

# Higher Nationals

**Computing** (Data Analytics)



**YES** PROFESSIONