low code environments, front-end and back-end processing.

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 and inclusivity standards and guidelines, e.g. W3C, Equality Act 2010 and other relevant legislation, 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 and inclusivity guidelines to implement an appropriately branded, multipage site.

Guidelines and recommended good practice to ensure the website and associated data is ‘secure by design’.

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		**LO1 and LO2**
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 regard to designing, publishing and accessing a website.	**M1** Analyse the impact of common web development technologies and frameworks with regard 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.	**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 they relate to presentation and application layers. **P4** Discuss the differences between online website creation tools and custom-built sites with regard to design flexibility, performance, functionality, User Experience (UX) and User Interface (UI).	**M3** Analyse 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		**D2** Evaluate the design and development process of the multipage website against the design document including any technical challenges faced.
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 the design document with appropriate principles, standards and guidelines to produce a branded, multipage website supported with realistic content.	**M4** Justify the multipage website implementation decisions against the design document.	
LO4 Create and use a Test Plan to review the performance and design of a multipage website		**D3** Evaluate the results of the Test Plan and the overall success of the multipage website with recommendations for improvement.
P7 Create a suitable test plan, identifying key performance areas to review the functionality and performance of the multipage website developed	**M5** Analyse the Quality Assurance (QA) process and review how it was implemented during the multipage website design and development stages.	

Recommended Resources

Textbooks

Frain, B. (2012*) Responsive Web Design with HTML5 and CSS3*. 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.

Web Links

developers.google.com/web/tools	Google web development tools (General Reference)
getbootstrap.com	Open source web development tool kit (General Reference)
www.w3.org	World Wide Web Consortium (General Reference)

Links

This unit links to the following related unit:

Unit 36: User Experience and Interface Design.

Unit 14: Maths for Computing

Unit code	**R/618/7421**
Unit level	**4**
Credit value	**15**

Introduction

In 1837, English mathematicians Charles Babbage and Ada Lovelace in collaboration, described a machine that could perform arithmetical operations and store data in 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 still rely fundamentally 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 in 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 have gained confidence in the mathematics that is needed in other computing units. They will have developed 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

LO3 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		**D1** Produce a detailed written explanation of the importance of prime numbers in the field of computing.
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.	
LO2 Analyse events using probability theory and probability distributions		**D2** Evaluate probability theory to an example involving hashing and load balancing.
P3 Deduce the conditional probability of different events occurring in independent trials. **P4** Identify the expectation of an event occurring from a discrete, random variable.	**M2** Calculate probabilities in both binomially distributed and normally distributed random variables.	
LO3 Determine solutions of graphical examples using geometry and vector methods		**D3** Construct the scaling of simple shapes that are described by vector co-ordinates.
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.	

Pass	Merit	Distinction
LO4 Evaluate problems concerning differential and integral calculus		**D4** Justify, by further differentiation, that a value is a minimum.
P7 Determine the rate of change in 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.	

Recommended Resources

Textbook

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

Journal

Journal of Computational Mathematics. Global Science Press.

Links

This unit links to the following related units:

Unit 18: Discrete Maths

Unit 33: Applied Analytical Models.

Unit 15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems

Unit code **K/618/5660**

Unit level **4**

Credit value **15**

This unit is aligned to the Microsoft Azure AI Fundamentals Certification. See section 3.1.4 for further guidance on claiming certification.

Introduction

Intelligent Systems are revolutionising industry and changing the way we accomplish daily routines. They help to introduce flexibility, quality and energy efficiency to name a few to an increasing range of applications. For example, transportation, healthcare, education, and the defence sector. Intelligent Systems are enabled by various underpinning technologies, especially Artificial Intelligence (AI). AI offers opportunities to gain insights from data or perceive the environment to take intelligent actions that maximize the chances of performing a task faster or not previously possible. The growth in AI potential offers companies opportunities to reduce costs, increase productivity and introduce new products to the market. Therefore, people skilled in AI and its applications are in high demand.

This unit is designed to introduce the science behind machine intelligence and the philosophical debate around the ambitions of simulating human intelligence to solve real-world problems. Students will be guided to appreciate AI types and applications and develop a better understanding of aspects related to intelligent agents. Other topics included in the unit covers Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), Ambient Intelligence, the major differences between top-down and bottom-up approaches to AI, and understanding Machine Learning (ML) algorithms (e.g. SVM, Naïve Bayes, Random Forest and KNN) and processes including dataset preparation.

On successful completion of this unit, students will be able to investigate AI fundamentals including data gathering, validation, and processing. Additionally, how the results can be visualised and explained. They will also develop their skillset to study deployed Intelligent Systems and evaluate technical and ethical challenges and opportunities.

Learning Outcomes

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

LO1 Discuss the theoretical foundation of Artificial Intelligence and its impact on users and organisations

LO2 Analyse the approaches, techniques and tools to deploy Intelligent Systems in an organisation

LO3 Modify an AI-based system to improve how exhibits intelligence in response to a real-world problem

LO4 Evaluate the technical and ethical challenges and opportunities of Intelligent Systems.

Essential Content

LO1 **Discuss the theoretical foundation of Artificial Intelligence and its impact on users and organisations**

AI Fundamentals:

Understanding what defines Artificial/Machine Intelligence; philosophical debates around the ambitions of simulating human intelligence; and the phenomenon of the “AI effect”.

AI and the phenomenon of combinatorial explosion.

The requirements of the underlying Data and its influence on AI outcomes.

How to handle large (big data) versus small datasets.

Understanding what “Learning from experience” means for Intelligent Agents and Intelligent Systems.

Appreciating the difference between AI and its subfields such as Machine Learning and related interdisciplinary research areas such as Robotics

How AI leverages other disciplines such as computer science, mathematics, psychology, software engineering, and linguistics.

Recognising traditional problems (goals) of AI such as reasoning, planning, learning, natural language processing, perception, prediction/forecasting, anomaly detection, computer vision, knowledge mining, and conversational AI.

Decision-making including basics of utility theory, sequential decision problems, elementary game theory, decision theory.

Understanding Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents.

AI Types:

The difference between weak AI and strong AI.

Artificial Narrow Intelligence (ANI), also referred to as weak AI with applications focused on singular tasks e.g. Alexa, Siri, prediction tools, spam filters.

Artificial General Intelligence (AGI), also known as strong AI or deep AI e.g. Recognition, Recall, Hypothesis testing, Imagination, Analogy, Implication.

Artificial Super-intelligence (ASI), a hypothetical concept.

AI Applications:

The role of AI on the principles of a Universal Design.

Ambient Intelligence enabling electronic environments that are sensitive and responsive to the presence and preferences of people.

Finance e.g. to detect anomalies in charges outside of the norm, flagging these for human investigation.

Agriculture e.g. predicting the time it takes for a crop to be ripe and ready for picking, harvesting robot, predicting and extending storage and shelf life.

Business and eCommerce e.g. chatbots, visual searches, intelligent virtual assistants.

Engineering e.g. Computer Aided Design (CAD) and automation in factories.

Healthcare e.g. care of the elderly, heart beats analysis, computer-aided interpretation of medical images, drug discovery.

Cybersecurity e.g. profiling anomalous user behaviour, automating response against large-scale attacks.

Logistics and Supply Chain e.g. autonomous trucks and robotic picking systems.

Other examples include any application which exhibit intelligence via AI techniques such as strategy games, autopilot in autonomous cars, intelligent routing in computer networks, and military simulations.

LO2 **Analyse the approaches, techniques and tools to deploy Intelligent Systems in an organisation**

Approaches:

The major differences between top-down and bottom-up approaches to AI.

Explainable AI (XAI).

Statistical methods, computational intelligence, and traditional symbolic AI.

AI Tools, Libraries, Platforms, and Frameworks:

Options include but not limited to Tensorflow, Torch, Theano, Azure Machine Learning, Azure Cognitive Services, Azure Bot Service, MathWorks Matlab (plus Simulink), CNTK (Computational Network Toolkit), Deeplearning4j, Scikit-Learn, Swift AI IBM Watson, Keras, Pybrain, Google ML kit, Caffe, H20: open source AI platform.

Algorithms and techniques:

Understanding Machine Learning algorithms and processes including dataset preparation, feature engineering and selection, training and validating datasets, model training, selecting and interpreting model evaluation metrics and model deployment and management.

Linear Regression, Logistic Regression, Decision Tree, K-Nearest Neighbour, SVM (Support Vector Machine), Naïve Bayes, KNN (K- Nearest Neighbours), K-Means, Random Forest, Dimensionality Reduction Algorithms, Gradient Boosting & AdaBoost.

Tools and required relationships for testing, e.g. accurate and clear documentation, role of static testing and review in early defect detection, the need to follow specific industry standards (e.g. GDPR, health informatics, safety critical) and psychology mindset of tester-developer relationship.

LO3 **Modify an AI-based system to improve how it exhibits intelligence in response to a real-world problem.**

AI-based system

Common types of computer vision solution including image classification, object detection solutions, optical character recognition, facial detection, recognition and analysis.

Common types of natural language processing including key phrase extraction, entity recognition, language modeling, speech recognition and synthesis, and translation.

Common types of conversational AI e.g. webchat bots.

Modification:

Modify existing AI-based system using cloud based solutions e.g. Azure Machine Learning studio, Azure Cognitive Services and Azure Bot service.

Identifying the need to make modifications.

Modifying commands.

Impact of modification on cost and quality.

Improvement identification e.g. accuracy, efficiency, speed.

Application selection:

Criteria for AI-based application selection, e.g. any application software, system or agent which exhibits intelligence as part of its problem-solving approach e.g. open-source projects from Google and GitHub.

AI Analysis:

Overfitting, underfitting.

Data collection, data sources and assessment of data reliability to modify AI-based system.

LO4 **Evaluate the technical and ethical challenges and opportunities of Intelligent Systems**

Ethics in the Use of AI:

Identify guiding principles for responsible AI e.g. fairness, reliability, safety, privacy, security, inclusiveness, transparency and accountability.

Use of deep learning in recruiting new employees e.g. Deepfake.

AI bias and the ethical dilemma e.g. potential to widen socio-economic inequality, AI powered hiring processes (employment opportunities), access to skilling, health/life extension, algorithmic quantitative trading.

Autonomous weapons (mass casualties), AI arms race, Ethical implications of autonomous weapons.

Challenges:

Overfitting, AI lack of reasoning e.g. naïve physics, folk psychology.

The impact of data quality and quantity e.g. on the accuracy of an AI algorithm.

Job automation, risks of mass unemployment.

Intelligent Systems and Intelligent Agents have no emotions or out-of-the-box thinking.

Limited understanding of the AI decision making process e.g. deep learning.

Challenges related to the lack of compliance frameworks while considering legal and emerging legal factors e.g. GDPR, Data Protection and governance.

Risks; privacy and security e.g. Deepfake technology, emerging technology, aligning AI goals with objective(s).

Challenges related to readiness e.g. Lack of understanding of AI (and the value of data) among non-technical employees, lack of business alignment, robust testing, alignment of AI goals with defined objectives.

AI and Intelligent Systems are emerging technologies, not fully tested.

The environmental footprint of AI e.g. the carbon impact of AI.

Myth and fiction around AI e.g. mythical worry of “AI turning conscious” vs actual worry, “AI turning competence with objectives misaligned with ours”.

Opportunities:

Artificial cognitive abilities could make faster and more accurate decisions e.g. intelligence advice in health care.

Enabling affordability of services e.g. automation reduces operational costs.

Meeting demand e.g. the optimisation of routine processes increases productivity.

Inform strategic decision making e.g. profiling and risk assessment based on large datasets to predict high-risk events/actors.

Mitigate physical harm e.g. an AI-driven robot replaces a human in a dangerous location.

Availability an AI system can work 24x7.

Introducing new innovations e.g. AI as a competitor advantage (AI is an emerging technology with growing potential enabled by increasing processing power).

Collaborative work with human input e.g. AI and humans work together to reduce false positives.

Collaborative Robots (Cobots) and use in industry, healthcare, etc.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Discuss the theoretical foundation of Artificial Intelligence and its impact on users and organisations</td><td rowspan="4">LO1 and LO2
D1 Evaluate the potential impact of deploying several types, approaches and tools of AI and Intelligent Systems on both users and organisations.</td></tr>
<tr><td>P1 Describe the fundamental aspects of Artificial Intelligence.
P2 Describe the types and areas of application to solve current real-world problems.</td><td>M1 Analyse the advantages and disadvantages of using Artificial Intelligence to an area of application.</td></tr>
<tr><td colspan="2">LO2 Analyse the approaches, techniques and tools to deploy Intelligent Systems in an organisation</td></tr>
<tr><td>P3 Investigate options around the approaches, techniques and tools for the deployment of modern Intelligent Systems.
P4 Compare the advantages and challenges of several tools and techniques for the development of Intelligent Systems.</td><td>M2 Demonstrate how different approaches and tools work together for the deployment of Intelligent System.</td></tr>
<tr><td colspan="2">LO3 Modify an AI-based system to improve how it exhibits intelligence in response to a real-world problem</td><td rowspan="2">D2 Evaluate your own role to improve the performance of an AI-based system.</td></tr>
<tr><td>P5 Investigate the technical implementation of an AI-based system.
P6 Explore the technical options to enhance the performance on an AI-based system.
P7 Modify an AI-based system to enhance performance.</td><td>M3 Demonstrate a technical modification, to an existing deployment of an AI based system, using benchmarking to enhance its performance.</td></tr>
</table>

Pass	Merit	Distinction
LO4 Evaluate the technical and ethical challenges and opportunities of Intelligent Systems		**D3** Analyse the technical and ethical challenges while appreciating the opportunities of Intelligent Systems.
P8 Investigate the security and ethical issues with Intelligent Systems. **P9** Discuss the technical challenges involved in managing and maintaining Intelligent Systems.	**M4** Review the legal implications and security risks to both users and organisations of using Intelligent Systems.	

Recommended resources

Textbooks

Géron, A. (2019). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems.* O'Reilly Media.

Lauterbach, A., & Bonime-Blanc, A. (2018). *The artificial intelligence imperative: a practical roadmap for business.* ABC-CLIO.

Liu, Y. (2019). *Python Machine Learning By Example: Implement machine learning algorithms and techniques to build intelligent systems.* 2nd edn. Packt Publishing.

Marcus, G., & Davis, E. (2019). *Rebooting AI: Building artificial intelligence we can trust.* New York, USA: Pantheon.

Russell, S., & Norvig, P. (2019). *Artificial intelligence: a modern approach*. 4th edn. Pearson.

Zaccone, G., & Karim, M. R. (2018). *Deep Learning with TensorFlow: Explore neural networks and build intelligent systems with Python.* Packt Publishing Ltd.

Web

https://www.journals.elsevier.com/artificial-intelligence	Artificial Intelligence. Elsevier. (Journal)
https://cis.ieee.org/publications/ieee-transactions-on-artificial-intelligence	IEEE Transactions on Artificial Intelligence. (Journal)
https://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=9670	IEEE Intelligent Systems. (Journal)
https://www.mdpi.com/journal/ai	AI, MDPI. (Journal)
https://dl.acm.org/journal/tist	ACM Transactions on Intelligent Systems and Technology (Journal)
https://opensource.google/projects/list/machine-learning	Google's Open-source Machine Learning projects (General Reference)

Links

This unit links to the following related units:

Unit 25: Machine Learning

Unit 46: Robotics

Unit 47: Emerging Technologies

Unit 48: Virtual and Augmented Reality Development.

Unit 16: Computing Research Project (Pearson-set)

Unit code	**K/618/7425**
Unit type	**Core**
Unit level	**5**
Credit value	**30**

Introduction

This unit is assessed through a Pearson-set assignment. Students will choose their own project based on a theme provided by Pearson (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 give students the opportunity to engage in sustained research in a specific field of study. Students will be able to demonstrate the capacity and ability to identify a research theme, to develop research aims, objectives and outcomes, and to present the outcomes of such research in both written and verbal formats. Students are encouraged to reflect on their engagement in the research process, during which recommendations for 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. Students will have fundamental knowledge and skills that will enable them to investigate workplace issues and problems, determine appropriate solutions and present evidence to various stakeholders in an acceptable and understandable format.

Students will have developed 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' 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 methodologies:

Key theoretical frameworks for research.

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

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

Research as a process:

Follow distinct phases of research to support a coherent and logical argument including using secondary research to inform a primary, empirical study.

Identify the reason and goal of the business research project, e.g. solving identified problems, business expansion, improve competitiveness, response to developments in technology, changes in the industry.

Elicite information from stakeholders.

Application of key skills and behaviours to guide the research project and ensure success, e.g. critical thinking, analysis and reasoning, dealing with difficult situations, misunderstanding or mistakes.

Selecting a sample:

The importance of gathering primary and secondary 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 (random) sampling.

Ethics, reliability and validity:

Conduct research ethically including reporting of findings.

Consider how to ensure reliable and valid research.

Analysing data:

Using data collection tools such as interviews and questionnaires.

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

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

Stakeholders:

Techniques to support the identification and analysis of internal and external stakeholders.

Stakeholder analysis to determine approaches to communications, including who the stakeholders are, high and low priority status, type of communication, frequency of communication, level to which the project outcomes are conveyed.

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.

Considerations when communicating with stakeholders, e.g. maintaining privacy and security, tone of voice, use of technical vocabulary or jargon, maintaining or promoting company image.

Convincing arguments:

No matter what the method/medium, all research should be convincing and presented logically where the assumption is that the audience has little or no knowledge of the research process.

The importance of developing evaluative conclusions.

LO4 **Reflect on the application of research methodologies and concepts**

Reflection for learning and practice:

Difference between reflecting on performance and evaluating a research project. The former considers the research process; the latter considers the quality of the research argument and use of evidence.

Reflection on the merits, limitations and potential pitfalls of the chosen methods.

The cycle of reflection:

To include reflection in action and reflection on action.

Considering how to use reflection to inform future behaviour and future considerations.

Reflective writing:

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

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Examine appropriate research methodologies and approaches as part of the research process</td><td rowspan="4">LO1 and LO2

D1 Critically evaluate research methodologies and processes in application to a computing research project to justify chosen research methods and analysis.</td></tr>
<tr><td>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.</td><td>M1 Analyse different research approaches and methodology and make justifications for the choice of methods selected based on philosophical/theoretical frameworks.</td></tr>
<tr><td colspan="2">LO2 Conduct and analyse research relevant to a computing research project</td></tr>
<tr><td>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.</td><td>M2 Discuss merits, limitations and pitfalls of approaches to data collection and analysis.</td></tr>
</table>

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** Analyse the extent to which outcomes meet set research objectives and communicate judgements effectively for the intended audience	**D2** Evaluate outcomes and make valid, justified recommendations.
LO4 Reflect on the application of research methodologies and concepts		
P6 Discuss the effectiveness of research methods applied, for meeting objectives of the computing research project. **P7** Discuss 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., Smithson S. (2005) *Project Research in Information Systems: A Student's Guide*. Paperback. Palgrave Macmillan.

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

Fink, A. (2020) *Conducting Research Literature Reviews: From the Internet to Paper*. 5th edn. Sage Publications Inc.

Flick, U. (2020) *Introducing Research Methodology: A Beginner's Guide to Doing a Research Project.* London: Sage Publications Ltd.

Gray, D.E. (2009) *Doing Research in the Real World.* 2nd edn. London: SAGE.

Saunders, M., Lewis, P. and Thornhill, A. (2012) *Research Methods for Business Students.* 6th edn. 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

Links

This unit links to the following related units:

Unit 3: Professional Practice

Unit 6: Planning a Computing Project (Pearson-set)

Unit 7: Software Development Lifecycles.

Unit 17: Business Process Support

Unit code A/618/7428

Unit type Core

Unit level 5

Credit value 15

Introduction

Data and information are core to any organisation and business process. Accurate data and meaningful information are of high value to an organisation and are key drivers for effective decision making and problem solving. Business intelligence relies on the use of data science, which makes use of a range of tools and methods, including 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 used for acquiring data and processing it into meaningful information that can be used to support business functions and processes.

Students will examine how data and information support business processes, the mechanisms to source and utilise data and turn it in to usable, and valuable, information output. Students will explore real-world business problems, the emergence of data science and how the application of data science can be used to support business processes. Finally, students will demonstrate practical application of data science techniques to support real-world business problems.

On successful completion of this unit, students will appreciate the importance and value of data and information in terms of optimising decision making and performance. By exploring the tools, techniques and systems that support business processes, students will be aware of the role and contribution of these technologies and methodologies, 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 the use of data and information to support business processes and the value they have for an identified organisation

LO2 Discuss the implications of the use of data and information to support business processes in a real-world scenario

LO3 Explore the tools and technologies associated with data science and how it supports business processes

LO4 Demonstrate the use of data science techniques to make recommendations to support real-world business problems.

Essential Content

LO1 **Discuss the use of data and information to support business processes and the value they have for an identified organisation**

Data and information in organisations:

Value of data and information for an organisation, including decision making (strategic, tactical and operational), deliver and improve services, optimise workflow and efficiency, increase profit margins, diversification, reduce overheads.

Types of data used by organisations, including structured and unstructured data.

Impact on business processes in terms of elicitation and storage.

The importance of reliable data and impact on businesses.

Use of data and information to support business processes:

Analysing market trends to identify patterns.

Factors impacting fluctuations in supply and demand, and prices of goods.

Monitoring system performance metrics.

Monitoring and controlling the quality of a product or service.

Analysing levels of user or customer interaction and engagement.

Analysing trends in browsing and purchasing for targeted marketing purposes.

Mechanisms:

Data generation, including human generated, e.g. social media posts, documents and files, email and text messages, website content.

Machine generated data, e.g. sensor readings, log files, system performance metrics, transactional data.

Tools to collect, store, manage, analyse and display data and information, including application software, content management systems, social media platform analytics tools, databases, scripting languages.

LO2 **Discuss the implications of the use of data and information to support business processes in a real-world scenario**

Social, legal and ethical implications:

Recognise the social, ethical and professional issues related to the use of data and information to support business processes, e.g. how data and information is collected and used, use of cookies and other transactional data, sharing of data, e.g. between departments, services and organisations.

Legal and regulatory issues related to the use of data and information to support business processes in reference to current legislation and principles of good practice, as recommended by computing professional bodies.

Cybersecurity management:

Common threats to data and information, e.g. internal and external threats.

Impact of human behaviour on cyber security, e.g. how motive and opportunity combine to become a threat.

Concept of 'secure by design' when developing and using systems to handle data and information.

Ways to mitigate common threats to data and information at personal and organisational level.

Organisational implications of failing to adequately protect data and information, e.g. legal actions, financial impact, disruption of operations and reduction in productivity, damage to public image.

LO3 **Explore the tools and technologies associated with data science and how it supports business processes**

Data science overview:

Explore how the exponential growth of the amount of data generated impacts on the way data is collected and used.

The core aims of data science, including making data useful and retrievable, extracting actionable intelligence to improve business performance, automating extraction and implementation.

Key job roles, including data engineer and data scientist, and how they work with other members of a team, e.g. senior managers, business and data analysts, software engineers in change and development lifecycles.

Data-science-related skills, including mathematics and statistics, programming and scripting skills, investigation and integration of data, core business knowledge.

Sub-disciplines in the data science field, including data engineering, machine learning and artificial intelligence.

Using data:

Core data handling techniques and concepts, including input and capture, data processing and conversion, information output and security considerations.

Forms of data, including unstructured and semi-structured data, and implications on use and analysis.

Data types, e.g. date, integer, real, character, string, Boolean.

Format of source and target data files, e.g. JSON, fixed-width text file, CSV, ASCII, XML.

The use of coding and scripting languages to automate data science processes, e.g. Python, R.

Turning data into usable information, including data mining techniques to find anomalies, cluster patterns and relationships between data sets, web scraping, descriptive and predictive analysis, converting data into visual information, e.g. charts, graphs, histograms, other visual mediums.

Predictive modelling, e.g. forecasting, use of statistical models to predict and identify trends.

Communicating information effectively to a range of stakeholders.

LO4 **Demonstrate the use of data science techniques to make recommendations to support real-world business problems**

Solutions:

Supporting a business process, including techniques to elicit end user requirements, systems requirements, application to automate procedures, including when it is most appropriate to use each one.

Designing a tool, program or package that can perform a specific task to support problem solving or decision making, e.g. e-commerce function for a website to support purchase analysis, a user dashboard to investigate specific market trends, optimising delivery routes for a logistics company.

Analysing and modelling business processes using relevant techniques, standards, notation and software tools.

Design considerations:

Addressing user and system requirements, e.g. user-friendly and functional interface, considering user engagement and interaction, quality risks inherent in data, mitigate or resolve risks, meaningful data output, customisation to satisfy the user and system requirements, phases of testing of business system changes.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Discuss the use of data and information to support business processes and the value they have for an identified organisation		**LO1 and LO2**
P1 Discuss how data and information support business processes and the value they have for organisations. **P2** Discuss how data is generated and the tools used to manipulate it to form meaningful data to support business operations.	**M1** Assess the value of data and information to individuals and organisations in relation to real-world business processes.	**D1** Evaluate the wider implications of using data and information to support business processes in an identified organisation.
LO2 Discuss the implications of the use of data and information to support business processes in a real-world scenario		
P3 Discuss the social legal and ethical implications of using data and information to support business processes. **P4** Describe common threats to data and how they can be mitigated at on a personal and organisational level.	**M2** Analyse the impact of using data and information to support business real-world business processes.	

Pass	Merit	Distinction
LO3 Explore the tools and technologies associated with data science and how it supports business processes		**LO3 and LO4**
P5 Discuss how tools and technologies associated with data science are used to support business processes and inform decisions.	**M3** Assess the benefits of using data science to solve problems in real-world scenarios.	**D2** Evaluate the use of data science techniques against user and business requirements of an identified organisation.
LO4 Demonstrate the use of data science techniques to make recommendations to support real-world business problems		
P6 Design a data science solution to support decision making related to a real-world problem. **P7** Implement a data science solution to support decision making related to a real-world problem.	**M4** Make justified recommendations that support decision making related to a real-world problem.	

Recommended Resources

Textbooks

Boyer, J. (2010) *Business Intelligence Strategy*. MC Press (US).

Jeston, J. and Nelis, J. (2018) *Business Process Management*. 4th edn. 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 edn. John Wiley & Sons, Ltd.

VanderPlas, J. (2016) *Python Data Science Handbook: Tools and Techniques for Developers: Essential Tools for Working with Data*. O'Reilly.

Journals

International Journal of Business Intelligence and Data Mining

International Journal of Business Intelligence Research (IJBIR)

Web

gartner.com/en	Research and Advisory (General Reference)
datascience.codata.org	Data science (Online data science journal)

Links

This unit links to the following related units:

Unit 6: Planning a Computing Project (Pearson-set)

Unit 8: Data Analytics

Unit 33: Applied Analytical Models

Unit 34: Analytical Methods.

Unit 18: Discrete Maths

Unit code F/618/7429

Unit level 5

Credit value 15

Introduction

Digital computer technologies operate with distinct steps and data is stored 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 a computer science course and aids, ultimately, 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 task-based assessments, students will explore set theory and functions in a variety of scenarios, perform analysis using graph theory, apply Boolean algebra to applicable scenarios and, finally, explore additional concepts in 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 have gained confidence in the discrete mathematics that is needed to understand software engineering concepts. As a result, they will have developed 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 and surjective functions, and transitive relations

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 undirected 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. Production of 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 a Eulerian and Hamiltonian circuit exists in an undirected graph.	**D2** Construct a proof of the Five Color Theorem.

Pass	Merit	Distinction
LO3 Investigate solutions to problem situations using the application of Boolean algebra		
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.	**D3** Design a complex system using logic gates.
LO4 Explore applicable concepts within abstract algebra		
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.	**D4** Explore, with the aid of a prepared presentation, the application of group theory relevant to your given example.

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 14: Maths for Computing

Unit 33: Applied Analytical Models.

Unit 19: Data Structures & Algorithms

Unit code T/618/7430

Unit level 5

Credit value 15

Introduction

Knowing how 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 with data structures 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. Students are introduced to the specification of abstract data types and will explore their use in concrete data structures. Using 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, students 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, students will have developed 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 and conquer, branch and 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:

Apply algorithms, logic and 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.

Create logical and maintainable codes.

Testing and debugging:

Testing code to ensure it is secure and can handle user errors, identifying and creating test scenarios, applying structured techniques to problem solving, debugging code, understanding the structure of programmes to identify and resolve issues.

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 Specify the abstract data type for a software stack using an imperative definition.	**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 offering a justification for the view.

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. et al (1990) *Introduction to Algorithms*. MIT Press.

Cormen, T. et al (2002*) Instructor's Manual: Introduction to Algorithms.*
MIT Press.

Heineman, G. et al (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: Applied Programming and Design Principles

Unit 30: Applied Cryptography in the Cloud.

Unit 20: Applied Programming and Design Principles

Unit code	**T/618/4902**
Unit level	**5**
Credit value	**15**

Introduction

The advanced features of programming languages are used to develop software that is efficient, robust and can be mathematically proven to work. Well-designed code can positively impact the performance of an application as well as the readability and extensibility of the code, thereby improving productivity and reducing cost.

Effective object orientated programming (OOP) should have low coupling, high cohesion and strong encapsulation, which is something that the SOLID principles help to obtain. The idea is that by applying those principles together, it makes it easier to write better quality code with greater diversity and robustness. The system created becomes easy to maintain, to reuse and to extend over time. SOLID principles help software developers to achieve scalability and avoid creating code that breaks every time it needs a change. Clean coding maintains the readability of the programs produced by encouraging descriptive naming of objects and keeping to a single purpose model for each entity. Programming patterns work to ensure that designs produced are language independent, encapsulate ideas and are reusable in multiple circumstances.

The development of an application to process a large data set is a practical example of how to solve a problem that can be used in many different situations, can help deepen the understanding of OOP and help improve software design and reusability.

The aim of this unit is to familiarise students with these concepts and their best practices to ensure that their code is in line with industry standards. Among the topics included in this unit are object-orientated programming, introduction to design patterns and SOLID, including its version of five principles of object-oriented programming and automated software testing.

The unit is especially useful for those intending to move into computer science, software development, programming, systems analysis and software testing.

Learning Outcomes

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

LO1 Investigate the impact of SOLID development principles on the OOP paradigm

LO2 Design a large dataset processing application using SOLID principles and clean coding techniques

LO3 Build a data processing application based on a developed design

LO4 Perform automatic testing on a data processing application.

Essential Content

LO1 **Investigate the impact of SOLID development principles on the OOP paradigm**

Object-orientated programming (OOP) paradigm characteristics:

Understand the OO characteristics and their application in developing code, including encapsulation, polymorphism, constructors and destructors, sub-objects, abstraction, interface, method overriding and redefinition, templates and containers.

Object-orientated class relationships:

Understand the elements of the OO relationships, including generalisation and inheritance, realisation, dependency, aggregation and composition.

Design patterns:

Aims and benefits of reusable design patterns, e.g. general reusable solution, represent an idea and language independent.

Grouping of design patterns into creational, structural and behavioural groups.

Clean coding techniques:

Simple design, e.g. keeping configurable data at high levels, polymorphism, consistency in methods, meaningful variable and constant names and encapsulate boundary conditions.

Creating small functions by including single action, minimal parameters, descriptive names, comments to explain code and warn of consequences.

Structure source code to separate concepts vertically, declare variables close to usage and keep lines short.

Develop objects and data structures for one action so that they are small.

Understand why non-static methods are preferable to static methods.

Design tests to ensure they are readable, fast and independent.

Understand bad test design, e.g. rigid, fragile, immobile, complex, repetitive.

SOLID design principles:

Understand and apply the component parts of SOLID design principles to make software understandable, flexible and maintainable, including Single-responsibility principle, Open-closed principle, Liskov substitution principle, Interface segregation principle and Dependency inversion principle.

LO2 **Design a large dataset processing application using SOLID principles and clean coding techniques**

Large datasets (public domain):

Design of application that can accommodate pre-existing large (500+) datasets, e.g. list of members of parliament, register of members' interests (Commons and Lords), list of public domain films (e.g. in the USA), list of public domain books, list of public domain music.

Data structures:

Use of data structures in application development, e.g. stack, array, multi-dimensional array, set, queue, list and linked list.

Apply tree types, including active, passive and recursive.

Operations:

Use of operations in application development, e.g. hash functions and pointers.

Utilise sorts, e.g. insertion, quick, merge and heap.

Utilise searches, e.g. linear, binary tree and recursive.

LO3 **Build a data processing application based on a developed design**

Implementation:

Utilise an appropriate language and development tools, incorporate security and maintainability expectations.

Produce program code that implements a design based on SOLID principles, clean coding techniques and programming patterns.

Understand and interpret design features, meet requirements, input, output, processing security, portability and maintainability.

LO4 **Perform automatic testing on a data processing application**

Types of automatic testing:

Understand the uses of automation in setting up regression tests, data set up generation, product installation, GUI interaction, defect logging, unit testing and integration testing of main application.

Tool automation parameters:

Understand the meaning of data driven capabilities, debugging and logging capabilities, platform independence, extensibility and customisability, email notifications, version control friendly.

How automated testing features support unattended test runs.

Understanding of testing logic and updates code to make testing easier through the use of stubbing/patching.

Follow common testing frameworks and methodologies:

Understand the circumstances where different frameworks perform best, Data Driven Automation Framework, Keyword Driven Automation Framework, Modular Automation Framework and Hybrid Automation Framework.

Tools:

Investigate a range of tools that are commercially available.

Functional, e.g. QuickTest Professional (HP), Coded UI (Microsoft), Selenium, Open IT (open source).

Non-functional, e.g. LoadRunner (HP), JMeter (Apache), Burp Suite (PortSwigger).

Self-built testing tools:

Investigate the value of developer-designed and built tools to test features and functions of a specific application.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate the impact of SOLID development principles on the OOP paradigm		**LO1 and LO2**
P1 Investigate the characteristics of the object-orientated paradigm, including class relationships and SOLID principles. **P2** Explain how clean coding techniques can impact on the use of data structures and operations when writing algorithms.	**M1** Analyse, with examples, each of the creational, structural and behavioural design pattern types.	**D1** Evaluate the impact of SOLID development principles on object-orientated application development.
LO2 Design a large dataset processing application using SOLID principles and clean coding techniques		
P3 Design a large data set processing application, utilising SOLID principles, clean coding techniques and a design pattern. **P4** Design a suitable testing regime for the application, including provision for automated testing.	**M2** Refine the design to include multiple design patterns.	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Build a data processing application based on a developed design</td><td rowspan="4">LO3 and LO4

D2 Analyse the benefits and drawbacks of different forms of automatic testing of applications and software systems, with examples from the developed application.</td></tr>
<tr><td>P5 Build a large dataset processing application based on the design produced.</td><td>M3 Assess the effectiveness of using SOLID principles, clean coding techniques and programming patterns on the application developed.</td></tr>
<tr><td colspan="2">LO4 Perform automatic testing on a data processing application</td></tr>
<tr><td>P6 Examine the different methods of implementing automatic testing as designed in the test plan.

P7 Implement automatic testing of the developed application.</td><td>M4 Discuss the differences between developer-produced and vendor-provided automatic testing tools for applications and software systems.</td></tr>
</table>

Recommended Resources

Textbooks

CLARKE JILL, (2020) *Software Developer*, London: BCS

FISHPOOL B & FISHPOOL M, (2020) *Software Development in Practice*, BCS

FREEMAN E., FREEMAN E., SIERRA K., BATES B. (2004) *Head First Design Patterns*, London: O'Reilly

GAMMA E, HELM R, JOHNSON R, VLISSIDES J, (1994) *Design Patterns: elements of reusable object-oriented software*, Addison Wesley

MARTIN, RC, (2017) *Clean Architecture: A Craftsman's Guide to Software Structure and Design.* London Pearson, Addison Wesley

Web

academic.oup.com	*Oxford Academic*
	ITNow: British Computer Society (General Reference)
baeldung.com	Baeldung
	A Solid Guide to SOLID Principles (General Reference)
tutorialspoint.com	*Software Testing Dictionary* (General Reference)

Links

This unit links to the following related units:

Unit 1: Programming

Unit 7: Software Development Lifecycles

Unit 19: Data Structures and Algorithms

Unit 22: Application Development

Unit 24: Advanced Programming for Data Analysis.

Unit 21: Application Program Interfaces

Unit code	**L/618/7434**
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 one is taken and used to build on. 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 to 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 that are developed by the software author and which can provide services and functionality to other application developers without having to 'reinvent the wheel'. Existing APIs provide a huge range of functionality that 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 a proof-of-concept application that utilises existing APIs for common tasks, such as 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 in an application from a given scenario. They will also be able to test and document the results 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 the role of an API and its suitability for a given scenario

LO2 Design a solution that extends an existing application using relevant APIs for a given scenario

LO3 Implement an application in a suitable development environment based on a designed solution

LO4 Test an API developed for a given scenario to determine security vulnerabilities.

Essential Content

LO1 Examine the role of an API and its suitability for a given scenario

Principles and uses 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.

Evaluate suitable APIs for use in an application (web/mobile/desktop) for a given scenario.

Examine security issues of APIs, e.g. inefficient coding, inadequate authentication and authorisation.

LO2 Design a solution that extends an existing application using relevant APIs for a given scenario

Design of APIs:

Investigate an existing application and identify ways that it could be extended, e.g. adding social media integration, linking to a webstore/payment handling; integrating stock control/stock levels with webstore, reactive layouts for different platforms.

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 based on a designed solution

Utilise appropriate tools and techniques to develop an API solution:

Select suitable implementation processes to understanding the stages involved in development of APIs.

Consider the use of a suitable development environment.

Utilise tools and features available in a range of development environments for developing code and integrating APIs.

Utilise best practices for implementing the API.

LO4 **Test an API developed for a given scenario to determine security vulnerabilities**

Testing and evaluation:

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

Apply structural testing techniques.

Apply common functional testing techniques to derive test conditions and test cases, e.g. Equivalence Partitioning, Boundary Value Analysis, Decision Table Testing and State Transition Testing.

Reflect on the application development process, including identifying the chosen API's strengths, weaknesses, security concerns, ease of use and access to features within it.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the role of an API and its suitability for a given scenario		**D1** Evaluate a selected API for a given scenario, including potential security issues.
P1 Examine the relationship between an API and a software development kit (SDK). **P2** Review a range of APIs for different platforms.	**M1** Assess a range of APIs that covers a variety of uses, suitable for a given scenario.	
LO2 Design a solution that extends an existing application using relevant APIs for a given scenario		**D2** Critically review the designed solution to inform improvements, including utilising a range of APIs.
P3 Investigate an existing application that could be extended with a suitable API.	**M2** Design a solution that extends the existing application using an API for a given purpose.	
LO3 Implement an application in a suitable development environment based on a designed solution		**LO3 and LO4** **D3** Evaluate the APIs used in the application developed, based on the test results, including a data security report of the application.
P4 Build on an existing application framework to implement an API.	**M3** Refine an application framework, utilising multiple APIs based on a designed solution.	
LO4 Test an API developed for a given scenario to determine security vulnerabilities		
P5 Conduct structural and functional testing of the application, recording the results.	**M4** Refine the application based on the results of testing.	

Recommended Resources

Textbooks

Guinard, D. D. Trifa, V. M. (2016) *Building the Web of Things*. Manning Publications.

Pandian, P. (2018) *Building Node.js REST API with TDD Approach*. Independently published.

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

Web

www.developers.google.com	Google Developers (Development Tool)
www.khronos.org	The Khronos Group Inc.
	Vulkan API (Development Tool)
www.outsystems.com	OutSystems – developer community, tools and knowledge bases (Development Tool)

Links

This unit links to the following related units:

Unit 7: Software Development Lifecycles

Unit 22: Application Development.

Unit 22: Application Development

Unit code Y/618/7436

Unit level 5

Credit value 15

Introduction

Application development is a process of planning, creating, testing, and deploying an information system. Often applications are developed to automate a process, build a product to address business need or to get ahead of the competition by being innovative. Professionalism and critical thinking supported by an ability to work independently and as part of a team are core skills for a developer.

This unit introduces students to application development. It 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.

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; 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. They will be able to select and use design and development methodologies, with tools and techniques associated with the creation of a business application. They will also be able to 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, 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 Produce a software design document for a business-related problem based on requirements

LO2 Research design and development tools and methodologies for the creation of a business application

LO3 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 for a business-related problem based on requirements**

Business-related problem and solutions:

Problem definition statement including highlighting and describing the issues that need to be addressed.

Consider possible business application solutions which address problem.

Predict the overall success of the application.

Produce a software design document:

Proposed solution including relevant details on requirements, system analysis, system design, coding, testing and implementation.

The value of software design documents with regard to application development.

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

LO2 **Research design and development tools and methodologies for the creation of a business application**

Discuss different design and development methodologies:

Consider current design and development methodologies e.g. Agile, DevOps, Rapid Application Development (RAD), Waterfall

Strengths and weaknesses commonly associated with each methodology.

Security implications of design and development methodologies.

Selection of a design and development methodology for use with the creation of a proposed application development.

Use appropriate tools and techniques:

Different tools and techniques available to create a business application.

Advantages and disadvantages of your preferred or selected tools and techniques.

LO3 **Plan and produce a functional business application with support documentation**

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

Peer review a development plan.

Interpret and implement a given design whist remaining compliant with security and maintainability requirements.

Communicate and defend effectively the ideas in a software design document.

Discuss differences with regards to the possible strengths and weakness of each software design document.

Modify software design document to reflect any new insights or considerations.

Prepare and produce a functional business application:

Use a software design document with a preferred design and development methodology and selected tools and techniques.

Functional business application including data set for testing.

Apply appropriate algorithms, logic and data structures as required in the development of an application.

Build, manage and deploy code for the business application into a relevant environment and link code to data sets.

Create and quality check appropriate support documents for an application.

LO4 **Evaluate the performance of a business application against its software design document and initial requirements**

Assess the performance of a business application:

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

Review of the performance and development of a developed application against all identified factors and any adopted design and development methodologies.

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

Plan improvements to a business application:

Strengths and weaknesses of a business application against its software design document and initial requirements.

Detailed planning of possible revisions (including implementation) in terms of improving application's performance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Produce a software design document for a business-related problem based on requirements		**LO1 and LO2**
P1 Produce a well-defined problem definition statement, supported by a set of user and system requirements for a business problem. **P2** Review areas of risk related to the successful development of a proposed application.	**M1** Analyse a business-related problem using appropriate methods to produce a well-structured software design document.	**D1** Evaluate the solution to a business-related problem and the preferred software development methodology by comparing the various software development tools and techniques researched.
LO2 Research design and development tools and methodologies for the creation of a business application		
P3 Research the use of software development tools and techniques for the development of a proposed application.	**M2** Justify the software development tools and development methodology selected.	

Pass	Merit	Distinction
LO3 Plan and produce a functional business application with support documentation		**LO3 and LO4**
P4 Conduct a peer review of the problem definition statement, proposed solution and development strategy, documenting any feedback given. **P5** Develop a functional business application with support documentation based on a specified business problem.	**M3** Interpret 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** Justify improvements to the business application system made because of feedback and also feedback which was not acted upon, including opportunities for improvement and further development.
LO4 Evaluate the performance of a business application against its software design document and initial requirements		
P6 Review the performance of the business application against the problem definition statement and initial requirements.	**M5** Critically review the design, development and testing stages of the application development process including risks.	

Recommended Resources

Textbooks

Cormen, 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: Planning a Computing Project (Pearson-set)

Unit 7: Software Development Lifecycles.

Unit 23: Risk Analysis & Systems Testing

Unit code **D/618/7437**

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 give students the knowledge and skills they need to use risk-based testing (RBT), using a medium-sized application, developing a full and detailed RBT procedure and documenting the results. Students 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 to 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 of studying this unit, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

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:

Understand 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 and criticality, develop risk weighted matrix, develop risk quality matrix, assess risk reduction methods, detail project risks, identify methods of reporting progress.

The principles underpinning the psychology of testing, including required mindset and development mindset difference, how this can influence success of software testing activities.

LO2 Create a customised risk-based test strategy, plans and techniques for a given specification

Risk-based test strategy planning:

Identify and create test scenarios including identification of typical security vulnerabilities to be addressed by different types of testing e.g. penetration testing for known or unknown software flaws.

Develop test risk matrix with selection of risk-based tests, considering latest knowledge of technological developments in software testing.

Classification of tools to support testing.

Develop risk test plan and build environment rollout plan including functional testing, structural testing, automated testing as part of the systems development lifecycle and regression testing, sub-system integration (use-case, whole system, interface).

Maintenance following changes or reviews, after length of time or stress/overload.

User evaluation, including analysis of requirements, actual outcomes, acceptance, alpha, beta.

Ensuring requirements traceability.

Testing plan:

Examine test cycles, prioritising security testing.

Example test data, including normal, erroneous and extreme.

Define expected outcomes, including valid, invalid and information gained, reporting of risk.

Understand the difference between error, defect and failure, including the distinction between the root cause of a defect and its effects.

Analyse test coverage and follow up, fault density analysis.

Choose appropriate testing methods, e.g. static testing, change related, sequential, iterative and suitable metrics for the defect management process.

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.

Techniques:

Apply static testing techniques, e.g. review, static analysis visual evaluation.

Functional testing, e.g. control flow, data flow.

Structural testing, e.g. boundary value, branch condition, validation, verification.

Apply a regression strategy, including selection of tests, maintenance of regression suites and identifying tests suitable for automation.

Understand the importance of defect management, using defect tracking tools.

LO3 **Demonstrate a risk-based Test Plan, producing associated outcomes**

Outcomes:

Follow software testing frameworks and methodologies including conforming to appropriate industry standards e.g. GDPR, health informatics, safety critical.

Test code and analyse results to correct errors found using unit testing.

Review code coverage results and analysis, analyse cause defects, check fault density results.

Conduct a range of test types, e.g. integration, system, user acceptance, non-functional, performance and security testing.

Review actual results against expected results, e.g. valid information or action, invalid information, or action, system-generated messages, program-generated messages.

Modifications:

Prioritisation of further test cycles, including changes to specification, changes to analysis, design, amendments to code written, modifications to risk test strategy and plan, create risk reduction reports.

Links between the testing and software development lifecycles (sequential and iterative), the role of testing in continuous development and integration, the importance of regression testing, approaches to defect tracking and version control.

LO4 **Evaluate a risk-based Test Plan and its associated outcomes**

Evaluation:

Evaluation to include developing risk heuristics evaluation criteria (probability, severity, classification), identifying risk-based testing benefits and drawbacks, defining 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.

Create analysis artefacts, such as use cases and/or user stories.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine risk-based testing and requirements		**LO1 and LO2**
P1 Investigate the testing stages involved in relation to a risk-based testing model and the key information to be communicated post testing. **P2** Discuss the type of risks involved in systems testing in relation to the given specification.	**M1** Analyse the advantages and disadvantages of applying risk-based testing by comparing two risk-based test strategies.	**D1** Justify test strategy and selection of test cases, based on quantified risk for a given specification.
LO2 Create a customised, risk-based test strategy, plans and techniques for a given specification		
P3 Create 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.	**M2** Develop a test risk matrix, showing how the risks were evaluated. **M3** 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 including how prioritisation of test cycles can improve testing
P5 Perform the tests identified in the risk-based Test Plan, providing a detailed log of all test results and modifications made.	**M4** Justify the modifications made at each stage of the risk-based test procedure.	
LO4 Evaluate a risk-based Test Plan and its associated outcomes		**D3** Report on how test risk heuristics are identified, evaluated and monitored in a risk-based test strategy, providing justification.
P6 Discuss the effectiveness of the risk-based test strategy, including an assessment of security testing cycles.	**M5** Propose a strategy for designing and building an improved risk-based test environment based on the lessons learned.	

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 unit:

Unit 7: Software Development Lifecycles.

Unit 24: Advanced Programming for Data Analysis

Unit code **H/618/5723**

Unit level **5**

Credit value **15**

Introduction

The world of programming and software engineering is vast and includes many occupational pathways to pursue. Most areas of modern computing involve some form of data analysis. These range from enhanced reality development through to robotic control and communication systems, to medical imaging machines. All of these require significant management of data but the area with the most common requirements is in data analysis and manipulation for business intelligence. An analyst’s role is becoming increasingly complex. Experienced analysts use modelling and predictive analytics techniques to generate useful insights and actions, which they present to interested parties and decision makers in an appropriate, clearly understood way.

This unit is designed to develop the skills required to become a skilled data analyst. It includes investigation of a range of different programming languages, aimed at both data analytics and general use, good development guidelines and the design, development and testing of a sizeable tool to analyse and utilise a large data set.

These skills are especially relevant to today’s data analyst, data scientist, social researcher, market researcher and others who utilise large data sets in their work.

Learning Outcomes

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

LO1 Explore the tools a programmer can use to manipulate large data sets for data analysis

LO2 Design a software tool to analyse a large data set for a given scenario

LO3 Develop a software tool to analyse a large data set for a given scenario

LO4 Test a software tool used to analyse a large data set for quality of information produced.

Essential Content

LO1 **Explore the tools a programmer can use to manipulate large data sets for data analysis**

Data analysis languages:

Explore data analysis languages, e.g. R, SAS, SQL, Julia, Matlab.

General programming languages:

Explore general programming languages: C++, C, C#, Java, F#, Visual Basic, Python.

Identify interaction methods, R.Net, linking at runtime, direct manipulation of objects.

Proposal:

What dataset will be used, the language to be used, what outcomes are to be achieved and the method of interrogating and analysing the dataset.

Good coding techniques:

Simple design, e.g. keeping configurable data at high levels, consistency in methods, meaningful variable and constant name.

Create small functions and procedures by including single action, minimal parameters, descriptive names, comments to explain code functions and variables clearly.

Structure source code logically, declare local variables close to usage and keep lines short. Keep global variables together with comments on function and where used.

Develop objects and data structures for one action so that they are small.

Design tests to ensure they are readable, effective and test boundary conditions too.

Understand bad test design, e.g. over complex, repetitive, miss conditions.

Large datasets:

Investigate the availability of large public domain and other datasets suitable for use with your software tool, data.NASA.gov, data.gov.uk, etc.

LO2 **Design a software tool to analyse a large data set for a given scenario**

Software design:

Design to include details of acquisition, cleaning and analysis of digital data.

Dataset operations:

Use of operations in application development, e.g. hash functions and pointers, sorts, e.g. insertion, quick, merge and heap, searches, e.g. linear, binary tree and recursive. acquisition, cleaning and analysis of digital data.

Data analysis methods:

Apply an appropriate range of data analysis methods.

Qualitative methods, e.g. content analysis.

Quantitative analysis methods e.g. standard deviation, frequency, range and average and hypothesis testing and descriptive analysis.

Specific descriptive analysis techniques e.g. regression analysis, factor analysis, dispersion analysis, discriminant analysis and time series analysis.

LO3 **Develop a software tool to analyse a large data set for a given scenario**

Implementation:

Utilise an appropriate language and development tools.

Produce good quality program code that implements a design for a data analysis software tool.

LO4 **Test a software tool used to analyse a large data set for quality of information produced**

Types of testing:

Understand the uses of unit testing and integration testing of main application.

Understand the meaning of data driven capabilities, debugging and logging capabilities, platform independence, extensibility and customisability, email notifications, version control friendly.

Assessing effectiveness of the data analysis:

Evaluate how effective the data analysis tool is, e.g. level of detail, accuracy, validity, execution and clarity of outcomes.

Present results:

Methods, summary, e.g. charts, histogram, frequency polygon, imaginative use of diagrams, narrative, interpretation, tables, interpretation.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explore the tools a programmer can use to manipulate large data sets for data analysis</td><td rowspan="4">LO1 and LO2

D1 Analyse the ways code written in different programming languages can be linked and called at run time to extend functionality of computationally intensive tasks and manipulate data analysis objects directly.</td></tr>
<tr><td>P1 Investigate the functions of a data analysis language.

P2 Prepare a proposal for analysing a large dataset, including the method of analysis and the outcomes to be achieved.</td><td>M1 Examine the ways that general programming languages can interact with a data analysis language.</td></tr>
<tr><td colspan="2">LO2 Design a software tool to analyse a large data set for a given scenario</td></tr>
<tr><td>P3 Design a software tool to carry out a specific analysis on a chosen large dataset.

P4 Create a detailed test plan for a software tool, identifying expected outcomes of the analysis.</td><td>M2 Apply program code from both a general programming language and a data analysis-based language in designing the software tool.</td></tr>
<tr><td colspan="2">LO3 Develop a software tool to analyse a large data set for a given scenario</td><td rowspan="4">LO3 and LO4

D2 Analyse the output of the data analysis process with focus on the quality of information produced from the dataset and identify possible improvements.</td></tr>
<tr><td>P5 Build a software tool for analysing a large dataset according to a developed design.</td><td>M3 Modify the program to include code from both a general programming language and a data analysis-based language in building the software tool.</td></tr>
<tr><td colspan="2">LO4 Test a software tool used to analyse a large data set for quality of information produced</td></tr>
<tr><td>P6 Implement a detailed test plan on a data analysis software tool.

P7 Present the results of the analysis on the chosen data set.</td><td>M4 Review the outcomes, utilising the software tool and the results of testing.</td></tr>
</table>

Recommended resources

Textbooks

Clarke, J. (2020) *Software Developer*, BCS.

Fishpool, B. & Fishpool, M. (2020) *Software Development in Practice*, BCS.

Martin, R. C. (2017*) Clean Architecture: A Craftsman's Guide to Software Structure and Design.* London Pearson, Addison-Wesley.

Journal

academic.oup.com	*Oxford Academic*
	ITNOW: British Computer Society (General Reference)

Web

data.nasa.gov	NASA public domain datasets (General Reference)
github.com/niderhoff/nlp-datasets	Alphabetical list of free/public datasets (General Reference)
smartdatacollective.com	Big data sources – public domain datasets (General Reference)
tutorialspoint.com	Software Testing Dictionary (General Reference)

Links

This unit links to the following related units:

Unit 1: Programming

Unit 8: Data Analytics

Unit 20: Applied Programming and Design Principles

Unit 22: Application Development

Unit 26: Big Data Analytics and Visualisation.

Unit 25: Machine Learning

Unit code	**H/618/7438**
Unit level	**5**
Credit value	**15**

Introduction

Machine learning is the science of getting computers that have 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 many more.

This unit introduces students to the basic theory of machine learning, the most efficient machine learning algorithms and practical implementation of these algorithms. Students will gain hands-on experience of 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 neighbor, support vector machine etc.).

On successful completion of this unit, students will understand the concept of machine learning and machine learning algorithms. They will have gained 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, Microsoft AzureML. 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

What machine learning is:

Definitions of machine learning.

Core terminologies of machine learning.

Types of learning problems:

Classification, regression, optimisation, clustering.

How machine learning works, including 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 neighbor, 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 etc.).

Data preparation:

Separate the data as training sets and testing set in order to better expose 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.

Underfitting situations: underfitting happens when a model is too simplistic, usually with less data and is unable to establish an accurate relationship of the variables, causing a high error rate on training and new data.

Overfitting 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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Analyse the theoretical foundation of machine learning to determine how an intelligent machine works</td><td rowspan="4">LO1 and LO2

D1 Critically evaluate why machine learning is essential to the design of intelligent machines.</td></tr>
<tr><td>P1 Analyse the types of learning problems.

P2 Demonstrate the taxonomy of machine learning algorithms.</td><td>M1 Evaluate the category of machine learning algorithms with appropriate examples.</td></tr>
<tr><td colspan="2">LO2 Investigate the most popular and efficient machine learning algorithms used in industry</td></tr>
<tr><td>P3 Investigate a range of machine learning algorithms and how these algorithms solve learning problems.

P4 Demonstrate the efficiency of these algorithms by implementing them using an appropriate programming language or machine learning tool.</td><td>M2 Analyse these algorithms using an appropriate example to determine their power.</td></tr>
</table>

Pass	Merit	Distinction
LO3 Develop a machine learning application using an appropriate programming language or machine learning tool for solving a real-world problem		**LO3 and LO4**
P5 Prepare training and test data sets in order to implement a machine learning solution for an appropriate learning problem. **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 stage of this activity.	**D2** Critically evaluate the implemented learning solution and its effectiveness in meeting end user requirements.
LO4 Evaluate the outcome or the result of the application to determine the effectiveness of the learning algorithm used in the application		
P7 Discuss whether the result is balanced, underfitting or overfitting. **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 edn. Wiley.

Flach, P. (2012) *Machine Learning: The Art and Science of Algorithms that Make Sense of Data.* 1st edn. Cambridge: Cambridge University Press.

Kirk, M. (2014) *Thoughtful Machine Learning: A Test-Driven Approach*. O'Reilly Media.

Web

archive.ics.uci.edu/ml	University of California, Irvine Machine Learning Repository (Data sets)
azure.microsoft.com	Microsoft Azure (Development Tool)
accord-framework.net	Accord.NET Framework (Development Tool)
codechef.com	CodeChef educational initiative List of Compilers (Wiki)
cran.r-project.org	The R Project for Statistical Computing R Archive Network (Development Tool)
cs.waikato.ac.nz	University of Waikato – Machine Learning Group Data Mining Software in Java (Development Tool)
julialang.org	Julia Programming Language (Development Tool)
knime.org	Konstanz Information Miner – KNIME (Development Tool)
lfd.uci.edu	University of California, Irvine – Laboratory for Fluorescence Dynamics Binaries for Python Extension Packages (Development Tool)

Links

This unit links to the following related units:

Unit 15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems

Unit 46: Robotics.

Unit 26: Big Data Analytics and Visualisation

Unit code	**F/618/5664**
Unit level	**5**
Credit value	**15**

Introduction

Raw data can be complicated, confusing and a challenge to understand. But when raw data is organised and structured properly it can reveal patterns and information that can be very powerful in business decision making. Without the ability to organise and visualise data, key information would otherwise remain hidden in raw data. Once a business can understand historic patterns of data sets this information can help predict future trends and behaviours.

Data and visualisation is an area which has seen rapid advancement and there has been considerable challenges for data specialists to develop the skills, experience and growth required to maintain innovation in the sector. As data continues to be the fuel for the digital economy, this area remains a constant topic of conversation for organisations, governments and the public who share an interest in its growing commercial use, manipulation, and presentation.

This unit introduces students to the concepts of big data and visualisation and how this is used for decision making. It explores the industry software solutions available to investigate and present data, before assessing the role and responsibility of data specialists in this current environment. Topics including data driven decision-making, manipulating data and automation, and building ethics into a data-driven culture are examined. Students will demonstrate their use of tools and software to manipulate and prepare a visual presentation for a given data set. They will also assess how data specialists are responsible for adhering to legislation and ensuring data compliance.

On successful completion of this unit students will be able to investigate the value of data for decision making to both end users and organisations, compare how different industry leading tools and software solutions are used to analyse and visualise data, carry-out queries to summarise and group a given data set and analyse the challenges faced when building ethics into a data-driven culture. Students will have the opportunity to progress to a range of roles within the digital sector, and will develop industry-led skills, analysis, and interpretation, which are crucial for developing practical experiences with big data and gaining employment.

Learning Outcomes

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

LO1 Examine data visualisation for decision making of complex data sets

LO2 Discuss statistical and graphical tools and techniques used to present big data for a given use case

LO3 Demonstrate statistical and graphical techniques used to present big data as a visualisation

LO4 Investigate the challenges faced by data professionals in carrying out their role.

Essential Content

LO1 **Examine data visualisation for decision making of complex data sets**

Big Data:

Explore common fundamental concepts e.g. Bayesian classification, rule-based classification, The 'Vs' of big data (Volume, Velocity, Variety, Variability, Veracity, Visualization, and Value).

Big data lifecycle to include purpose, capturing data, searching and filtering, retrieving data for processing, combining multiple data sources, validation and cleansing, visualisation, analysis and querying, utilisation and storage, obsolete and deleted data.

Visualisation:

Identify the target audience needs, e.g. context, reporting, dissemination, accessibility, breadth of data, depth of analysis.

Explain the phases of data visualisation design process to include formulating the brief, working with data, establishing editorial thinking and developing design solution.

Apply principles of good design to data visualisation e.g. Dieter Rams' Ten Principles for Good Design, Gestalt principles of visual perception and Pareto Chart.

Evaluate effective visual elements e.g. charts, graphs, plots, tables, points, lines, bars, area, maps, narratives, metaphors, symbols and aesthetics e.g. position, size, shape, colour and transparency.

Data for decision making:

Explore processes of data driven decision making (DDDM) e.g. define objective, establish hypothesis, identify data need, build data process, sampling methods, collect data, analyse data, interpret results and make decision.

The role of the Data Analysis Lifecycle as part of DDDM (e.g. Discovery, Data preparation, Model Planning, Model Building, Operationalise, Communicate results).

Discuss the advantages of data driven decision-making e.g. continuous improvement and planning, collaborative decisions, reduce costs, real-time insights and new opportunities, digital literacy and data-driven cultures.

Challenges e.g. inconsistent and unstandardised data, aligning decision making with business strategy, bias and discrimination, descriptive vs. predictive trends and probabilities.

LO2 **Discuss statistical and graphical tools and techniques used to present big data for a given use case**

Statistical and graphical techniques for big data analysis and visualisation:

Analyse and apply big data analytics techniques taking account of different data structures and database designs e.g. descriptive, prescriptive, diagnostic and predictive analytics.

Apply principles of mathematics and statistics for analysing data sets.

Explore the various kinds of analysis techniques e.g. anomaly detection, cluster, association by rule, classification and regression analysis.

Examine how to organise semi-structured and unstructured data variety e.g. word-cloud visuals, data catalogue, taxonomies and ontologies.

Forecasting estimates of future values e.g. applied forecasting and decision tree algorithms.

Industry leading tools and software solutions to analyse data:

Apply tools to analyse data e.g. programming or scripting languages such as Python or R and associated libraries, Application Programming Interfaces (APIs).

Industry leading tools and software solutions to visualise data:

Apply leading tools to a solution e.g. Microsoft Excel, Tableau, PowerBI and Azure, AWS, Oracle Visual Analyzer, Qlikview, Canvas, SAS Visual Analytics.

Explore how user experience and domain context influences approaches to data analytics and visualisation.

LO3 **Demonstrate statistical and graphical techniques used to present big data as a visualisation**

Manipulating data:

Construct activities using industry software to manipulate data e.g. importing datasets, data cleansing, data frame manipulation, testing and training a model, summarising analysis process and steps taken.

Apply query basics e.g. reports, calculate aggregate statistics, use built-in functions summarising and grouping data.

Explore advanced data manipulation and automation concepts e.g. generalised linear models and regression, multilevel modelling and techniques, data pipelines, machine learning and deep reinforcement learning (DRL).

Prepare visual presentations:

Visual presentations to include using insight analysis to understand data in context, selecting visual elements and aesthetic design e.g. find and filter content in dashboards, view and export data from dashboards to create report, presentation or infographic.

Data set requirements:

Understanding the data and its context including summary of data collection, sampling procedures and data type; stakeholder requirements, interests and needs.

LO4 **Investigate the challenges faced by data professionals in carrying out their role**

Roles and responsibilities:

Explain roles in a data-driven industry e.g. data analyst, data scientist, data engineer, visualisation specialist, data administrator, business analyst, middle-managers and senior management teams.

Explore the responsibilities of a data specialist e.g. preparing, analysing, modelling, managing and visualising data, and storage and access rights.

Strategies to ensure data compliance:

Explain organisational data architecture, policies, standards and rules e.g. how data is stored, managed, used and disseminated.

Assess data protection, informed consent and privacy issues for compliance e.g. personally identifiable information, protected health information, General Data Protection Regulation (GDPR) rights obligations, enforcement and regulatory legal penalties.

Explore and select the most appropriate industry compliance management software tools e.g. Microsoft Compliance Manager, AWS Compliance, IBM DataOps.

Identify and escalate quality risks in data analysis with suggested mitigation or resolutions as appropriate.

Challenges for data specialists:

Understand challenges such as applying data governance framework to ensure value of outcomes, accountability, trust, collaboration, transparency, risks and security, and role of the data steward.

Explain how to guard from poor practice e.g. cherry picking, disclosure of assumptions, conflict of interest, bias from single view and/or choice of technique.

Risks and challenges to combing data from different sources in data analysis activity.

Develop ethics into a data-driven culture and joining community of good practice e.g. Data for Good Exchange (D4GX); Fairness, Accountability and Transparency in Machine Learning group (FAT/ML), Data Ethics Framework (gov.uk).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine data visualisation for decision making of complex data sets		
P1 Explain the fundamental concepts of big data and its value in decision making for end users and organisations. **P2** Examine the processes of data driven decision making (DDDM) when using complex data sets.	**M1** Discuss the advantages and challenges to an organisation of using complex data sets for decision making.	**D1** Predict the potential impact of using complex data sets on both users and organisations for decision making.
LO2 Discuss statistical and graphical tools and techniques used to present big data for a given use case		**LO2 and LO3**
P3 Discuss statistical and graphical tools and techniques used in industry for big data manipulation and visualisation.	**M2** Assess the suitability of industry leading tools and software solutions for analysing and visualising data for the given use case.	**D2** Evaluate how well the chosen data preparation and manipulation methods, the tools selected, and the data derived will impact on business decision making for the given use case.
LO3 Demonstrate statistical and graphical techniques used to present big data as a visualisation.		
P4 Demonstrate the use of data manipulation and automation to present a visualisation for a given user case.	**M3** Interpret the findings derived from the data manipulation to support conclusions made.	
LO4 Investigate the challenges faced by data professionals in carrying out their role.		
P5 Investigate the different roles, responsibilities and key issues faced by data specialists in their day-to-day role.	**M4** Review the different strategies used by data specialists to ensure data compliance.	**D3** Evaluate the impact of the key issues faced by data specialists when working in a data-driven culture.

Recommended resources

Textbooks

DIETEL, P. (2020) *Intro to Python for Computer Science and Data Science: Learning to Program with AI, Big Data and The Cloud*. London: Pearson.

FRANKS, B. (2020) *97 Things About Ethics Everyone in Data Science Should Know*. USA: O'Reilly Media.

GRAESSER, L. and KENG, W.L. (2020) *Foundations of Deep Reinforcement Learning: Theory and Practice in Python*. London: Addison-Wesley Professional.

KIRK, A. (2019) *Data Visualisation: A Handbook for Data Driven Design*. London: Sage Publications.

KNAFLIC, C. N. (2015) *Storytelling with Data: A Data Visualization Guide for Business Professionals*. USA: John Wiley & Sons.

LOUKIDES, M., MASON, H. and PATIL, D.J. (2018) *Ethics and Data Science*. USA: O'Reilly Media.

MARR, B. (2017) *Data Strategy: How to Profit from a World of Big Data, Analytics and the Internet of Things*. London: Kogan Page.

McCORMICK, K., and SALCEDO, J. (2017) *SPSS Statistics for Data Analysis and Visualization*. USA: John Wiley & Sons.

ROSS, J. (2019) *Data Science Foundations Tools and Techniques: Core Skills for Quantitative Analysis with R and Git.* London: Addison-Wesley Professional.

VIESCAS, J.L. (2018) *SQL Queries for Mere Mortals: A Hands-On Guide to Data Manipulation in SQL.* 4th edn. London: Addison-Wesley Professional.

WILKE, C.O. (2019) *Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures.* USA: O'Reilly Media.

Journals

Big Data & Society, Online

Journal of Data Science, Statistics and Visualisation, Online

Journal of Big Data, Online

International Journal of Computer Applications, Online

Web

ukdataservice.ac.uk	UK Data Service (General Reference)
gov.uk	UK Government (Data Ethics Framework)

Links

This unit links to the following related units:

Unit 4: Database Design and Development

Unit 8: Data Analytics

Unit 24: Advanced Programming for Data Analysis

Unit 33: Applied Analytical Models.

Unit 27: Transport Network Design

Unit code **K/618/7439**

Unit level **5**

Credit value **15**

Introduction

The exponential growth of the World Wide Web has put unprecedented demand on private and public networking infrastructures. The traffic generated by private and commercial networks has become dominated by Voice over Internet Protocol (VoIP) and video on demand. These developments require existing infrastructures to be adapted, that the design of new networks mitigates best-effort delivery issues, avoiding low bandwidths and high latency problems, and that they are based on traffic priority. For enterprise networks and internet infrastructures to meet expected demand, 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 (ISP) 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 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, students will apply network design principles to the design and implementation of redundant networks to provide Layer 2 and Layer 3 redundant solutions. Students are expected to evaluate Wide Area Network (WAN) technologies and make choices based on specific enterprise requirements. They will implement a range of WAN connections and protocols, such as Point-to-Point (PPP), Frame Relay and Virtual Private Network (VPN) with Internet Protocol Security (IPSec), using network simulators or network lab equipment. 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, Local Area Network (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, 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 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).

Explore the characteristics and functions of routing protocols, e.g. OSPF (open shortest path first), RIPng (Routing Information Protocol next generation).

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 of modularity, stackability, port density, subnets, static and dynamic routes, switch forwarding, multi-layer switching and router requirements in the selection process.

Configuring LAN devices:

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

Describe the concepts related to VLAN.

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, e.g. OSPFv3 (open shortest path first V3), RIPng (RIP New Generation), stateless address auto-configuration.

Configuring, managing and verifying interior routing protocols, e.g. OSPF, RIP.

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 algorithms, latency, QoS models, 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.

Investigate the need for and methods of performing IOS upgrades to a router.

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 including Syslog, Network Time Protocol (NTP), NetFlow and Simple Network Management Protocol (SNMP).

Network troubleshooting including establishing network baselines, optimising network performance troubleshooting methods with a systematic approach, e.g. root cause analysis, 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 (ACL), denying and allowing errors, ACL misconfigurations, Network Address Translation (NAT), Domain Name System (DNS) and Dynamic Host Configuration Protocol (DHCP) related issues.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explore LAN design principles and their application in the network design process</td><td rowspan="4">LO1 and LO2

D1 Evaluate different implementations of link aggregation, using EtherChannel to solve bandwidth and load issues.</td></tr>
<tr><td>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.</td><td>M1 Analyse the switch and router redundancy protocols and their effectiveness in supporting scalable networks.</td></tr>
<tr><td colspan="2">LO2 Implement a network using LAN design principles based on a predefined set of requirements</td></tr>
<tr><td>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.</td><td>M2 Analyse different switch redundancy protocols and their effectiveness in solving redundancy issues.

M3 Analyse Layer 3 redundancy implementations for IPv4 and IPv6.</td></tr>
</table>

Pass	Merit	Distinction
LO3 Produce an appropriate WAN solution to a set of organisational requirements		**LO3 and LO4**
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** Analyse features and benefits of different VPN types based on organisational needs.	**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,* 4th edn*.* 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.

Web

www.cisco.com	Cisco International networking company (General Reference)
www.ncsc.gov.uk	National Cyber Security Centre (General Reference)
www.sciencedirect.com	ScienceDirect online science journal Computer science section (General Reference)

Links

This unit links to the following related units:

Unit 2: Networking

Unit 9: Computer Systems Architecture

Unit 29: Network Security

Unit 39: Network Management

Unit 40: Client/Server Computing Systems.

Unit 28: Cloud Computing

Unit code	**K/618/7442**
Unit level	**5**
Credit value	**15**

This unit is aligned to the Microsoft Azure Fundamentals Certification. See section 3.1.4 for guidance on claiming certification.

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 that it uses the internet to deliver data and other IT services such as storage, printing, server facilities. In other words, end users and 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. This 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 they would be managed by the cloud service provider. Cloud computing is a natural evolution of networking and is adapting modern network-oriented technologies such as virtualisation, service-oriented architecture, utility computing and ubiquitous computing.

This unit is designed to develop understanding of the fundamental concept of cloud computing, cloud segments and cloud deployment models and the need for cloud computing. Students will gain appreciation of issues associated with managing cloud service architecture and 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. They will have hands-on experience of configuring a cloud service from major providers such as ECM, Google, Amazon, Microsoft and IBM and of 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 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:

Definition and history of cloud computing, principles of cloud computing, cloud ecosystem, cloud architecture and infrastructure, virtualisation, network connectivity, managing the cloud, application migration to the cloud.

Explore storage virtualisation, including storage architecture for virtualisation; physical disk types and related techniques; difference between centralised and distributed storage, virtualised and non-virtualised storage features, difference between capex and opex, methods for planning and managing costs and Service Level Agreements (SLAs).

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:

Infrastructure as a service (IaaS) a form of cloud computing providing virtualised computing resources over the internet.

Platform as a service (PaaS), providing a complete development and deployment environment.

Software as a service (SaaS), offering users access to a vendor's cloud-based software.

Analytics as a service (AaaS), offering provision of analytics software and operations through web-delivered technologies.

Cloud computing use cases.

Technological drivers:

Service-oriented Architecture (SOA), virtualisation and cloud computing, multicore technology, memory and storage technology, networking technology, Web 2.0, & 3.0, software process models for cloud, programming models, pervasive computing, application environment.

Explore architecture and components used for virtualisation, and traffic flows between VMs.

LO3 **Develop cloud computing solutions using service provider frameworks and open source tools**

Cloud Service Providers (CSPs):

Explore the features of different cloud service providers and virtualisation software, e.g. Microsoft, EMC, Google, Amazon Web Services, IBM, VMware, KVM, FusionCompute.

CSP architectural components:

Explain architectural components using service provider terminology, e.g. regions, zones, resource groups, subscriptions, management groups.

CSP core resources, core solutions and management tools:

Compute, networking and storage.

Describe service provider's core solutions, e.g. IoT solutions, Big Data Analytics, artificial intelligence (AI) and machine learning, DevOps.

Describe CSP management tools, e.g. Azure Portal, AWS Management Console, Command Line Interface (CLI), Cloud Shell, and application monitoring.

CSP cost management and service level agreements (SLAs):

Factors affecting cost, pricing calculators, reducing costs, forecasting costs.

Purpose of SLAs and factors affecting them.

Open source:

Open source tools for IaaS, open source tools for PaaS, open source tools for SaaS, distributed computing tools, e.g. Cassandra, Hadoop, MongoDB, NGrid, Ganglia.

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

Security aspects:

Data security, virtualisation, network security, alerts, resource hygiene, defence in depth.

Identity, including authentication and authorisation.

Governance, including role-based access control, policy and templates.

Privacy and compliance.

Platform-related security:

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

CSP security features:

Describe CSP security features, e.g. Azure Security Centre, Key Vault, AWS GuardDuty, Azure Sentinel, Dedicated Hosts, Network Security Groups (NSG), DDoS protection.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Demonstrate an understanding of the fundamentals of cloud computing and its architectures		**LO1 and LO2**
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.	**D1** Justify the tools chosen to realise 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 selected deployment models with real-world examples.	

Pass	Merit	Distinction
LO3 Develop cloud computing solutions using service provider frameworks and open source tools		
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 that can be faced during the development process.	**D2** Critically discuss how issues and constraints during the development process can be overcome.
LO4 Analyse the technical challenges for cloud applications and assess their risks		
P7 Analyse the most common problems that arise in a cloud computing platform and discuss appropriate solutions. **P8** Assess the most common security issues in cloud environments.	**M4** Discuss how to overcome security issues when building a secure cloud platform.	**D3** Critically discuss how an organisation should protect its data when migrating to a cloud solution.

Recommended Resources

Textbooks

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

Erl, T., Puttini, R., Mahmood, Z. (2013) *Cloud Computing: Concepts, Technology & Architecture*. Prentice Hall.

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

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

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

Ying Zhu, S., Hill, R. Travati, M. (Editors) (2016) *Guide to Security Assurance for Cloud Computing*. Springer.

Links

This unit links to the following related unit:

Unit 49: Systems Integration.

Unit 29: Network Security

Unit code	**M/618/7443**
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 I 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, and putting a password on all your network devices, are 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 and total system failure. Special planning and provision need 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 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 carried out on a network and methods of preventing attacks such as man-in-the-middle (MITM) (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, Media Access Control (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 confidently discuss several types of network security measures and associated protocols, and cryptographic types and configuration settings of network security environments.

They will also 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:

Formation and role of Computer Emergency Response Team (CERT), common and advanced cyber security threats and techniques, e.g. malware, DoS etc, network vulnerabilities, threat actors, threat actor tools, threat actor motivations and opportunities.

Network security devices:

Security frameworks, Authentication, Authorisation, Accounting (AAA), historical network security principles and associated physical and virtual aspects such as firewalls, routers and switches.

Network security protocols:

MD5, SSL, VPN, AES, SHA-1/2, RSA, DES, 3DES, IPsec.

Network protocols:

DNS, DHCP, HTTP, HTTPs, FTP, FTPs, POP3, SMTP, IMAP.

Network security cryptographic types:

Understand the types of cryptography, including symmetric encryption, asymmetric encryption and hashing.

Different types of public and private key cryptography such as Vigenère, Hash, Triple Data Encryption (3DES) and Feistel cipher.

The Advanced Encryption Standard (AES known as Rijndael), Data Encryption Standard (DES), Message Authentication Code (MAC).

Key Encapsulation Mechanisms (KEMs), Data Encapsulation Mechanisms (DEMs) and hybrid Public Key Encryption (PKE).

LO2 **Design a secure network for a corporate environment**

Planning a network:

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

Backup, recovery and business continuity requirements.

Compliance with legislative and regulatory requirements.

Hardware and software considerations:

What hardware and software will be used on the network.

Size considerations:

Consideration of the size and distance between nodes on the network, use of public, private or hybrid connections between sites, who has access to the network, how connections are secured.

LO3 **Configure network security measures for the corporate environment**

Configure network security:

Select the appropriate tools and comply with organisational policies and processes when configuring and upgrading systems.

Configure network security measures such as firewalls, routers, switches, gateways, SSL, IPSec, HTTPs, FTPs, passwords and back-up devices.

Cybersecurity:

Explain the different threats posed to networks, e.g. malware and phishing, ransomware.

Identify different types of attacks on computer systems, illustrate the potential impact of different attacks.

Discuss ways in which system users affect system vulnerability and potential physical vulnerabilities to systems, data and information.

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

Testing methods:

Different testing methods, e.g. network scanning, penetration testing, vulnerability scanning, ethical hacking.

Testing in terms of checks on network connection speed, testing for network vulnerabilities, network connections types, e.g. cabled and wireless.

Collection and interpretation of relevant data to identify potential issues, e.g. latency, traffic, packet data, system logs.

Create a Test Plan:

Development of a test plan to include testing data, expected results, actual results.

Application of key behaviours to develop an effective test plan and correct defects, including consideration of cause and effect to design appropriate tests and test data.

Critical thinking and application root cause analysis to interpret results and identify and correct defects, e.g. critical thinking, effective questioning and deconstruction.

Comprehensively test all devices and the whole environment:

Tests should be carried out on all devices including firewall, servers, domain controllers, email servers, routers, switches, gateways and passwords.

Make recommendations:

Recommendations for improving the network security.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Examine network security principles, protocols and standards</td><td rowspan="4">LO1 and LO2
D1 Evaluate the importance of network security to an organisation.</td></tr>
<tr><td>P1 Discuss the different types of network security devices.
P2 Examine network security protocols and the use of different cryptographic types in network security.</td><td>M1 Compare and contrast at least two major network security protocols.</td></tr>
<tr><td colspan="2">LO2 Design a secure network for a corporate environment</td></tr>
<tr><td>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 a secure network.</td><td>M2 Create a design of a secure network according to a given scenario.</td></tr>
<tr><td colspan="2">LO3 Configure network security measures for the corporate environment</td><td rowspan="4">LO3 and LO4
D2 Critically evaluate the design, planning, configuration and testing of the network.</td></tr>
<tr><td>P5 Configure network security for a network.</td><td>M3 Justify the choices made in the implemented network security configuration.</td></tr>
<tr><td colspan="2">LO4 Undertake the testing of a network using a Test Plan</td></tr>
<tr><td>P6 Comprehensively test the network using a devised Test Plan.</td><td>M4 Analyse the results of testing to recommend improvements to the network.</td></tr>
</table>

Recommended Resources

Textbooks

Burns, B., et al (2009) *Hacking: The Next Generation.* O'Reilly.

Cole, E., et al (2008) *Network Security Fundamentals*. John Wiley & Sons, Inc.

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

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

Harris, S., et al (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 edn. 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.

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

Schneier, B. (2000*) Secrets and Lies: Digital Security 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

The Computer Journal – Oxford Academic

Links

This unit links to the following related units:

Unit 2: Networking

Unit 5: Security

Unit 9: Computer Systems Architecture

Unit 27: Transport Network Design

Unit 39: Network Management

Unit 40: Client/Server Computing Systems.

Unit 30: Applied Cryptography in the Cloud

Unit code F/618/4899

Unit level 5

Credit value 15

Introduction

Almost every interaction we make with an electronic device will involve cryptography in some form. Cryptography is an indispensable tool for protecting information in computer systems. Applied cryptography for cloud services uses encryption techniques that protects data used, shared and stored in the cloud. Cryptography underpins many aspects of security and is a crucial component in protecting the confidentiality and integrity of information. Given the considerable information on individuals and organisations identified in the cloud, concerns are often raised regarding the safety of the cloud environment. Dangers of uploading data into this new environment requires cryptographers and cryptanalysts to protect the cloud environment using a variety of technologies, processes and forms of encryption. The complexity with how cloud computing manages data secrecy and information security is another reason people avoid the cloud. As a result, despite the hype surrounding cloud computing, some users remain reluctant to deploy their personal information or deploy commercial enterprises into the cloud. Understanding cloud security issues, the application of crypto algorithms and to ensure data is secured are vital to its continued functionality, longevity and sustainability. In addition, students are expected to understand the differences between the roles and responsibilities of a cryptographer and cryptanalyst.

This unit introduces students to the applied principles of cryptography and looks at its practical applications and methods, many of which are fundamental to secure data in the cloud. Students are expected to analyse fundamental symmetric, asymmetric and hashing encryption methods, and investigate examples of these in practice. Students are expected to demonstrate the use of cryptography and cryptanalysis tools, methods and their applications. Students are also expected to appraise the inner workings of cryptographic protocols and principles, including transport layer security (TLS) and blockchain, and evaluate how they can be used by organisations to enhance security when considering a move to a cloud environment. Among the topics included in this unit are: the mathematical algorithms used in cryptography, the mechanisms by which cryptographic and cryptanalysis work, hashing and salting, cloud-hosted public key infrastructure (PKI), benefits of encryption techniques, quantum cryptography, secure multi-party computation, security risks and issues with public key encryption, practical applications of cryptography and Cryptography as a Service (CaaS).

On successful completion of this unit students will be able to analyse functions of stream ciphers and block ciphers, produce code implementing ciphers, analyse methods such as KEM, DEM and PKE's to secure data in a cloud environment. Students will design a security case and implement it demonstrating the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network, for an organisation considering a move to the cloud. 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 Analyse encryption ciphers and algorithms as methods to secure data in a cloud environment

LO2 Discuss security risks and issues related to public key encryption in practice

LO3 Demonstrate the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network

LO4 Evaluate advanced encryption protocols and their application for an organisation considering a move to the cloud.

Essential Content

LO1 **Analyse encryption ciphers and algorithms as methods to secure data in the cloud environment**

Symmetric Encryption:

Use of ciphers for e.g. secure messages, cloud storage.

Symmetric to include Transposition Cipher, Substitution Cipher, Lorenz Cipher.

Feistel Cipher including Data Encryption Standard (DES).

Triple Data Encryption (3DES).

Rijndael Cipher e.g. Advanced Encryption standard (AES).

Stream cipher (e.g. Rivest Cipher 4).

Block Cipher Mode (e.g. Blowfish, Twofish, Rivest Cipher 5).

Message Authentication Code (MAC).

One-time pad.

Asymmetric Encryption:

Use of algorithms for e.g. authenticity using digital signatures, website security, withdraw or transfer bitcoin.

Asymmetric to include digital signature algorithm (DSA), public key encryption algorithms such as Rivest Shamir Adleman (RSA) algorithm (e.g. RSA cryptosystem), Diffie-Hellman, El Gamal, Elliptic Curve Cryptography (ECC), ECSTR for Efficient and Compact Subgroup Trace (XTR).

Hashing:

Use of hashing for e.g. sharing documents, database encryption, safeguarding passwords.

Hashing to include message digest, secure hashing algorithm. Galois/Counter mode (GCM), MD5, Secure Hash Algorithm 1 (SHA-1), Secure Hash Algorithm 2 (SHA-2), RIPE Message Digest (RIPEMD), homomorphic encryption.

LO2 **Discuss security risks and issues related to public key encryption in practice**

Attacks on public key schemes:

Exploring most common attacks on public key encryption schemes using a range of examples e.g. Wiener's attack on RSA, Lattice-based attacks on RSA, partial key exposure attacks, Meet-in-the-Middle (MITM) attack, Distributed Denial of Service (DDoS) bots, and fault analysis.

Different definitions of security:

Examining security of encryption, security of actual encryption algorithms, semantically secure systems, security of signatures.

Analysing provable security, explaining random oracles, security of encryption algorithms and encryption algorithms with random oracles.

Explaining provable security without random oracles, using examples such as strong RSA assumption, provable security-absolute assurance, signature and encryption schemes.

Analysing encryption techniques to include Key Encapsulation Mechanisms (KEMs), Data Encapsulation Mechanisms (DEMs), and hybrid public key encryption (PKE), for security.

LO3 **Demonstrate the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network**

Cryptographic tools, methods and applications:

Secret Key to include secret key distribution, key exchange and signature schemes, Diffie-Hellman key exchange, digital signatures and authenticated key agreement.

Public Key to include one-way functions, obtaining authentic public keys, confidentiality and integrity, digital certificates and Public Key Infrastructure (PKI), analysing examples of PKI.

Hash functions to include designing hash functions, using hash functions in signature schemes, analysing hash functions.

Cryptographer role, responsibilities and continual professional development.

Cryptanalysis tools, methods and applications:

Attacking methods to include brute force, chosen plaintext, SQL injection, dictionary and rainbow tables.

Solving ciphers to include linear (i.e. Fast data Encipherment Algorithm); non-linear (i.e. linear masking), differential (i.e. mixed integer linear programming), block (i.e. simplified Tiny Encryption Algorithm).

Frustrating statistical cryptanalysis, including confusion and diffusion.

Impact of high-performance computing and quantum cryptography.

Web-based tools e.g. CrypTool, EverCrack, AlphaPeeler.

Cryptanalyst role, responsibilities and continual professional development.

Security case and system response:

Security case to include design of a system at network layer, crypto to meet defined security objectives, key management plan, evidence of system with required security controls, format e.g. Common Criteria Protection Protocol.

System response to include security objectives and common threats, assumptions, functional requirements and security controls e.g. technical, implementation, policy or process.

LO4 **Evaluate advanced encryption protocols and their application for an organisation considering a move to the cloud**

Assessing advanced encryption protocols and their applications:

Exploring access structures for secret sharing schemes for cloud security, general secret sharing, Reed-Solomon codes, Shamir sharing scheme.

Applying RSA key generation, securID and strategy in popular cloud environments.

Analysing Zero-Knowledge proofs, Sigma protocols, electronic voting systems.

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

Evaluating different applications of cryptography and hybrid cryptosystems to include Cryptography as a Service (CaaS), digital cash, Bitcoin, Transport Layer Security (TLS) protocol, including configuration such as ciphersuites, blockchain, blockcloud and ZKsnarks.

Influencing factors affecting choice of cryptographic techniques for an organisation's move to the cloud:

Cost e.g. implementing encryption, network support, resourcing.

General considerations including suitability for business needs, infrastructure, scaling, reliability, support, storage capacity, content delivery, protection, user access and training.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse encryption ciphers and algorithms as methods to secure data in a cloud environment		
P1 Analyse the functions of stream cipher and block cipher, using a range of appropriate examples in practice. **P2** Produce code that implements mathematical ciphers and algorithms to encrypt and decrypt data.	**M1** Critically analyse the operational differences between stream cipher and block cipher, using a range of appropriate examples in practice.	**D1** Justify improvements introduced by stream ciphers compared to block ciphers for public and private key encryption.
LO2 Discuss security risks and issues related to public key encryption in practice		
P3 Discuss risks and issues in security of public key encryption schemes, using a range of appropriate examples in practice.	**M2** Analyse key benefits of encryption techniques including KEMs, DEMs and PKEs and the importance of securing public key systems.	**D2** Provide justified recommendations, synthesising different definitions of provable security, suitable for securing public key systems.
LO3 Demonstrate the use of cryptographic and cryptoanalysis tools for improving security in a virtual private network		
P4 Illustrate, using a diagram, encryption and decryption process functions in a PKI environment for a business scenario. **P5** Design a security case, representative of a business scenario, to solve a security threat.	**M3** Assess security risks and challenges of using cloud-hosted PKI in a private network. **M4** Implement the system designed, in response to a security case, using cryptographic and cryptanalysis methods or tools.	**D3** Provide a critical review of the implemented system in terms of how it meets defined security objectives and make suggestions for improvement.

Pass	Merit	Distinction
LO4 Evaluate advanced encryption protocols and their application for an organisation considering a move to the cloud		**D4** Justify the use of different cryptographic applications, for an organisation, that will inform their move to the cloud.
P6 Evaluate the key benefits of using a range of cryptography and hybrid cryptosystems to improve cloud security. **P7** Assess common factors influencing an organisations choice of cloud solution(s) to improve security.	**M5** Critically analyse the use of selected cryptography and hybrid cryptosystems in protecting data within an organisation.	

Recommended resources

Textbooks

BALACHANDRAN, M.J. (2020) *Cloud Engineering and Architecture Design Patterns.* Chennai: Notion Press.

CARLET, C. (2020) *Boolean Functions for Cryptography and Coding Theory.* Cambridge: Cambridge University Press.

CHAUBEY, N.K., PRAJAPATI, B.B. (2020) *Quantum Cryptography and the Future of Cyber Security.* USA: IGI Global.

GOYAL, D., BALAMURUGAN, S., PENG, S.L., VERMA, O.P. (2020) *Design and Analysis of Security Protocol for Communication.* USA: John Wiley & Sons.

MENEZES, A.J., VAN OORSHOT, P.C., VANSTONE, S.A. (2018) *Handbook of Applied Cryptography.* 2nd edn. Boca Raton: CRC Press, Taylor & Francis.

NIELSON, S.J., MONSON, C.K. (2019) *Practical Cryptography in Python: Learning Correct Cryptography by Example.* USA: Apress.

PACHGHARE, V.K. (2019). *Cryptography and Information Security.* 3rd edn. Delhi: PHI Learning.

SCHMEH, K. (2006) *Cryptography and Public Key Infrastructure on the Internet.* UK: Wiley.

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

STINSON, D.R., PETERSON, M.B. (2018) *Cryptography: Theory and Practice.* 4th edn. Boca Raton: CRC Press, Taylor & Francis.

SWAMMY, S., THOMPSON, R., LOH, M. (2019) *Crypto Uncovered: The Evolution of Bitcoin and the Crypto Currency Marketplace.* (eBook) Palgrave Macmillan.

Journals

International Association for Cryptologic Research, Online

International Journal of Applied Cryptography, Online

International Journal of Network Security, Online

Journal of Emerging Trends in Computing and Information Sciences, Online

Web

ncsc.gov.uk	National Cyber Security Centre (General Reference)

Links

This unit links to the following related units:

Unit 5: Security

Unit 31: Forensics

Unit 32: Information Security Management.

Unit 31: Forensics

Unit code	**T/618/7444**
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 cyber attacks, 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 digital devices in the past. Students will have the opportunity to learn about some of the lower-level structures of data storage devices and the 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 cyber attacks.

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. They will also understand the low-level file structures of several OS and be able to 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 cyber attacks

LO4 Develop a forensic examination 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.

Identify the processes and procedures for carrying out digital forensic investigation, including policy and procedure development, evidence assessment, evidence acquisition, evidence examination (including extraction and analysis).

Sources of information:

Log files, digital system monitors, access control logs, file/folder access logs, operational anomalies, current and future threats, newly identified vulnerabilities, manufacturer's bulletins, hacker blogs and social media, collation of multiple sources to address and identify system security breach, root cause analysis.

LO2 Discuss the legal and professional guidelines and procedures for carrying out digital forensic investigation

Law enforcement:

Summarise 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 2018; Computer Misuse Act 1990 and the Freedom of Information Act 2000.

Other stakeholders:

Forensic Science Society, BCS.

LO3 Use a tool or tools to conduct digital forensic investigation on devices or networks or cyber attacks

Tools required to conduct digital forensic investigation:

Hardware and software tools, e.g. Security Information and Event Management (SIEM) tools, system logs, penetration testing tools, network performance tools.

Conducting digital forensic investigation:

Conducting digital forensic investigation of devices, networks or cyber attacks to identify anomalies in observed digital system data structures, e.g. network packet data and digital system behaviours, including protocol behaviours, traffic levels and latency.

Identification and minimisation of false readings, e.g. negatives and positives generated by the available tools.

Examine Operating systems, e.g. MS-DOS, Windows, UNIX, Linux, MacOS, Android,.

LO4 Develop a forensic examination plan and make some recommendations for use in digital forensic investigation

Develop a forensic examination plan for digital devices or networks or cyber attacks:

Apply risk assessment and audit methodologies to identify potential vulnerabilities to inform a digital forensic examination plan.

Recommendations for improving system security based on identified vulnerabilities and potential emerging threats.

Explore current 'best practice' recommendations from professional and legal bodies for conducting digital forensic investigations and developing a forensic examination plan.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine the processes and procedures for carrying out digital forensic investigation		D1 Evaluate the advantages and disadvantages of conducting digital forensic investigation to improve system security.
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** Assess 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** Evaluate the impact of both following and not following guidelines in a legal case, with regard to digital forensic evidence.
P3 Examine law enforcement guidelines for conducting digital forensic investigations. **P4** Discuss legal and ethical requirements for conducting digital forensic investigations.	**M2** Assess how ethical it is to conduct digital forensic investigation on a suspected individual, with reference to their legal rights.	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Use a tool or tools to conduct digital forensic investigation on devices or networks or cyber attacks</td><td rowspan="5">LO3 and LO4

D3 Critically evaluate the forensic investigation carried out, suggesting improvements to the current digital forensic investigation guidelines, processes and procedures.</td></tr>
<tr><td>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</td><td>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 cyber attack.</td></tr>
<tr><td colspan="2">LO4 Develop a forensic examination plan and make some recommendations for use in digital forensic investigation</td></tr>
<tr><td>P7 Develop a forensic examination plan for conducting an analysis on digital devices or networks or cyber attacks.

P8 Recommend improvements based on investigation analysis.</td><td>M5 Compare the recommendations for best practices for conducting digital forensics.</td></tr>
</table>

Recommended Resources

Textbooks

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

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

Hayes D. (2020) *A Practical Guide to Digital Forensics Investigations*. USA Pearson.

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

Parasram, S. (2020) *Digital Forensics with Kali Linux.* 2nd edn. Packt Publishing

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

Web

bcs.org/membership/member-communities/cybercrime-forensics-specialist-group/	British Computer Society Forensics Specialist Group (General Reference)
gchq.gov.uk/	GCHQ (General Reference)
nsa.gov/	NSA (General Reference)

Links

This unit links to the following related units:

Unit 5: Security

Unit 30: Applied Cryptograpy in the Cloud

Unit 32: Information Security Management.

Unit 32: Information Security Management

Unit code	**J/618/7447**
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 that 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 manage the ongoing protection of sensitive information they hold effectively. 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 on.

This unit covers information security management in a business context and will give students an understanding of 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 that international standards play in developing an ISMS. 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

Principles of an ISMS:

What an ISMS is and why it is important to an organisation.

Policies, including privacy policy, acceptable use, information security, separation of duties and least privilege.

Internal and external risks, including impact, likelihood, quantitative, qualitative, vulnerabilities and threats.

Risk treatment, including avoid, transfer, accept or mitigate.

Managing compliance and stakeholders.

The role of a company's internal policies, including service level agreements (SLAs) with providers, impact on defining the scope and approach.

Use of recognised sources of threat intelligence and vulnerabilities to predict possible, current, and future threats, e.g. horizon scanning.

Key principles:

Understanding the key principles of an ISMS, including scope and boundaries, information classification, risk management methodology, risk treatment, statement of applicability, incident handling, physical security, controls that meet the organisation's business activity.

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

Implementing an ISMS:

Steps required to implement an ISMS, including creating a project mandate, initiation of the project, adopting a methodology for the ISMS, creating a management framework, identifying baseline security criteria, developing a risk management process, creating a risk treatment plan, measuring, monitoring and reviewing the results.

Planned design, including asset identification, stakeholder requirements, risk assessment, risk treatment planning, policy development, procedure development, senior management buy-in, audit (internal, external).

Maintaining an ISMS:

Elements and processes for maintaining an ISMS using a framework or an ISO standard, e.g. 27001, 27002.

Performance monitoring and continual improvement strategy.

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

Appraising an ISMS:

Review ISMS documentation for potential weaknesses by examining audit and performance monitoring output, business impact analysis, review of current 'security culture' in the organisation.

Suggest improvements to an ISMS.

Planning an ISMS:

Business requirements, including strategic, functional and non-functional requirements of digital systems.

Impacts on the business, including interruption costs, cost of failure analyses, worst-case scenario, possibility of new impacts or vulnerabilities.

Audit and stages of audit for an ISMS:

Scoping and pre-audit survey, planning and preparation, fieldwork, analysis, reporting.

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

Implementing ISMS standards:

Determining ISMS scope, including leadership commitment, policy, organisational roles and responsibilities, actions to address risks, information security objectives.

Resources and competence, awareness, communications, documented information, operational planning, risk assessment, risk treatment, monitoring, measuring, analysis and evaluation.

Management review and taking nonconformity and corrective action, as well as continual improvement.

Key purpose of ISO standards:

ISO 27001:2013; the organisation and its context, expectations of interested parties.

Advantages and disadvantages of ISO 27001:2013 certification, annex A (ISO 27002:2013) controls, ISO 8000 and data standards.

Examination of principles and good practice recommended by computing professional bodies and their impact on organisational compliance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the basic principles of information security management		**LO1 and LO2**
P1 Examine the key principles of an ISMS and its relevance to the successful operation of an organisation.	**M1** Analyse the benefits an effective ISMS can have on an organisation.	**D1** Critically analyse what is required to establish and maintain an ISMS for a selected organisation, ensuring that the key principles are met.
LO2 Critically assess how an organisation can implement and maintain an Information Security Management System (ISMS)		
P2 Assess the elements and processes required to establish and maintain an ISMS.	**M2** Justify the steps required for implementing an ISMS for a selected organisation.	
LO3 Appraise an ISMS and describe any weaknesses it may contain		**LO3 and LO4**
P3 Plan the design of an ISMS for a selected organisation, including an implementation map. **P4** Appraise the planned ISMS designed, against the organisational requirements.	**M3** Justify the planned ISMS design for a selected organisation by following the stages of audit.	**D2** Critically examine the advantages and disadvantages of the planned ISMS against the key ISO and international standards.
LO4 Examine the strengths and weaknesses of implementing ISMS standards		
P5 Recognise the purpose of the key ISO and international ISMS standards.	**M4** Analyse the relationship between ISO standards and establishing an effective ISMS in an organisation.	

Recommended Resources

Textbooks

Alexander, D., Finch, A., Sutton, D. and Taylor, A. (2020) *Information Security Management Principles* BCS. 3rd edn. BCS The Chartered Institute for IT.

Calder, A. and Watkins, S. (2019*) IT Governance: An International Guide to Data Security and ISO27001/ISO27002*. 7th edn. Kogan Page.

Journal

Information Management & Computer Security - Emerald Insight

Web

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

Links

This unit links to the following related units:

Unit 5: Security

Unit 30: Applied Cryptography in the Cloud

Unit 31: Forensics.

Unit 33: Applied Analytical Models

Unit code L/618/7448

Unit level 5

Credit value 15

Introduction

Applied analytical modelling has become prevalent in many industries and has developed in terms of 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 give students knowledge of skills in 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 and operating on a large data set.

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 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 or descriptive analytics:

Statistical look at data using visualisations, e.g. graphs, charts, reports, dashboards.

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 collection and data processing.

Semi-structured and unstructured metadata processing and 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**

Improvements:

The advantages and disadvantages of a range of investigative techniques.

Support the development of models for future state business situations.

Other considerations including data quality, data assumptions, sampling, segmentation, uplift data modelling, algorithm selection, pattern and relationship discovery, qualitative and quantitative use, validating results, output communication methods and 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.	**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.	**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 the investigation, promoting the benefits of using applied analytical models in a business.

Recommended Resources

Textbooks

Carlberg, C. (2016*) 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. (2020) *Data Analytics: Models and Algorithms for Intelligent Data Analysis.* Springer Vieweg.

Web

www.ericsson.com	Ericsson white paper *Big Data Analytics – Actionable Insights for the Communication Service Provider* (Research)
aisel.aisnet.org	Association for 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 8: Data Analytics

Unit 14: Maths for Computing

Unit 17: Business Process Support

Unit 18: Discrete Maths.

Unit 34: Analytical Methods

Unit code	**J/618/7450**
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 advanced analytical techniques that will be relevant to them as they progress with their studies in computing. The unit also advances their 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. 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 in 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 in 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.

LO4 **Investigate the concepts of formal methods within computer science**

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** Model the correctness of a given computer program using Hoare's notation.	**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.

Journal

Communications on Pure and Applied Mathematics. Wiley.

Links

This unit links to the following related unit:

Unit 14: Maths for Computing.

Unit 35: Systems Analysis & Design

Unit code	**L/618/7451**
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 and 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 a database system, or a web, game or mobile application, and failure to do this adequately could lead to a costly systems failure.

Students will explore 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.

Students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation.

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 to be developed to solve a business-related problem

LO3 Assess systems analysis methodologies to effectively solve business-related problems

LO4 Design a system to meet user and system requirements.

Essential Content

LO1 Evaluate the strengths and weaknesses of the traditional and agile systems analysis methodologies

Traditional systems analysis methodologies:

Principles of the traditional Systems Development Life Cycle (SDLC) models, including Waterfall, Prototyping and Spiral.

Agile systems analysis methodologies:

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, among the many variations.

Comparison of systems analysis methodologies:

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 to be developed to solve a business-related problem

Carry out a feasibility study:

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 **Assess systems analysis methodologies to effectively solve business-related problems**

System analysis considerations:

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 a system to meet user and system requirements.**

Use an appropriate methodology to design a system:

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.

Design sign-off.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Evaluate the strengths and weaknesses of the traditional and agile systems analysis methodologies</td><td rowspan="4">LO1 and LO2

D1 Critically evaluate the strengths and weaknesses of the traditional and agile methodologies and feasibility study in solving a specific business-related problem.</td></tr>
<tr><td>P1 Discuss the strengths and weaknesses of the traditional and agile systems analysis methodologies.</td><td>M1 Compare the strengths and weaknesses of the traditional and agile systems analysis methodologies with reference to a specific business-related problem.</td></tr>
<tr><td colspan="2">LO2 Produce a feasibility study for a system to be developed to solve a business-related problem</td></tr>
<tr><td>P2 Produce a system feasibility study for a business-related problem.</td><td>M2 Evaluate the importance of the feasibility criteria in the systems investigation for the business-related problem.</td></tr>
<tr><td colspan="2">LO3 Assess systems analysis methodologies to effectively solve business-related problems</td><td rowspan="4">LO3 and LO4

D2 Justify the choice of the methodology used in the context of the business problem.</td></tr>
<tr><td>P3 Review a system using a suitable methodology for a business-related problem.</td><td>M3 Assess the effectiveness of the methodology used in providing a solution for a given business context.</td></tr>
<tr><td colspan="2">LO4 Design a system to meet user and system requirements</td></tr>
<tr><td>P4 Design a fully functional system to meet user and system requirements for a business-related problem.</td><td>M4 Assess the effectiveness of the system design, with reference to the methodology used and how the design meets user and system requirements.</td></tr>
</table>

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. (2021) *Systems Analysis and Design*. 5th edn. 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. (2020) *Modern Systems Analysis and Design*. 9th edn. Pearson Higher Ed.

Kenneth, K. and Kendall, J. (2019*) Systems Analysis and Design.* 10th edn. Pearson.

Larman, C. (2004) *Agile and Iterative development: A Manager's Guide.* Addison-Wesley Professional.

Martin, R. C. (2013) *Agile Software Development, Principles, Patterns, and Practice*. New International Edition. Pearson.

Journals

The Computer Journal - Oxford Academic

Journal of Emerging Trends in Computing and Information Sciences – Eldis

Journal of Systems Analysis and Software Engineering – American Scientific Publishers

Web

agilemodeling.com	Agile Modelling *Agile Analysis* (Article)
batimes.com	Resources for business analysts *Applying Agile Principles To Requirement Analysis* (Article)
sparcedge.com	SPARC *What an Agile Design Process Looks Like* (Article)

Links

This unit links to the following related units:

Unit 6: Planning a Computing Project (Pearson-set)

Unit 7: Software Development Lifecycles.

Unit 36: User Experience and Interface Design

Unit code	**Y/618/7453**
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 to provide desirable end-user outcomes utilising insight and understanding of 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 the user's interactions so that they 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 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, understanding a user's emotions, desires and attitudes relating to 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 user feedback and research.

On successful completion of this unit, students will be able to explain the basic concepts of UX and UI Design. They will be able to plan, build and measure the success of an appropriate UI Design, and design an interface and experience with a specific end user in mind. Students will also be able to conduct testing to gather meaningful feedback in order to evaluate the success or failure of a user interface. They will develop skills such as communication literacy, design thinking, team working, critical thinking, analysis, reasoning and 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 Research User Experience and Interface Design in relation to end user requirements in a User Interface concept

LO2 Plan a User Experience map and Interface Design for a User Interface concept for a target end user

LO3 Build a User Interface concept and test it with end users for enhancement purposes

LO4 Evaluate user feedback and test results from interaction with the User Interface concept to determine improvements.

Essential Content

LO1 Research User Experience and Interface Design in relation to end user requirements in a User Interface concept

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.

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.

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 a User Experience map and Interface Design for a User Interface concept for a target end user.

UX and UI Design:

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 end users for enhancement purposes**

Tools to develop a UX and UI Design:

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

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 and test results from interaction with the User Interface concept to determine improvements**

Success of UX and UI design:

Assemble and appraise end-user 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 User Interface and discuss your UX insights.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Research User Experience and Interface Design in relation to end user requirements in 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 lifecycle. **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 a User Experience map and Interface Design for a User Interface concept for a target end user.		**LO2 and LO3**
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 Interface Design methodology and tools to conduct end user testing.	**D2** Develop multiple iterations of your User Interface concept and modify each iteration with enhancements gathered from user feedback and experimentation.
LO3 Build a User Interface concept and test it with end users for enhancement purposes		
P5 Examine appropriate tools to develop a User Interface. **P6** Conduct end-user experiments and examine feedback see if it satisfies emotions, desires and attitudes as planned.	**M5** Employ an appropriate set of tools to develop your plan into a User Interface. **M6** Analyse end-user feedback and build a new iteration of your User Interface modified with the most important feedback and enhancements.	
LO4 Evaluate user feedback and test results from interaction with the User Interface concept to determine improvements		
P7 Review end-user feedback from multiple iterations of the User Interface. **P8** Suggest steps to improve future versions of the User Interface.	**M7** Undertake a critical review and compare the final User Interface and test results with the original plan.	**D3** Critically evaluate the overall success of the User Interface concept and discuss insight using prototyping.

Recommended Resources

Textbooks

Kalbach, J. (2021) *Mapping Experiences: A Complete Guide to Creating Value through Journeys, Blueprints, and Diagrams*. 2nd edn. 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 edn. Rockport Publishers.

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

Tidwell, J. (2011) *Designing Interfaces.* 2nd edn. O'Reilly Media.

Links

This unit links to the following related units:

Unit 13: Website Design & Development

Unit 54: Prototyping.

Unit 37: Architecture

Unit code K/618/7456

Unit level 5

Credit value 15

Introduction

Computer architecture engineers work in industries such as telecoms, automotive and aerospace and the aim of this unit is to give students knowledge of computer systems, functionality and organisation. Students will examine systems architecture and elements of computing machines and the principles and fundamentals of how computer systems work.

The unit introduces students to the hardware and software architecture of computer systems and low-level language program development using CPU registers to manipulate data. They 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.

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 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 synchronization, processor (CPU), buses, memory maps and interrupt request (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 one JMP instruction) to manipulate stored data using CPU registers; I/O memory and IRQ locations.

LO4 Investigate advanced computer architectures and performance

Advanced architectures:

Multiple instruction, multiple data (MIMD) parallelism (Flynn's 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		
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.	**D1** Evaluate through illustration how the processor is physically connected to memory and input/output (I/O) devices using the system buses.
LO2 Discuss how data and programs can be represented within computer systems		
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.	**D2** Evaluate how locating a program absolutely in memory can aid ICE target system debugging.

Pass	Merit	Distinction
LO3 Demonstrate the principles of processor operations		
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 that includes decision making, branching and I/O operations. **M5** Investigate the function of an interrupt handler.	**D3** Examine how the width of the data bus and address bus affect processor performance and complexity.
LO4 Investigate advanced computer architectures and performance		
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.	**D4** Critically evaluate, with illustrations, computer performance improvements with MIMD architectures.

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 9: Computer Systems Architecture

Unit 40: Client/Server Computing Systems.

Unit 38: Analytic Architecture Design

Unit code T/618/7461

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, scheduling ability, fault tolerant, security etc.) distributed computer systems.

This unit introduces students to the AADL. It introduces the language and AADL specifications, which is defined in the standards of SAE International. The SAE International 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, sub-components and their interactions. The AADL is a useful tool to model and analyse existing systems and to 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; understand the use of the AADL flows concept and present examples of the specification of abstract flows throughout a system and describe the constructs for organising an AADL specification. It includes examples of AADL architectural pattern sets. 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 detailed and problem-oriented material to gain a conceptual overview of the AADL abstractions for a given function

LO2 Demonstrate the software component and execution platform component abstractions for a system

LO3 Design 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 through AADL flow concepts for a composite system.

Essential Content

LO1 **Explore detailed and problem-oriented material to gain a conceptual overview of the AADL abstractions for a given function.**

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 **Demonstrate the software component and execution platform component abstractions for a system**

Semantics:

Textual representation, graphical representation, how to define software and hardware components and their interactions, top component; root system, other component clusters: hardware, software, and hybrid.

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 **Design 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.

Sub-component:

Introduction to implementation of the sub-components in system and the access of data in difference sub-components.

Software components:

Implementation of software components in system design.

Execution platform components:

Implementation of execution platform components in system design.

Benefits of AADL:

Analyses the system structure and runtime behaviour.

Complements functional simulation.

Allows early and life-cycle tracking of modelling and analysis.

Provides a standard with precise syntax and semantics for performance-critical systems.

Able to model large-scale multi aspect architectures into a single analysable model capable of incremental refinement.

LO4 **Show the specification of alternative operational states of a system through AADL flow concepts for a composite system**

Modes and flow:

Properties, structure and instantiation.

Mode specifications:

Basic introduction to the modes and the representations of modes.

Mode 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 to gain a conceptual overview of the AADL abstractions for a given function.		**LO1 and LO2**
P1 Demonstrate the basic concept of elements and methods of AADL using an example. **P2** Design a system using AADL to implement a specific function.	**M1** Build a system using AADL to implement a specific function. **M2** Differentiate between the different AADL representations including advantages and disadvantages.	**D1** Critically analyse components, physical design and logical elements of the AADL process with reference to the system built.
LO2 Demonstrate the software component and execution platform component abstractions for a system		
P3 Present a software component and execution platform components in a system using different representations.	**M3** Assemble components under AADL specification. **M4** Implement different components in a system.	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Design composite systems and their instances, and describe the abstractions that support the specification of component interactions</td><td rowspan="5">LO3 and LO4

D2 Evaluate the composite system designed, the flow methods and selection of elements used including the refinement produced from organising an AADL specification.</td></tr>
<tr><td>P4 Design a composite system that consists of various types of elements showing the design logic and the relationships between components in the design process.

P5 Discuss the strong and weak points of the designed system.</td><td>M5 Analyse the data communication in the whole system including data interaction processes between components.</td></tr>
<tr><td colspan="2">LO4 Show the specification of alternative operational states of a system through AADL flow concepts for a composite system</td></tr>
<tr><td>P6 Redesign the composite system in flow and modes format.

P7 Show different flows and identify the operating process for the composite system.</td><td>M6 Produce relevant information in design process of flow, including ideas and selection of elements.</td></tr>
</table>

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 edn. Springer.

Gluch, D. and Feiler, P. (2012*) Model-Based Engineering with AADL: An Introduction to the SAE Architecture Analysis & Design Language*. 1st edn. Addison-Wesley Professional.

Kordon, F., Hugues, J., Canals, A. and Dohet, A. (2013) *Embedded Systems: Analysis and Modeling with SysML, UML and AADL*. 1st edn. Wiley-ISTE.

Links

This unit links to the following related unit:

Unit 20: Applied Programming and Design Principles.

Unit 39: Network Management

Unit code	**F/618/7463**
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 and 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 today and in the future, including multimedia applications such as VoIP, IPTV and mobile network, and 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 and IPS, network protocols and standards such as Simple Network Management Protocol (SNMP), the Network Configuration Protocol (NETCONF), IEEE, MIBII, Remote Network Monitoring (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, and 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 plan and manage network risks and cloud computing. 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 concepts and principles of network management

LO2 Plan, design, setup and configure a network

LO3 Review the protocols and standards related 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

Effective network management activities:

Security, networking technologies, networking topologies, networking protocols, self-learning networks and Service Level Agreements (SLAs).

Automatic management:

Data formats, e.g. JSON (JavaScript Object Notation), YAML (YAML ain't a markup language), XML (eXtensible Markup Language).

Computer to computer communications, e.g. via APIs (Application Programming Interfaces), via REST (Representational State Transfer).

Configuration management tools, e.g. Puppet, Chef, Ansible, SaltStack.

LO2 Plan, design, setup and configure a network

Planning and design:

Planning methodology, topological design, protocols, transmission technologies, hardware, network realisation.

Setup and configuration:

Devices, cabling, protocols, ACLs, security and optimisation.

LO3 Review the protocols and standards related with networking and network management

Network protocols and standards:

Protocols, including SNMP, NTP, 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, GRE (Genetic Routing Encapsulation), HHTPs, FTPs, DNS, firewall, passwords, cryptography.

Risk management:

Approaches to risk assessment, including risk identification, risk mitigation, risk avoidance, risk management and risk grading, e.g. severity, likelihood, impact.

Troubleshooting and maintenance:

Troubleshooting methodologies for network and IT infrastructure.

Diagnostic techniques and tools to interrogate and gather information on systems performance.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore the concepts and principles of network management		**LO1 and LO2**
P1 Investigate network management concepts and principles. **P2** Discuss the implications of automatic network management.	**M1** Evaluate the importance of network management.	**D1** Critically evaluate a comprehensive network configuration for a predefined network specification.
LO2 Plan, design, setup and configure a network		
P3 Produce a comprehensive design of a network according to pre-defined network specification.	**M2** Implement a network design according to a predefined network specification.	
LO3 Review the protocols and standards related with networking and network management		
P4 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.	**D2** Evaluate the role and functions of SNMP and RMON.
LO4 Use tools and methods to manage a network, including network security and risk management		
P5 Use tools and methods to manage a network. **P6** Implement network security on a network. **P7** Conduct a risk assessment on a network.	**M4** Justify the importance of network security to a network.	**D3** Critically evaluate the importance of carrying out a risk assessment on a network.

Recommended Resources

Textbooks

Anderson, A. and Benedetti, R. (2009) *Head First Networking*. O'Reilly Media.

Comer, D. and Droms, R. (2003) *Computer Networks and Internets*. 4th edn. Upper Saddle River: Prentice Hall.

FitzGerald, J., Dennis, A. and Durcikova, A. (2021) *Business Data Communications and Networking*. 14th edn. Hoboken. John Wiley.

Hallberg, B. (2013) *Networking: A Beginner's Guide*. 6th edn. McGraw-Hill Osborne.
Harrington, J. L. (1999) *Ethernet Networking Clearly Explained*. Morgan Kaufman.

Kurose, J. F. and Ross, K. W. (2016) *Computer Networking: A Top-Down Approach Featuring the Internet*. 7th edn. London: Addison-Wesley.

Lowe, D. (2012) *Networking All-in-One For Dummies*. 5th edn. 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 edn. O'Reilly Media.

Stallings, W. (2003) *Data and Computer Communications*. 7th International edn. Upper Saddle River: Prentice Hall.

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

Tanenbaum, A. and Wetherall, D. (2013) *Computer Networks*. 5th edn. Pearson.

Web

www.dmtf.org	Distributed Management Task Force (General Reference)
www.ietf.org	Internet Engineering Task Force (General Reference)
www.iso.org	International Organization for Standardization (General Reference)
www.itu.int	International Telecommunication Union (General Reference)
www.tmforum.org	TM Forum (General Reference)

Links

This unit links to the following related units:

Unit 2: Networking

Unit 9: Computer Systems Architecture

Unit 27: Transport Network Design

Unit 29: Network Security

Unit 40: Client/Server Computing Systems.

Unit 40: Client/Server Computing Systems

Unit code Y/618/7467

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 and receiving emails, and using VoIP software and other application, 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 and 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) and 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

LO3 Create a client/server model in a Linux system utilising a range of protocols.

Essential Content

LO1 **Explore the concepts of servers, clients and processes, and the differences between PPID and PID**

Client-server relationship:

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.

Security:

Measures to ensure server security.

LO2 **Analyse the communication processes between clients and servers in different application protocols**

Internet services:

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 utilising a range of protocols**

Introduction of Linux:

Introduction to the Linux system: concept, history, advantages and disadvantages.

Basic 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 including UDP-based socket API, UDP-based client, UDP-based server.

Simple TCP client/server program including 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 and 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		
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.	
LO3 Create a client/server model in a Linux system utilising a range of protocols		
P5 Create a UDP system in Linux. **P6** Create a TCP system in Linux.	**M5** Build a system with DNS and illustrate it with 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 Vol. I Principles, Protocols and Architecture.* 6th edn. Pearson.

Comer, D. (2000) *Internetworking with TCP/IP, Vol. III: Client-Server Programming and Applications. Linux/Posix Sockets Version*. 1st edn. Pearson.

Edwards, J. and Bramante, R. (2009) *Networking Self-Teaching Guide: OSI, TCP/IP, LANs, MANs, WANs, Implementation, Management, and Maintenance.* 1st edn. Wiley.

Johansen, A. (2015) *LINUX: The Ultimate Beginner's Guide!* 3rd edn. CreateSpace Independent Publishing Platform.

Links

This unit links to the following related units:

Unit 2: Networking

Unit 9: Computer Systems Architecture

Unit 27: Transport Network Design

Unit 29: Network Security

Unit 39: Network Management

Unit 50: Operating Systems.

Unit 41: Database Management Systems

Unit code	**H/618/7472**
Unit level	**5**
Credit value	**15**

Introduction

As globalisation increases and the 24-hour economy develops, 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 owing to technological advancements and changes in the way that 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.

Among 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 and 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, 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**

Database structure principles and systems:

Types of database management systems (DBMS) and their operating system support, e.g. MySQL, Oracle.

Data models, e.g. 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, including key, domain, referential integrity.

Normalisation in developing efficient data structures.

Modelling languages, e.g. 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**

Design considerations:

Determine user and system requirements.

Examine design tools and techniques for a relational database management system.

Physical system design.

Logical design, including design for relational databases, tables, data elements, data types, keys and indexes, entity relationship modelling, data-flow diagrams, flowcharts.

DBMS selection, e.g. MySQL.

Hardware, software and other resource requirements.

Mathematical relations, e.g. relational algebra, relational calculus.

Application development:

Data input, including verification, validation, calculated fields, masks, directed input.

Reports, including queries, presentation of data, layouts.

Task automation, e.g. imports, updates, deletions.

Queries using multiple criteria, form values and wild cards, action queries, calculated queries, queries across multiple tables.

Error checking and quality assurance:

Test plans to check correctness of data, security, functionality, accessibility and usability.

Quality, effectiveness and appropriateness of the solution, including 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**

Development of DBMS:

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 effectiveness:

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.

Optimising the solution:

Reviewing the solution, including quality of the database, fitness for purpose, suitability against the original requirements, technology constraints, strengths and improvements, platforms and compatibility.

Optimisation of data types.

Optimisation of data size, e.g. size on disk.

Tables, e.g. overheads for many tables.

Query optimising.

LO4 **Demonstrate the system administration and management tools available on the chosen platform**

Demonstrations of server management:

Describe core database administration tasks and tools.

Setting up and managing data storage for servers and users.

Back-up 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

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Analyse different types of database management systems</td><td rowspan="2">D1 Evaluate different database management systems available in relation to open source and vendor-specific platforms, justifying the criteria used in the evaluation.</td></tr>
<tr><td>P1 Compare the different types of database models.</td><td>M1 Assess how relational database models and the process of normalisation can provide reliable and efficient data structures.</td></tr>
<tr><td colspan="2">LO2 Design a database management system using a relational model to meet client requirements</td><td rowspan="4">LO2 and LO3
D2 Evaluate the effectiveness of the system design and development against client and system requirements.</td></tr>
<tr><td>P2 Produce a design for a relational database management system to meet client requirements.</td><td>M2 Analyse how the design will optimise system performance.</td></tr>
<tr><td colspan="2">LO3 Develop a database management system using a suitable platform</td></tr>
<tr><td>P3 Develop a fully functional system that meets client and system requirements, using an open source language with an application software.
P4 Test the system for functionality and performance.</td><td>M3 Implement effective features in the solution to handle concurrency, security, user authorisations and data recovery.</td></tr>
</table>

Pass	Merit	Distinction
LO4 Demonstrate the system administration and management tools available on the chosen platform		**D3** Analyse any future improvements that may be required to ensure the continued effectiveness of the database system.
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.	

Recommended Resources

Textbooks

Connolly, T. and Begg, C. (2014) *Database systems: A Practical Guide to Design, Implementation and Management*. 6th edn. Addison-Wesley.

Elmasri, R. and Navathe, S. (2015) *Fundamentals of Database Systems*. 7th edn. Addison-Wesley.

Hoffer, J. (2008) *Modern Database Management*. Pearson Education.

Jeffrey A., Ramesh, V. and Topi Heikki, T. (2016) *Modern Database Management*. 12th edn. Pearson Education.

Silberschatz, A., Korth, H. F. and Sudarshan, S. (2011) *Database System Concepts*. 6th edn. McGraw-Hill Edition.

Plus other textbooks linked to the version of the software used for a given platform.

Journals

The Computer Journal - Oxford Academic

International Journal of Database Management Systems - AIRCC

Journal of Database Management - IGI Global

Journal of Emerging Trends in Computing and Information Sciences - CIS Publishers

Links

This unit links to the following related units:

Unit 4: Database Design & Development

Unit 11: Strategic Information Systems.

Unit 42: Game Design Theory

Unit code	**K/618/7473**
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. It is a completely different story, however, 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. The unit starts by establishing an overall history of games and reviews, and how they have evolved – and still are evolving. Students are introduced to assessing common game features and identifying the roles and responsibilities of people involved in game design, and its challenges. Students will become familiar with a range of standard documents associated with games design, including the 'Game Design Document'. Before they 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. They will be 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 review, before finally presenting a 'High Concept' pitch. To help maximise 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 regard 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 regard 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**

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.

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**

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.

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 regard to game development and production**

Roadmap for the game design process:

Roadmap to include 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.

Game development constraints and possible pitfalls, platforms commonly available to support development.

Testing methods, purpose of Quality Assurance (QA) and business and monetisation models, e.g. Steam, retail, Free-to-Play (F2P).

Techniques such as item-purchase, affiliate, advertising, freemium, restricted access, subscription,

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.**

Game concept:

Gather and document a range of original game ideas using research on existing game types and styles for inspiration.

Peer-review and evaluation of feedback on game ideas.

Justify the selection of a specific game idea.

Apply game design practices and principles to develop a specific game idea into a full, well-structured concept.

Game Design Document and 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		**LO1 and LO2**
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 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.	**D1** Evaluate each section of a Game Design Document and explain the effect of game loops and Metagame design with regard to game play.
LO2 Analyse the concepts and elements required for the production of a Game 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 regard 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 regard 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, Game Design Document and High Concept pitch, and fully justify opportunities for improvement and further development.

Recommended Resources

Textbooks

Gibson, J. (2021) *Introduction to Game Design, Prototyping, and Development. New Jersey:* Pearson Education.

Gregory, J. (2018) *Game Engine Architecture*. 3rd edn. 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 7: Software Development Lifecycles

Unit 43: Games Development

Unit 44: Games Engine & Scripting.

Unit 43: Games Development

Unit code L/618/7479

Unit level 5

Credit value 15

Introduction

In the field of computing, games development is a multidisciplinary art form creating worlds that blend player psychology, problem solving and artificial intelligence with knowledge of dedicated hardware and software platforms. This level of ability can often require significant effort on the part of students, in terms of time and practice but as students gain more experience, their skills and abilities quickly improve. 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. It 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 will discuss and review a number of original game ideas before synthesising them into a single game concept. Once the game concept is defined, students will need to adopt appropriate methods and practices to analyse, break down and discuss the issues, then decide on, 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.

Among the topics included in this unit are: game design and developer documentation, problem analysis, research, system and user requirements, design methodologies, development methodologies, unified modelling language (UML), games engines, hardware platforms, graphic manipulation, physics, maths for games, sound, networking, collision detection, teamwork, peer review, 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 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, and 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.

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**

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 including predicting the overall success of fully developing the game.

Game Design Document:

Review the value of Game Design Documents in terms of games development.

Evaluate and synthesise game ideas to describe game concept.

Research and use information relating to games testing in order to create a suitable test plan.

LO2 **Use different design and development methodologies with tools and techniques associated with the creation of a video game**

Design and development methodologies:

Present overviews on current design and development methodologies.

Understand strengths and weaknesses commonly associated with each methodology.

Select or synthesise a design and development methodology.

Tools and techniques:

Evaluate different tools and techniques available to create a video game.

Establish development plan, including the advantages and disadvantages of 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**

Team working to plan and prepare a functional video game:

Peer review and debate development plan and Game Design Document, including communicating effectively and defending ideas and reasoning.

Discuss differences with regard to the possible strengths and weaknesses of each Game Design Document and development plan.

Modify design document or plans to reflect any new insight or considerations.

Functional video game:

Use a Game Design Document with a development plan to produce a functional video game.

Create and quality check appropriate support documents.

LO4 **Evaluate the performance of a video game against its Game Design Document and original concept**

Performance of a video game:

Factors that influence the performance of a video games system requirements.

Critical review of the performance and development of video game against identified factors and adopted design and development methodologies.

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

Improvements to a video game:

Evaluate the overall strengths and weaknesses against original concept.

Plan revisions to implementation to improve 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 a video game.	**M1** Analyse common game design elements and combine with the 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.

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO2 Use different design and development methodologies with tools and techniques associated with the creation of a video game</td><td rowspan="4">LO2 and LO3

D2 Evaluate any new insight, ideas or potential improvements to the concept, methodology or use of tools and justify the reasons why they have been included (or not included) as part of the development.</td></tr>
<tr><td>P3 Research the use of different design and development methodologies, tools and techniques, and determine which have been selected for the development of the video game.</td><td>M2 Compare the differences between the various design and development methodologies, tools and techniques researched, and justify a preferred selection.</td></tr>
<tr><td colspan="2">LO3 Work individually and as part of a team to plan and produce a functional video game, including support documentation</td></tr>
<tr><td>P4 Review the video game concept, preferred design, and development methodologies and selected tools and techniques.

P5 Develop a functional video game based on a specified game concept and gather feedback.</td><td>M3 Interpret the 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.</td></tr>
</table>

Pass	Merit	Distinction
LO4 Evaluate the performance of a video game against its Game Design Document and original concept		
P6 Evaluate the performance of a video game against the original concept.	**M5** 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 a video game. Conclude the review by discussing previously identified risks reflectively.	**D3** Critically evaluate the strengths and weaknesses of the video game and fully justify opportunities for improvement and further development.

Recommended Resources

Textbooks

Gibson, J. (2021*) Introduction to Game Design, Prototyping, and Development*. New Jersey: Pearson Education.

Gregory, J. (2018) *Game Engine Architecture*. 3rd edn. 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 7: Software Development Lifecycles

Unit 42: Game Design Theory

Unit 44: Games Engine & Scripting.

Unit 44: Games Engine & Scripting

Unit code	**F/618/7480**
Unit level	**5**
Credit value	**15**

Introduction

Professional game development typically represents a significant investment in time, effort, skill and money. This is further complicated by the generally increasing differences in hardware platforms (such as PCs, Mac, Xbox, PlayStation, tablets and other mobile devices). Before 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. They would also 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. Despite using a games engine, however, 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. After being introduced to the core services of most engines and their advantages, students will evaluate a range of different engines and debate their features. While students assimilate, reflect on and consider the advantages and technical challenges of a games engine they will be issued with an existing Game Design Document (supported with all appropriate assets) and challenged with planning and using a specific engine to develop the design into a functional game. Students will review and reflect on the experience, and formally assess their functional game against the Game 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 in terms of 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**

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.

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, predict a possible future for games (short-, mid- and long term), including the development and use of games engines.

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

Features and architecture of a games engine:

Discuss the core features of games engines, including 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.

Investigate the implementation and technical challenges associated with identified features.

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, including the type of features commonly embedded in each.

Evaluate the strengths and weaknesses of a range of games engines.

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

Game Design Document with games engine features:

Evaluate existing Game Design Document with the features of a specific games engine to create a development plan.

Peer review development plan, including communicating effectively and defending ideas and reasoning.

Modify plan to reflect any new insights or considerations.

Creating and testing a playable game:

Use the Game Design Document (with assets) with the 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**

Performance of a playable game:

Analyse factors that influence the performance of a playable game in terms of game genre, style and player expectation.

Undertake a critical review of the performance and development of the game against all identified factors, including use of any games engine features.

Critique the overall success of the game and identify any new areas of personal insight.

Planning improvements to a playable game:

Evaluate the overall strengths and weaknesses of the game against its Game Design Document.

Discuss and plan in detail possible revisions (including implementation) in terms of improving game 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		**LO1 and LO2**
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, explaining how this could affect designers, developers and gamers.	**D1** Critically analyse each of the games engines evaluated.
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 feature. **P3** Review different published games and determine the types of features embedded in each game against the features available in a selected games engine.	**M3** Evaluate the features and architecture of different games engines and explain, giving technical detail, the purpose and operation of each feature. **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 Using an existing Game Design Document plan the development, testing and review of a playable demo, documenting feedback given. **P5** Use a Game Design Document, supported with a development and test plan and a selected games engine, to develop a playable demo.	**M5** Interpret peer-review feedback and identify opportunities not previously considered. **M6** Extend the playable demo into a game that supports splash screens, credits, scoring and losing player life.	**D2** Improve the 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 the playable demo or game against the Game Design Document.	**M7** Evaluate the strengths and weaknesses of the playable game against player expectation.	**D3** Critically evaluate the strengths and weaknesses of the playable game against player expectation and explain opportunities for improvement and further development.

Recommended Resources

Textbooks

Gibson, J. (2021) *Introduction to Game Design, Prototyping, and Development*. New Jersey: Pearson Education.

Gregory, J. (2018) *Game Engine Architecture*. 3rd edn. 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 42: Game Design Theory

Unit 43: Games Development.

Unit 45: Internet of Things

Unit code J/618/7481

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 those 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 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 problems that IoT applications solve; the potential impact on society, business and the end user, and the problems encountered when integrating into the wider IoT ecosystem. As a result, students will develop skills such as communication literacy, design thinking, team working, critical thinking, analysis, reasoning and 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 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 application**

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.

Explore NB-IoT and eLTE-IoT, including standards evolution and industry development; related technologies, differences, and similarities between NB-IoT and eLTE-IoT.

Appropriateness of various architecture, frameworks, tools, hardware and APIs for different problem-solving requirements, including architecture of NB-IoT solution and eLTE-IoT solutions, NB-IoT physical Layer, key NB-IoT Features, open Modules for integration, E2E Ecosystems, lightweight devices.

Describe application scenarios of NB-IoT and eLTE-IoT.

Recognise the various forms of IoT by researching its history, current trends and use in relation to, and in 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.

Common problems in smart campuses and cities, pain points, corresponding solutions.

Requirements of IoT technologies, including: ensuring appropriate functionality; the need to reduce power consumption of the smart grid and how this achieved.

Driving forces of IoT development and corresponding solutions.

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.

Explore key technologies that enable and support mobile/cellular communications, e.g. 3G, 4G, 5G.

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 a problem:

Specific problem to solve using IoT.

Evaluate the benefits, features, advantages and disadvantages of IoT to solve a specific problem.

Review different architecture, frameworks, tools, hardware and API techniques that can be used.

Select the most appropriate IoT architecture, frameworks, tools, hardware and API techniques to include in an application.

Describe a plan for an IoT application to solve a problem:

Outline the problem to solve including how IoT and a planned application addresses this problem.

Select an appropriate IoT application to achieve desired results.

Apply IoT architecture, frameworks, tools, hardware and API techniques appropriate to the problem identified.

Use 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 plan into an IoT application.

Run end user experiments and examine feedback.

Reconcile and evaluate end user feedback and determine advantages and disadvantages of 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 an IoT application:

Assemble and appraise end user feedback from IoT application.

Undertake a critical review and compare final application with the original plan.

Evaluate the advantages, disadvantages, strengths and weaknesses of IoT techniques.

Critique the overall success an IoT application including how well it solved problem, potential impact on people, business, society and the end user, possible problems when integrating into the wider IoT ecosystem.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Analyse what aspects of IoT are necessary and appropriate when designing software applications</td><td rowspan="2">D1 Evaluate specific forms of IoT architecture and justify their use when designing software applications.</td></tr>
<tr><td>P1 Explore various forms of IoT functionality.

P2 Review standard architecture, frameworks, tools, hardware and APIs available for use in IoT development.</td><td>M1 Analyse the impact of common IoT architecture, frameworks, tools, hardware and APIs in the software development lifecycle.

M2 Examine specific forms of IoT architecture, frameworks, tools, hardware and APIs for different problem-solving requirements.</td></tr>
<tr><td colspan="2">LO2 Outline a plan for an appropriate IoT application, using common architecture, frameworks, tools, hardware and APIs</td><td rowspan="4">LO2 and LO3

D2 Make multiple iterations of the IoT application and modify each iteration with enhancements gathered from user feedback and experimentation.</td></tr>
<tr><td>P3 Investigate architecture, frameworks, tools, hardware and API techniques available to develop IoT applications.

P4 Discuss a specific problem to solve using IoT.</td><td>M3 Plan the most appropriate IoT architecture, frameworks, tools, hardware and API techniques to include in an application to solve a problem.

M4 Apply selected techniques to create an IoT application development plan.</td></tr>
<tr><td colspan="2">LO3 Develop an IoT application using any combination of hardware, software, data, platforms and services</td></tr>
<tr><td>P5 Employ an appropriate set of tools to develop a plan into an IoT application.

P6 Create a detailed test plan and examine feedback.</td><td>M5 Reconcile end-user feedback and determine advantages and disadvantages of chosen IoT techniques.</td></tr>
</table>

Pass	Merit	Distinction
LO4 Evaluate your IoT application and the problems it might encounter when integrating into the wider IoT ecosystem		
P7 Review the IoT application, detailing the problems it solves. **P8** Investigate the potential problems the IoT application might encounter when integrating into the wider system.	**M6** Compare the final application with the original plan.	**D3** Critically evaluate the overall success of the application including the potential impact of the IoT application on people, business and society, and the end user.

Recommended Resources

Textbooks

Bahga, A. and Madisetti, V. (2014) *Internet of Things: A Hands-On Approach*. 1st edn. VPT.

McEwen, A. (2013) *Designing the Internet of Things.* 1st edn. John Wiley and Sons.

Links

This unit links to the following related units:

Unit 21: Application Program Interfaces

Unit 47: Emerging Technologies.

Unit 46: Robotics

Unit code	**L/618/7482**
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 for students to explore robotic systems, both historic and as an area of rapid contemporary development. 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 will be exposed to a wide range of practical applications of robotic 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 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 their advantages and disadvantages

LO2 Build and appraise a robot from the perspective of cost-benefit impact

LO3 Evaluate the operation and application of a range of sensors and how they can apply to a mobile or static robotic system

LO4 Evaluate the relevance of biologically inspired robotic systems and how they can benefit 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 their advantages and disadvantages

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 and appraise a robot from the perspective 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 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 they can benefit 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 their advantages and disadvantages		**LO1 and LO2**
P1 Analyse the types of robots and their use in industry. **P2** Discuss the advantages and disadvantages of using the robots.	**M1** Choose an industry and critically evaluate the use of robotics in that industry and the benefits of using them.	**D1** Critically evaluate the social and ethical impact of using the robots.
LO2 Build and appraise a robot from the perspective of cost-benefit impact		
P3 Assess all the components used to build a simple robot. **P4** Build a fully-functional, simple robot.	**M2** Discuss the construction process and explain the cost-benefit impact.	

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Evaluate the operation and application of a range of sensors and how they can apply to a mobile or static robotic system</td><td rowspan="4">LO3 and LO4

D2 Evaluate the impact of the chosen biologically inspired techniques used for the robot and detail the behavioural changes of the robot.</td></tr>
<tr><td>P5 Review a range of sensors and their use.

P6 Embed a sensory system for the built robot to enhance the robot’s intelligence.</td><td>M3 Analyse the construction process and explain the benefit of the enhancement.</td></tr>
<tr><td colspan="2">LO4 Evaluate the relevance of biologically inspired robotic systems and how they can benefit the understanding of biological systems and the design of individual or groups of robots</td></tr>
<tr><td>P7 Assess the range of biologically inspired techniques that can be embedded in a robot.

P8 Discuss how a biologically inspired robot can be used to study the understanding of the biological system.</td><td>M4 Choose a biologically inspired technique and analyse how the robot behaves after embedding the technique</td></tr>
</table>

Recommended Resources

Textbooks

Backstop Media and Waldron, R. (2015) *JavaScript Robotics: Building NodeBots with Johnny-Five, Raspberry Pi, Arduino, and BeagleBone.* Maker Media.

Bajd, T., Mihelj, M., Lenarčič, J., Stanovnik, A. and Munih, M. (2010) *Robotics*. Springer, London.

Ceceri, K. (2015) *Making Simple Robots: Exploring Cutting-Edge Robotics with Eveyrday Stuff.* Make Publications.

Cook, D. (2015) *Robot Building for Beginners*. 3rd edn. 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 edn. 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 15: Fundamentals of Artificial Intelligence (AI) & Intelligent Systems

Unit 26: Big Data Analytics and Visualisation.

Unit 47: Emerging Technologies

Unit code R/618/7483

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, it allows rapid development and the sharing of ideas, products and scientific understanding 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 to create entirely new scientific fields and novel technologies by converging different systems, technology, thinking and disciplines. Emerging technologies include changing technologies that display radical novelty, have the potential for significant commercial or social impact and fast growth and scalability, and which affect the future in uncertain ways.

This unit introduces students to the role, benefits, disadvantages and potential outcomes that emerging technologies have in the development of software applications and business practices. The aim of the unit is to enhance students' understanding of the current types, terminology, advantages, disadvantages, potential impact and benefits of emerging technologies.

Among the topics included in this unit are classification and terminology of emerging technologies, review of the most promising and impactful emerging technologies, trends of convergence, the impact of emerging technologies on software development and an understanding of the scale, scope that emerging technologies may have on organisations their employees and the individuals served by them.

On successful completion of this unit, students will be able to explain some of the most promising and impactful emerging technologies and the advantages and disadvantages. Students will also understand the impact that emerging technologies 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 Review which emerging technologies are necessary and appropriate when designing software applications for the future

LO2 Research an emerging technology and its impact on a given end-user group

LO3 Develop multiple iterations of an emerging technology solution based on requirements

LO4 Consider the ethical, social, economic and legal factors that play a role in the success of emerging technologies.

Essential Content

LO1 Review which emerging technologies are necessary and appropriate when designing software applications for the future

Formats, characteristics and trends of emerging technologies:

Overview of emerging technologies and their appropriate use in software development.

Emerging technology role, purpose and terminology.

Recognise the various forms of emerging technology e.g. educational technology, information technology, nanotechnology, biotechnology, cognitive science, robotics and artificial intelligence.

History and current trends in emerging technologies.

Characteristics of emerging technologies, how they can be used and how they differ from and converge with developed technology.

Recognise specific emerging technologies:

Current trends in emerging technologies and their use in software development and computing e.g. AI, blockchain, IoT, Virtual Reality (VR), Augmented Reality (AR).

Advantages of emerging technologies e.g. efficiency gains, increased effectiveness, new and innovative approach.

Risks of emerging technologies e.g. security and data breach risks, fairness and equity due to bias, costs could be high, ethical and legal compliance.

Emerging technologies versus disruptive technologies.

Appropriateness of using of emerging technologies to disrupt the status quo in industries, markets, user adoption and established practices.

LO2 Research an emerging technology and its impact on a given end-user group

Emerging technology impact:

Investigate specific emerging technology that will have the most impact on software application design and development.

Selection of a specific industry and end-user group that will be the most influenced by emerging technology e.g. doctors in diagnostic health setting, bankers in finance and predictive modelling.

Features of selected emerging technology:

Examination of features based on a specifically selected emerging technology to include key characteristics, area(s) of application, impact on user group and working practices e.g. change of job roles, automation, use of systems, working policies.

Contrast the features, advantages and disadvantages of chosen Emerging Technology.

Convergence:

Technologies cohabiting in a single device, sharing resources and interacting, creating new technology and convenience.

How chosen Emerging Technologies can converge with existing technologies or replace them e.g. blend of the mobile telephone and the Internet, design of hybrid vehicles.

LO3 **Develop multiple iterations of an emerging technology solution based on requirements**

Emerging technology solution:

Small scale prototype solution for a specific user need e.g. AI chatbot, VR video experience, IoT smart solution, 3D printing solution.

Iteration:

Understand end-user requirements by conducting a needs analysis.

Developing an initial prototype based on end user needs.

Iteration based on user feedback and testing.

LO4 **Consider the ethical, social, economic and legal factors that play a role in the success of emerging technologies**

Social, economic, and legal factors:

Understanding emerging technologies can produce unintended consequences.

Ability of emerging technologies to transform cultural mores and traditions, economic trends and structures, political behaviour, legal processes and principles, environmental systems and conditions.

The governance challenges associated with emerging technologies e.g. regulations, policies, laws, and constitutions staying abreast of technological advances.

Organisational decision-making process behind technological implementation including the choice between human capital and technology.

Balancing technology risks and rewards including achieving tangible benefits from emerging technologies and predicting threats associated with new innovations.

Replacing existing technologies or change ways of working:

Changes in practice e.g. AI and deep learning replacing traditional medical diagnosis methods, predictive maintenance in IT and industry versus scheduled processes, autonomous or self-driving vehicles replacing human drivers.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Review which emerging technologies are necessary and appropriate when designing software applications for the future</td><td rowspan="2">D1 Evaluate emerging technologies and justify their use when designing software applications for the future.</td></tr>
<tr><td>P1 Review various forms of emerging technologies, focusing on their relevance to software development and computing.

P2 Explore the benefits and risks of emerging technologies.</td><td>M1 Assess formats, characteristics and trends of emerging technologies.

M2 Justify the ability of emerging technologies to disrupt the status quo in industries, markets, user adoption and established practices.</td></tr>
<tr><td colspan="2">LO2 Research an emerging technology and its impact on a given end-user group</td><td rowspan="4">LO2 and LO3

D2 Evaluate the solution developed including its impact on a given end user group and their current systems and working practices.</td></tr>
<tr><td>P3 Research a specific industry and end-user group that will be the most influenced by a selected emerging technology.</td><td>M3 Examine the features, of the selected emerging technology.</td></tr>
<tr><td colspan="2">LO3 Develop multiple iterations of an emerging technology solution based on requirements</td></tr>
<tr><td>P4 Develop a solution using an emerging technology for a given end-user group</td><td>M4 Make multiple iterations of your solution based on feedback gathered from end-user group.</td></tr>
</table>

Pass	Merit	Distinction
LO4 Consider the ethical, social, economic and legal factors that play a role in the success of emerging technologies.		
P5 Summarise the importance of considering ethics in the development of emerging technologies. **P6** Discuss the influence of social, economic, and legal factors on the development and deployment of emerging technologies.	**M5** Analyse the regulatory challenges in keeping up with the pace of development of emerging technologies.	**D3** Defend the adoption of emerging technologies despite the ethical, social, economic, and legal challenges.

Recommended Resources

Textbooks

Christensen, C. M. (2015) *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (Management of Innovation and Change)*. Harvard Business Review Press.

Schwab, K. (2016) *The Fourth Industrial Revolution.* World Economic Forum

Thiel, P. and Masters, B. (2014) *Zero to One: Notes on Startups, or How to Build the Future.* Virgin Digital.

Web

frontiersin.org	Frontiers Politics of Technology—Specialty Grand Challenge (Article)
cipd.co.uk	CIPD – The Professional Body for HR and People Development The impact of emerging technologies on work (Article)

Links

This unit links to the following related unit:

Unit 17: Business Process Support.

Unit 48: Virtual & Augmented Reality Development

Unit code Y/618/7484

Unit level 5

Credit value 15

Introduction

Virtual (VR) and Augmented Reality (AR) 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 and entertainment purposes. VR and AR offers the potential to work, interact, play, collaborate and communicate in expansive simulated environments as well as 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 use them in the development of VR/AR computer applications. Students will gain an 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. They will know how to plan, build and measure the success of an appropriate VR or AR software application and 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 aspects of VR and AR technology necessary when designing VR and AR software applications

LO2 Plan a VR or AR software application using common architecture, frameworks, tools, hardware and APIs for a scenario

LO3 Design, build and simulate a VR or AR software application for a given scenario

LO4 Review a VR or AR software application developed, based on end user feedback, to judge success.

Essential Content

LO1 **Examine aspects of VR and AR technology necessary when designing VR and AR software applications**

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.

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.

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 a VR or AR software application using common architecture, frameworks, tools, hardware and APIs for a scenario**

Application concept to develop in AR/VR:

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.

Select the most appropriate AR/VR architecture, frameworks, tools, hardware and API techniques.

Plan to develop AR/VR application concept:

Use selected techniques to create an AR/VR application development plan.

LO3 **Design, build and simulate a VR or AR software application for a given scenario**

Appropriate tools and techniques to develop an AR/VR application:

Employ an appropriate set of tools to develop plan into an AR/VR application.

Run different types of end-user experiments to gather a range of feedback.

Reconcile and evaluate end user feedback to plan enhancements.

Advantages and disadvantages of chosen AR/VR techniques in terms of impact on designed software and meeting needs of the scenario.

LO4 **Review a VR or AR software application developed, based on end user feedback, to judge success**

End-user feedback on AR/VR application:

Undertake a critical review of both positives and negatives.

Compare final application with the original plan to determine how well it meets needs of the scenario.

Evaluate the advantages, disadvantages, strengths and weaknesses of AR/VR techniques selected.

Critique the overall success of your application including how successfully it met needs of the scenario and end user feedback.

Problems in development including quality of feedback, tools and platforms selected, timeframe, skill and technique.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Examine aspects of VR and AR technology necessary when designing VR and AR software applications		
P1 Explore the necessary aspects of AR/VR technology when designing applications. **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.	**D1** Evaluate the advantages and disadvantages of AR/VR technology in developing an AR/VR application for a given scenario, including that of the architecture and techniques that have been selected.
LO2 Plan a VR or AR software application using common architecture, frameworks, tools, hardware and APIs for a scenario		
P3 Propose architecture, frameworks, tools, hardware and API techniques to develop a specific AR/VR application for a given scenario.	**M2** Justify the use of the proposed architecture, frameworks, tools, hardware and API techniques selected for an AR/VR application.	**D2** Improve the application through multiple iterations from user feedback and experimentation, commenting on how the improvements will enhance the application.

Pass	Merit	Distinction
LO3 Design, build and simulate a VR or AR software application for a given scenario		**LO3 and LO4**
P4 Apply appropriate hardware, software, data, platforms and services to develop a planned design into an application. **P5** Examine feedback from end-user experiments to plan enhancements.	**M3** Adjust the application based on the enhancements planned from the feedback gathered. **M4** Determine the advantages and disadvantages of the chosen techniques.	**D3** Critically evaluate the overall success of the software application against the design objectives, detailing any problems or limitations.
LO4 Review a VR or AR software application developed, based on end user feedback, to judge success.		
P6 Summarise end-user feedback on the AR/VR application developed.	**M5** Examine how the final AR/VR application differs from the original design planned.	

Recommended Resources

Textbooks

Parisi, T. (2015) *Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop*, Web and Mobile. O'Reilly Media.

Schmalstieg, D. an Hollerer, T. (2016) *Augmented Reality: Principles and Practice (Usability).* Addison-Wesley Professional.

Links

This unit links to the following related units:

Unit 21: Application Program Interfaces

Unit 45: Internet of Things.

Unit 49: Systems Integration

Unit code D/618/7485

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, for example stock control, accounts, human resources, 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 communicate effectively with each other. However, IT systems from different vendors or suppliers often use different hardware and/or software platforms and services, creating the need for systems integration.

This unit introduces students to enterprise business requirements and the need for and purpose of systems integration to support organisational goals. Students will gather and review business objectives with the aim of developing a systems specification document. As part of a feasibility analysis, students will evaluate factors and issues affecting the successful completion of integration, including describing and documenting the functional architecture and design of a system. Students will explore the hardware and software technologies used to connect systems and subsystems and will establish an integration methodology to design and implement an integrated solution. Students will also investigate and compare different cloud service models and evaluate deployment methods, considering 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 in terms of business objectives. They will know how to investigate different hardware and software systems in terms of connectivity, communication and data transfer, and be able to prepare a suitable integrated solution based on a set of business requirements. They will also be able to compare a range of cloud computing providers and evaluate their services. 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 systems integration requirements in terms of business objectives

LO2 Investigate different hardware and software systems in terms of 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 in terms of the impact on systems integration.

Essential Content

LO1 **Analyse systems integration requirements in terms of business objectives**

Identification of business objectives:

The purpose and operation of 'systems integration'.

Interpreting business needs from different functional areas and departments.

Developing a systems specification document, including establishing and that ensuring requirements can be met.

The concept of non-functional requirements, including security, availability, scalability, and manageability.

Feasibility analysis:

Use of risk assessments to evaluate issues threatening the successful completion of integrating systems, including identifying any reasonable steps necessary to prevent or mitigate issues.

Appropriate risk mitigation strategy, including assuming and accepting some risk, avoidance of risk, control of risk, transference of risk and watching and monitoring risk.

Architectural development, including describing and documenting the functional architecture and design of the system and specifying all technical requirements and capabilities.

LO2 **Investigate different hardware and software systems in terms of connectivity, communication and data transfer**

Exploration of hardware and software technologies:

Research hardware and software servers, technologies, platforms and services impacted by the systems integration process.

Methods of connecting systems and subsystems, including custom software services and development.

Establishment of a systems integration methodology:

Operational configuration, including 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, including using top-down and bottom-up methodologies.

LO3 **Prepare a suitable integrated solution based on a set of business requirements**

Integrated systems solution document:

Based on using existing systems specification and risk assessment documents, including illustrated design diagrams and details on information flow.

Detailed integrated systems solution including fully annotated diagrams, details on information flow, risk, redundant systems, back-ups, security, connectivity, deployment and testing.

Establishment of a strategic approach:

Analysis of functional architecture and technical capabilities against a specification document, to determine the probability of successfully developing (and deploying) an effective integrated solution.

Establishment of a management strategy based on business needs.

System design, development and deployment:

Design, development and monitoring of an integrated system.

Quality Assurance, including deploying and testing an integrated system.

Evaluation of system functionality, including documentation, maintenance and upgrades.

LO4 **Compare a range of cloud computing providers and evaluate their services in terms of the impact on systems integration**

Investigation and comparison of cloud service models:

IaaS (Infrastructure as a Service).

PaaS (Platform as a Service).

SaaS (Software as a Service).

Investigation and comparison of deployment models:

Private, public and hybrid clouds and issues including security, privacy and constraints.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Analyse systems integration requirements in terms of business objectives		**LO1 and LO2**
P1 Discuss the objectives and effect of systems integration in terms of 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 systems integration and review the purpose and impact of assessing risk.	**D1** Critically evaluate the detailed system specification and risk assessment document, including justification of how each of the specified business objectives has been met.
LO2 Investigate different hardware and software systems in terms of 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.	**M2** Analyse selected systems, platforms, technologies and services, including system and service connectivity.	

Pass	Merit	Distinction
LO3 Prepare a suitable integrated solution based on a set of business requirements		**LO3 and LO4**
P5 Create an integrated systems solution to a set of specific business objectives. **P6** Create a systems deployment and test plan suitable for use with an integrated systems solution.	**M3** Produce a detailed integrated systems solution with a full review of the solution's functionality compared to the systems specification document.	**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 in terms of the impact on systems integration		
P7 Discuss the differences between IaaS, PaaS and SaaS services, and compare the private, public and hybrid deployment models offered by cloud computing providers.	**M4** 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. (2020) *Business Analysis*. 4th edn. 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 unit:

Unit 28: Cloud Computing.

Unit 50: Operating Systems

Unit code H/618/7486

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 foundation 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 operate any given operating system competently and undertake routine maintenance and optimisation of operating 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 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 and evolution of operating systems:

How operating systems started and developed.

The history of operating systems from legacy operating systems to current operating systems including the development from batch files to modern operating systems.

Operating system role:

What is meant by an operating system.

Understand why operating systems are needed.

Similarities and differences between operating systems and firmware.

LO2 **Explore the processes managed by an operating system**

Operating systems management:

Memory management including virtual memory.

Scheduling and process scheduling in operating systems including various CPU scheduling algorithms.

Concurrent processing.

Device management.

File management.

Resource management.

The functions of IoT operating systems including overview of IoT operating systems and firmware.

LO3 **Demonstrate the use of different operating systems with a range of commands**

Operating system knowledge:

Commands for manipulating a range of different operating systems, e.g. MS-DOS, Windows, UNIX, Linux.

Demonstration of operating systems tasks e.g. creating or removing a directory.

Operating systems' environments, including distributed operating systems concurrent operating systems.

Security and communications:

How secure different operating systems are including different environments and the conditions of use.

Functional and logical architecture of IoT Platforms, e.g. Huawei's OceanConnect, Amazon Web Services (AWS), Google Cloud Platform, IBM Watson IoT, Microsoft Azure.

Common IoT communication protocols, CIG functions and architecture, features of IoT platforms.

LO4 **Examine how operating systems will function in the future and the implications on security**

Future of operating systems:

Consider desktops, laptops, smartphones and other devices in terms of operating systems development environment.

Introduction of artificial intelligence and impact on operating systems development e.g. mobile operating systems like Android and iOS equipped with AI-based voice assistants.

Connectivity e.g. Internet of things.

Support for cloud computing and outsourcing of operating system functions in the cloud.

Open source operating systems and their impact on future development projects.

Review trends in virtualisation, emulation and use of sophisticated operating systems in mobile systems.

Security e.g. biometrics.

Multi-modal interaction e.g. touch, type, speech.

User centred design.

Automation of common tasks based on user habits.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Investigate different operating systems, their functions and user interfaces		**LO1 and LO2**
P1 Summarise what an operating system is and how it works with reference to different examples. **P2** Research the evolution of operating systems.	**M1** Discuss the importance of operating systems.	**D1** 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** Illustrate the importance of resource management in an operating system to aid its efficiency.	
LO3 Demonstrate the use of different operating systems with a range of commands		**LO3 and LO4**
P5 Demonstrate common commands on different operating systems. **P6** Compare how different commands are carried out on different operating systems.	**M3** Analyse the security of different operating systems.	**D2** Evaluate the role of different operating system in meeting the needs of future technologies and the implications on security.
LO4 Examine how operating systems will function in the future and the implications on security		
P7 Explore the core features modern operating systems will require to meet future needs.	**M4** Assess how the features of modern operating systems will support the development of future needs.	

Recommended Resources

Textbooks

Arpaci-Dusseau R.H., Arpaci-Dusseau, A.C. (2018) *Operating Systems, Three Easy Pieces.* CreateSpace Independent Publishing Platforms.

Davis, W. S. and Rajkumar, T. M. (2005) *Operating Systems: A Systematic View*. 6th edn. Harlow, Addison-Wesley.

McHoes, A. M. and Flynn, I. M. (2017) *Understanding Operating Systems*. 8th edn. Course Technology.

Tanenbaum, A. S. (2016) *Modern Operating Systems*. 4th edn. India. Pearson.

Tomsho, T. (2016) *Guide to Operating Systems*. 5th edn. Boston. Cengage Learning.

Woodhull, A. S. and Tanenbaum, A. S. (2006) *Operating Systems: Design and Implementation*. 3rd edn. Upper Saddle River. Prentice Hall.

Links

This unit links to the following related unit:

Unit 40: Client/Server Computing Systems.

Unit 51: E-Commerce & Strategy

Unit code K/618/7487

Unit level 5

Credit value 15

Introduction

Electronic Commerce, known as 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, including consumer-based retail sites, for example Amazon, sites that provide facilities such as auctions, for example eBay and business exchanges between different organisations. E-Commerce allows consumers to exchange goods and services electronically, 24/7 with no barriers in terms of time or geography.

This unit gives students an understanding of how and why businesses and organisations develop E-Commerce strategies to remain competitive in the global market. Students will gain appreciation of the elements and resources required to set up an E-Commerce site. They will engage in the design and implementation of 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. Students will research the technologies involved in setting up a secure E-Commerce site in preparation for implementing their own E-Commerce strategy. Students will devise their strategy based on an element of E-Commerce, such as the design of a shopping cart, an ordering system, payment system or an online marketing system. Their design should be fully implemented and evaluated accordingly in terms of its success or failure. Students will explore standards and levels of support, marketing, CRM, promotion and supply chain management in the context of developing their implementation strategy.

On successful completion of this unit, students 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 E-Commerce strategies and their impact on business organisations

LO2 Review 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 E-Commerce strategies and their impact 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 and services 24/7.

Drawbacks:

Visibility, security issues and threats, down-time, high se- up and maintenance costs, need to employ a technician or web-based administrator to manage the provision.

LO2 **Review 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:

Demonstration that the marketing, supply chain or payment-based E-Commerce strategy, e.g. designing an online ordering system or online payment system, devised has been implemented using suitable tools and applications.

Evaluation:

Evaluation of 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 E-Commerce strategies and their impact on business organisations		
P1 Discuss the importance of addressing and meeting customer expectations when employing an E-Commerce strategy.	**M1** Analyse organization case studies and examine how E-Commerce has been used to improve an element of business operations.	**D1** Critically review the benefits and drawbacks for an organisation that is utilising E-commerce.
LO2 Review 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. **P4** Design an E-Commerce solution based on a specified requirement or strategy.	**M3** Analyse the factors and resources that should be considered when designing an E-Commerce strategy. **M4** Differentiate between the types of payment systems that are integral to E-Commerce success.	**D3** Appraise the design and functionality of the E-Commerce solution.
LO4 Implement an E-Commerce strategy based on a given end-user requirement or specification		
P5 Implement a designed E-Commerce solution for an end-user based on a specified requirement or strategy.	**M5** Produce a detailed SWOT analysis to support the implemented E-Commerce design.	**D4** Evaluate how successful the E-Commerce implementation was and 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 edn. Kogan Page.

Chaffey, D. (2009) *E-Business and E-Commerce Management: Strategy, Implementation and Practice*. 4th edn. Financial Times: Prentice Hall.

Laudon, K. and Traver, C. (2015) *E-Commerce*. 11th edn. Pearson.

Phillips, J. (2016) *Ecommerce Analytics: Analyze and Improve the Impact of Your Digital Strategy.* 1st edn. Pearson FT Press.

Journals

Journal of Electronic Commerce Research (Online)

Journal of Electronic Commerce in Organizations (JECO) (Online)

Websites

networksolutions.com	Network Solutions Education Centre *Developing an E-Commerce Strategy* (Article)
ecommercefuel.com	E-Commerce Fuel (Discussion Forum)

Links

This unit links to the following related units:

Unit 4: Database Design & Development

Unit 17: Business Process Support

Unit 41: Database Management Systems.

Unit 52: Digital Sustainability

Unit code A/618/5694

Unit level 5

Credit value 15

Introduction

Living and working in the 21st century in the digital technologies sector presents a range of unforeseen sustainability challenges. These challenges are based on, among other potential issues, mineral resource, ethical working and employment practices, economic impact, supply chain and climate impact.

The Brundtland Commission of the United Nations in March 1987 defined sustainability as: 'sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Digital technologies is a sector in the frontline of the battle to overcome the challenges of creating a sustainable economy, but no single discipline has the capability to tackle the problems. Sustainability is a multidisciplinary challenge and technologists of the future will have to work collaboratively with a whole range of other stakeholders, such as engineers, scientists, governmental bodies and financiers, in order to find, within an urgent timescale, the practical and technological solutions needed.

On successful completion of this unit, students will have gained a wide range of knowledge and understanding of the issues and topics associated with sustainability and low impact digital technology solutions. They will have explored the interdisciplinary context of sustainability and how the development of a low carbon economy is essential in the digital technology sector. Students will have explored a current digital technology solution and evaluated its impact and potential sustainability, evaluating a range of solutions and data sources.

Learning Outcomes

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

LO1 Determine the nature and scope of the technical challenges, ensuring sustainability, within the digital technologies sector

LO2 Explore the importance of collaborating with other disciplines in developing digital technical solutions to sustainability problems

LO3 Evaluate the use of sustainable techniques in relation to their contribution to a low carbon economy

LO4 Calculate the carbon footprint of a digital technologies' solution.

Essential Content

LO1 **Determine the nature and scope of the technical challenges, ensuring sustainability, in the digital technologies sector**

The scope and social context of sustainability:

Current sustainable development and digital technology challenges.

Moore's Law and the Brundtland definition of sustainability in a digital technologies context.

Impact of global demographics, trends and predictions, population growth and how this affects demand, economics, employment ethics and resource availability.

Environmental issues:

Climate change, planetary energy balance, carbon cycle science, carbon footprint of digital technologies, including: power consumption, mineral and material use, shipping, heat/energy output, packaging, recycling and safe disposal, potential pollution issues, contaminants in older equipment, low carbon power sources, corporate social responsibility and sustainable use of technologies – extending lifetime utilisation.

LO2 **Explore the importance of collaborating with other disciplines in developing digital technical solutions to sustainability problems**

Systems thinking and socio-technical systems:

The politics and economics of sustainability, following the principles of the Kyoto Protocol, UN Climate Change Conference (COP) and European Union Emissions Trading System (EU ETS).

Maintaining sustainable infrastructures:

Low carbon transport systems, engaging with sustainable cities and societies, using green building and built infrastructure principles, ensuring the use of low impact power generation, power storage and power distribution. Assuring low impact, sustainable logistics and maintaining a low-waste-based system.

Ethical standards:

Assuring 3rd party supplier, manufacturer and supply chain contractors all conform to current ethical sustainable and fair employment standards, along with associated legislation, e.g. ethical sourcing and disposal of end-of-life electrical equipment – Waste Electrical and Electronic Equipment (WEEE) Regulations (2013). Use of environmentally neutral, beneficial 3rd party cloud solutions, reviewing ecological credentials of cloud provisioning organisation.

LO3 **Evaluate the use of sustainable techniques in relation to their contribution to a low carbon economy**

Sustainable techniques:

Evaluating how digital technologies can be maintained via nuclear, solar, wind, tidal and wave, geothermal, biomass and bioenergy. Ensuring whole life cycle costing and using the precautionary principle.

Exploring the cost, power consumption and impact of digital technologies in a sustainability context, e.g. data centres, robotics in engineering, digital manufacturing, automated transport, telecommunications, health technologies, agri-tech.

Evaluate the KWH (kilowatt hour) power consumption of cloud solutions, data transmission and device use (routers, switches, servers, desktop systems, mobile computing, smart devices, wireless, wired etc.). Powering down devices when unused, reducing standby time, power consumption on 'spin up' to full utilisation.

LO4 **Calculate the carbon footprint of a digital technologies' solution**

Impact of digital technologies on climate:

Direct carbon emissions associated with digital technology manufacture, use and disposal. Case studies, e.g. Google Carbon Offset Data Centers, Microsoft and Ørsted offshore wind power, HP ink cartridge recycling program, NHS Electronic Prescription Service (EPS), Coca Cola manufacturing and warehouse automated robots.

Indirect positive emission effects from using digital technologies, e.g. travel substitution and transportation optimisation.

Impact that digital technologies have on behaviours and references, e.g. reshaping how we lead our lives.

Carbon footprint:

Evaluating the digital technology carbon footprint perspective, including organisational, value and supply chain, product-based challenges, current carbon footprint science, calculation of footprint based on system boundaries (limits of sphere of influence and control), geographical location, e.g. Global Carbon Project (GCP) map.

Calculation of carbon footprint, e.g. ISO 14067:2018 – Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification.

Decarbonisation of digital technologies:

Significance of digital technology electricity consumption. Use of renewable energy, e.g. solar and wind power, to lower carbon emissions.

Impact of new and evolving digital technologies, e.g. artificial intelligence (AI).

Digital technologies as a driver of greater sustainability.

Approaches to reducing digital technologies carbon footprint, e.g. maintaining digital devices to prolong life, use digital devices for longer before upgrading, recycle/reuse equipment, consume digital services on smaller devices, charge batteries with electricity from renewable sources, purchase digital devices and services from companies that have science-based targets (SBTs), use digital technology to help to reduce carbon emissions.

Data sources:

Evaluating power consumption, manufacturers' ecological/green rating of device(s), data sheets, regional waste-management metrics, energy efficiency ratings.

Long-term sustainability:

Projecting long-term sustainability of selected digital technologies to include sustainability plan and practices, e.g. zero-carbon, carbon neutral, net-positive approach, green IT; voluntary sustainability report, stakeholder engagement.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Determine the nature and scope of the technical challenges, ensuring sustainability, in the digital technologies sector		
P1 Investigate the nature and scope of the technical challenges of ensuring sustainability for the digital technologies sector.	**M1** Analyse the impact of sustainability on the deployment of digital technologies.	**D1** Critically analyse the interrelationship between sustainability, digital technology demand and resource availability.
LO2 Explore the importance of collaborating with other disciplines in developing digital technical solutions to sustainability problems		
P2 Explain the interdisciplinary issues associated with the construction of sustainable infrastructures, with attention to the competing pressures within these infrastructures.	**M2** Analyse how political, economic and ethical standards can impact digital technical solutions.	**D2** Critically analyse how a systemic approach can be used to support interdisciplinary collaboration in developing sustainable digital technologies.
LO3 Evaluate the use of sustainable techniques in relation to their contribution to a low carbon economy		
P3 Discuss the sustainable techniques that need to be considered when selecting alternative low carbon energy sources.	**M3** Analyse the challenges present, when selecting low carbon sustainable techniques for a digital technology solution.	**D3** Critically analyse how current digital technology solutions could be improved via the application of low carbon sustainable techniques.
LO4 Calculate the carbon footprint of a digital technologies' solution		
P4 Calculate the carbon footprint of a digital technology solution.	**M4** Analyse the use of renewable energy to lower carbon emissions to support a digital technology solution.	**D4** Critically review the overall carbon footprint impact and long-term sustainability of an existing digital technologies solution.

Recommended resources

Textbooks

BERNERS-LEE, M. (2019) *There Is No Planet B: A Handbook for the Make or Break Years* Cambridge University Press

BERNERS-LEE, M. (2010) *How Bad Are Bananas?* Profile Books.

BOYLE, G. (2012) *Energy Systems and Sustainability: Power for a Sustainable Future.* Oxford University Press.

FENNER, A. and AINGER, C. (2013) *Sustainable Infrastructures: Principles into Practice.* ICE Publishing.

HAZAS, M. & NATHAN, L (2017) *Digital Technology and Sustainability: Engaging the Paradox,* Routledge

HELM, D. (2015) The Carbon Crunch: *Why we are Getting Climate Change Wrong and How to Fix It.* Yale University Press.

HONE, D. (2014) *Putting The Genie Back: 2°c Will Be Harder Than We Think.* Whitefox Publishing.

Websites

bsigroup.com	Product Carbon Footprinting for Beginners – guidance for smaller businesses on tackling the carbon foot printing challenge (Article)
carbontrust.com	Carbon Trust Carbon foot printing (General reference)
fern.org	FERN Trading Carbon How it Works and Why it is Controversial (E-book)
gov.uk/guidance/regulations-waste-electrical-and-electronic-equipment	UK Government Technology Waste Disposal (General Reference)
populationinstitute.org	Population Institute Demographic Vulnerability report (Report)

Links

This unit links to the following related units:

Unit 12: Management in the Digital Economy

Unit 53: Digital Technologies as a Catalyst for Change.

Unit 53: Digital Technologies as a Catalyst for Change

Unit code	**T/618/5662**
Unit level	**5**
Credit value	**15**

Introduction

Digital technology has transformed how people communicate, learn, and work. This sector is one of the most valuable and fastest growing economic areas in most of the world. Although the first electronic digital computer was created in the 1930s, the digital revolution began between the late 1950s and 1970s, when key developments of technologies from mechanical and analogue to digital took place. It was during this time that the use of digital computers and digital record keeping became the norm. The industry has grown rapidly in recent decades and digital technologies are now a part of our daily lives. The digital technologies we are familiar with today are the electronic tools, systems, devices and resources that generate, store or process data. Most popular examples include mobile phones, social media, online games, virtual reality and multimedia. Spanning cultural, creative, educational and many other industries, digital technologies are a vibrant sector with growth that has surpassed the rest of the economy. Digital technology has completely modified the way we live today and in years to come this will be even more incredible.

In this unit, students will explore the impact of both the current and emerging digital technologies across different industries and investigate how organisations and businesses use digital technologies to meet their needs. They will also look at how an organisations strategy and leadership decision making is impacted by digital technology implementation. They will plan a solution for a specific organisation to use a new or emerging technology.

This unit can be delivered alongside the Emerging Technologies unit where they must implement a planned solution, thus allowing students an opportunity to demonstrate putting their digital technology implementation plan into action.

On successful completion of the unit, students will have explored industry sectors that use digital technologies, the history of the industry, current and emerging digital technologies, and how organisations are adapting and solving problems using digital technologies and planning for the future.

Learning Outcomes

By the end of this unit a student will be able to:

LO1 Explore how digital technologies impacts organisational change

LO2 Evaluate how the use of digital technology impacts on an organisation's strategy and operations to meet its needs

LO3 Investigate how digital technologies influence leadership decision making in relation to a specific industry

LO4 Present a new or emerging digital technology solution to manage a change initiative within a specific organisation.

Essential Content

LO1 Explore how digital technologies impact organisational change

Evolution of current digital systems and technologies:

Development of the digital technologies sector and the impact on organisational change, e.g. evolution of digital technologies, computers, laptops, smartphones, tablets/touchscreen devices, SMART products and experiences, digital manufacturing, Cloud technologies, virtual reality experiences.

Industries using digital technologies:

The impact of digital transformation in different industries, e.g. automotive and manufacturing, banking and financial services, government/public sector, healthcare, marketing, retail and consumer packaged goods, sport, agriculture, telecom and media/entertainment, travel/transportation.

Emerging digital technologies:

Impact of emerging digital technologies on organisational change, e.g. robotics, Artificial Intelligence (AI) (including Machine Learning), cybersecurity, Internet of Things (IoT), Blockchain, Bitcoin, Virtual Reality and Augmented Reality, Edge Computing.

Purposes:

Purpose of digital technologies on organisational change, e.g. social connectivity, global communication/communication speed, wider consumer reach, support remote working, e.g. local, national, and international, versatile working, e.g. flexible working practices, increased connectivity options, information storage, reduce costs, improving productivity, increasing promotion and sales, meeting business goals, improving efficiency, recruitment, education, increase business support, enhance customer experience/providing instant customer service, technical support, news and updates, GPS and mapping.

Rationale for change management:

Digital transformation and the disruptive effects of emerging technologies on organisational change.

The value of digital transformation to improve organisational performance, seize new opportunities, address key issues, optimise the customer experience.

Types of organisational change:

Change in a business context, including large scale, e.g. radical, discontinuous, revolutionary and small scale, e.g. incremental, evolutionary.

Different types of change that include planned or emergent, initiated or imposed.

Types of internal organisational change: structural, strategic, people and process change.

Individual, group and organisational levels of change.

Change management models:

Different approaches to managing change within organisations, e.g. Kotter's 8 Step model, McKinsey 7-S, ADKAR (Awareness, Desire, Knowledge, Ability and Reinforcement), Kubler-Ross Change Curve, Lewin's change management model.

The benefits and drawbacks of the key change models.

LO2 **Evaluate how the use of digital technology impacts on an organisation's strategy and operations to meet its needs**

Responding to drivers of change:

Using systems theory and continuous improvement models to predict and proactively plan for change.

Burke-Litwen mode to make the change process efficient and effective.

Change impact assessment:

Organisational strategy, e.g. business plans, annual forecasts, aims and objectives, short/long-term goals, financial accounts (including profit and loss), financial projections.

Operational aspects, e.g. organisational structure, human resources, physical resources, working hours, staffing (internal and external), sales, advertising, marketing.

Business needs, business type e.g. large corporate, SME, freelance, self-employed.

Types of technology that organisations use to provide a product/service, needs and/or benefits of the customers/clients, hardware/software/network requirements, security requirements.

Methods to identify needs e.g. gap analysis process, feasibility study (based on organisation's needs, market research), digital strategy/digital policies of business plan, feedback from stakeholders, customers, employees.

Assessing if technology meets an organisation's needs:

Benefits realisation, e.g. improved efficiency, increased profit, increased productivity, reduction in wasted time, reduction in cost.

Risks and issues, e.g. customer feedback, complaints, loss of sales, profit loss.

Change management, e.g. training, transition from existing to new technology, risk of loss of service/data.

Ethical considerations, e.g. consultation with stakeholders, data ownership, impact on employees.

Data management and access, e.g. privacy, security of data.

Legal considerations of digital transformation use of data, technology and software as a means of generating meaningful business insight and conduct operations more efficiently. Legislation includes, e.g. Intellectual Property (IP), copyright, trademarks, trade secrets, compliance, e.g. data protection and security, data mining and control, use of data for advertising, Computer Misuse Act 1990.

Change management processes:

Sequence of steps or activities that move change from inception to delivery, e.g. identify need for change, impact analysis, approve/deny, implement, review/report.

LO3 **Investigate how digital technologies influence leadership decision making in relation to a specific industry**

Driving factors of change:

The external and internal drivers that are driving change.

The implications of current factors for future development of digital technologies and decision making, e.g. distributed ledger technology (DLT), and the impact for e-commerce, transformational impact of 5G networks on IT systems for faster and efficient decision making.

Barriers to change:

How barriers to change influence leadership decision making initiated or imposed change, e.g. deciding to be pre-emptive and proactive or responsive and reactive will be based on the situation and the nature/scope of the change.

Adaptive and constructive change.

The impact that the scope of the change may have on decision making.

Responding to barriers and resistance to change.

Barriers and resistance to change, e.g. force field analysis to understand likely opposition and support for change in a contemporary context.

Schein's organisational culture model, self-efficacy perceptions and situational resistance when determining barriers.

Leadership ethics for effective decision making e.g. respecting and valuing diversity, values and ethical beliefs.

Speed of change, e.g. pre-emptive and proactive or responsive and reactive.

Resource implications of digital development, e.g. financial, physical, human – requisite skills and experience.

Change factors:

Positive factors, e.g. increased skillsets, training opportunities, improve people's quality of life, wage increases, increased employment, enhanced career prospects.

Negative factors, e.g. loss of employment, reduced career progression opportunity, necessity to retrain in an alternative sector, impact of local community and wider economy.

Evolution of digital technologies and change management:

Current examples of digital technologies driving change.

Sustainability and the need for enhanced/refined digital technologies.

Agility and leadership in response to change.

Change at a time of crisis and long-term benefits, e.g. COVID 19 and rapid development of technology to provide lifesaving support, post-World War II enhanced vehicle manufacture, climate change.

Leadership skills and techniques to support change, e.g. focused, inspirational, flexible, ability to learn from mistakes, defined vision and outcome, clear communication, empowering, address unsatisfied employee issues, encourage team collaboration, challenge.

LO4 **Present a new or emerging digital technology solution to manage a change initiative within a specific organisation**

Initiating a change:

Influence of position and perception influence a view of change as negative or positive.

Types of organisational change as a result of digital technologies, e.g. structural and strategic, people and processes.

The impacts of change initiated by leaders, e.g. increased control, time and increased opportunity to select the best approach to apply.

The impacts of change that is imposed, e.g. opportunities are reduced or even negated.

The stages of the change lifecycle.

Managing change:

Different perspectives to dealing with change, e.g. individual, open system.

Change impact analysis, e.g. Bohner and Arnold, and impact analysis techniques.

The importance of stakeholder analysis and communication in change.

Application of the Burke-Litwin model to make the change process efficient and effective.

Planned and emergent change.

Strategies for managing different types of change, e.g. planning, communication, setting out a roadmap.

Developing solutions:

Project and time management plans.

The elements and principles of using digital technology hardware and software.

Equipment, techniques, and processes.

Suitability of selected equipment, techniques, and processes.

Health, safety, safe working practices.

Project reports and project evaluations.

Purpose and value of quality assurance techniques.

Present a resolved solution:

Different types of presentation formats, e.g. industry-standard presentation software.

Hierarchy of text-based and visual information.

The key considerations for delivering a presentation, e.g. timing, structure, pace.

Selection and editing of content presentation skills.

Audience:

The importance of understanding audiences and stakeholder requirements and the implications this has on presentation style etc.

Techniques for generating and collating audience feedback.

Justifications:

Supporting and justifying the choice of solutions using creative, cultural, social, political, economic trends and contexts.

Industry-specific terminology.

How to engage, interact and respond to audience feedback.

Reflective practice.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore how digital technologies impact organisational change		**LO1 and LO2**
P1 Investigate how digital technologies drive organisational change. **P2** Examine the impact of digital technologies, in the context of different industries.	**M1** Analyse the relationship between current and emerging technologies, their purposes and how these are being used in a specific industry context.	**D1** Make evidence-based recommendations on the use of emerging digital technologies for an organisation's strategy and operations to meet its needs, in a specific industry context.
LO2 Evaluate how the use of digital technology impacts on an organisation's strategy and operations to meet its needs		
P3 Assess how the use of digital technology impacts on an organisation's strategy and operations to meet business needs. **P4** Evaluate the methods used by an organisation to identify digital technology requirements.	**M2** Critically evaluate the methods used by an organisation to identify need and support the implementation of digital technology to meet its strategic goals.	
LO3 Investigate how digital technologies influence leadership decision making in relation to a specific industry		
P5 Examine barriers to change and determine how they influence leadership decision making in relation to digital technology implementation in a given industry context. **P6** Discuss the positive and negative factors that may arise as a result of a new digital technology implementation in relation to a given industry context.	**M3** Critically analyse the connection between positive and negative factors of digital technology development and its influence on the leadership decision making process.	**D2** Make valid conclusions based on critical analysis of factors of digital technology development, and their influence upon leadership decision making.

Pass	Merit	Distinction
LO4 Present a new or emerging digital technology solution to manage a change initiative within a specific organisation		
P7 Develop a plan to implement a digital technology solution for a specific organisational need. **P8** Conduct a change impact analysis to minimise the potential impact on the organisation of the digital technology solution.	**M4** Develop a strategic plan to implement a digital technology solution which minimises the impact of change.	**D3** Justify the digital technology solution developed, and its potential for successful implementation, and minimal organisational impact.

Recommended Resources

Textbooks

LEWIS, L. K. (2011) *Organizational Change: Creating Change Through Strategic Communication.* Chichester: Wiley-Blackwell.

SCHAEFFER, E. (2019) *Reinventing the Product: How to Transform your Business and Create Value in the Digital Age.* London: Kogan Page.

STANFORD, N. (2013) *Organization Design: Engaging with Change*. 2nd edn. London: Routledge.

VENKATRAMAN, V. (2017) *The Digital Matrix: New Rules for Business Transformation Through Technology.* Canada: Life Tree Media.

Journals

International Journal of Digital Enterprise Technology

Journal of Change Management

Journal of Organisational Change Management Leadership

International Journal of Digital Technology & Economy

Links

This unit links to the following related units:

Unit 47: Emerging Technologies

Unit 52: Digital Sustainability.

Unit 54: Prototyping

Unit code	**M/618/7488**
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 facet 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 the unit is to enhance 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 in order 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 and 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 and testing strategy for a specific end user

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:

Overview of prototyping, how prototypes are produced and their appropriate use in software development.

What a prototype is including role, purpose, terminology and methodology of prototyping.

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

Defining characteristics of a prototype, how they can be used, difference from complete applications.

Recognise appropriate prototyping formats to achieve specific end user-testing requirements and outcomes.

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

Agree current functionality and end-user testing trends and appropriate prototyping methodology.

Identify various forms of functionality and end-user testing methodology.

Advantages and disadvantages of using prototyping to perform end-user testing.

The value of following company, team or client approaches to continuous integration, version and source control.

Define standard tools available for use in prototyping:

Advantages and disadvantages of prototyping tools and standard tools available to develop prototypes. Categories of prototyping tools to support testing.

Use of prototyping tools to rapidly iterate and capture end-user feedback.

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

LO2 Plan a prototype and testing strategy for a specific end user

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

Conduct end user tests.

Benefits, features, advantages and disadvantages of different prototyping methodologies for various end-user testing outcomes.

Different end-user categorisations, classifications and behaviour modelling techniques.

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

Appropriate testing methods, e.g. static testing, change related, sequential, iterative and suitable metrics for the defect management process.

Appropriate prototyping methodology and tools to conduct end-user testing:

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

End-user characteristics, desired testing criteria and results your prototype addresses.

Difference between error, defect and failure, including the distinction between the root cause of a defect and its effects.

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

Prototyping plan including selected end user, appropriate prototyping methodology and desired testing criteria.

LO3 Develop multiple iterations of the prototype using appropriate tools

Utilise appropriate tools to develop multiple prototypes:

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

Run end-user experiments and examine feedback.

Reconcile and evaluate end-user feedback to build a new iteration of prototype.

Multiple iterations of prototype modified with enhancements gathered from end-user feedback and experimentation.

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

Assess the success of a prototype:

Assemble and appraise end-user feedback from multiple iterations of a prototype.

Review and compare final prototype and test results with the original plan including changes made to prototype which were not in the original plan.

The role of end-user testing and feedback in refining the prototype.

Advantages, disadvantages, strengths and weaknesses of prototyping methodology selected.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Explore forms of prototypes appropriate for various functionality and end-user testing requirements</td><td rowspan="4">LO1 and LO2

D1 Evaluate the impact of common prototyping methodologies on the software development lifecycle.</td></tr>
<tr><td>P1 Discuss specific forms of prototyping functionality and end-user testing requirements.

P2 Review standard tools available for use in prototyping.</td><td>M1 Assess specific forms of prototyping and the advantages and disadvantages of end-user testing requirements in terms of appropriateness to different testing outcomes.</td></tr>
<tr><td colspan="2">LO2 Plan a prototype and testing strategy for a specific end user</td></tr>
<tr><td>P3 Review different end-user categorisations, classifications and behaviour modelling techniques.

P4 Examine an appropriate prototyping methodology to test with a specific end-user.</td><td>M2 Apply end-user classification and behaviour modelling to select an appropriate prototyping methodology.

M3 Produce a plan suggesting an appropriate prototyping methodology and tools to conduct end-user testing.</td></tr>
</table>

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO3 Develop multiple iterations of the prototype using appropriate tools</td><td rowspan="4">LO3 and LO4

D2 Critically evaluate the prototype against the original plan and how user feedback and testing was implemented.</td></tr>
<tr><td>P5 Create a prototype based on a plan, using an appropriate prototyping methodology and tools.

P6 Perform end-user testing and examine feedback.</td><td>M4 Build multiple iterations of a prototype and modify each iteration with enhancements gathered from user feedback and experimentation.</td></tr>
<tr><td colspan="2">LO4 Evaluate end-user feedback and test results from multiple iterations of the prototype and end-user testing</td></tr>
<tr><td>P7 Review end-user feedback from multiple iterations of your prototype.</td><td>M5 Justify the updates to the final prototype based on end user feedback and testing.</td></tr>
</table>

Recommended Resources

Textbooks

Kalbach, J. (2021) *Mapping Experiences: A Complete Guide to Creating Value through Journeys, Blueprints, and Diagrams*. 2nd edn. 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 edn. Rockport Publishers.

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

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

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

Web

aws.amazon.com/devops	DevOps information and tools, including CI/CD (General Reference)
usability.gov	Information about product design, including prototyping and UX (General Reference)

Links

This unit links to the following related units:

Unit 1: Programming

Unit 7: Software Development Lifecycles

Unit 20: Applied Programming and Design Principles.

12 Appendices

Appendix 1: Mapping of 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	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 2: HNC/HND Computing Programme Outcomes for Students

	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
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		X	X	
2	X	X	X	X		X	X		X		X			X		X		X			X		X	X	X			X	X	X	X	X	X	X		X	X	X	X	X		X	X	
3	X	X	X	X	X	X			X		X		X		X	X		X	X	X		X						X	X	X	X	X	X	X	X		X	X	X		X	X	X
4	X	X	X	X		X	X		X	X	X	X	X	X		X	X	X			X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	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		
6	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X		X	X	X	X		X		X	X	X	X	X	X	X	X		X	X	X		X	X	X
7	X	X	X	X		X	X		X	X	X			X		X	X	X			X		X	X	X	X		X	X	X	X	X	X	X		X		X	X	X	X	X		
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	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	X	
10	X	X	X	X		X	X		X	X	X	X		X	X	X		X			X		X	X	X	X		X	X	X	X	X	X	X		X		X	X	X		X	X	X
11				X		X		X	X									X								X	X	X	X	X					X		X		X	X	X		
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	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	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	X	
18				X		X		X	X									X								X	X	X	X	X					X		X		X	X	X		
19	X		X	X		X		X	X		X			X		X		X			X		X	X	X	X		X	X	X	X	X	X	X		X		X	X	X		X	X	
20	X		X	X		X	X	X	X	X	X	X		X		X		X			X		X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X		X	X	
21	X	X	X	X		X		X	X	X	X			X		X	X	X			X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X		X		
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	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	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	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		
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	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	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
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	

	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
50	x		x	x		x	x		x	x	x			x			x				x		x	x	x	x		x	x	x	x	x	x	x		x		x		x		x	x	
51	x	x	x	x		x	x		x	x	x	x	x	x		x		x		x	x		x	x	x	x		x	x	x	x	x	x	x		x		x		x		x	x	
52	x	x	x	x		x		x	x		x			x	x	x	x	x		x			x	x	x		x	x	x	x	x	x	x	x		x		x		x		x	x	
53	x	x	x	x		x	x		x		x		x	x	x	x		x					x	x	x			x	x	x	x	x	x	x		x		x		x		x	x	x
54	x		x	x		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 3: 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			

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
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
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	
50		X	X	X	X			X	X	X	X			
51	X	X	X	X	X		X	X	X	X	X		X	X
52	X	X	X	X	X	X	X	X	X	X	X		X	X
53	X	X	X	X	X		X	X	X	X	X		X	X
54	X	X	X	X	X		X	X	X	X	X	X		

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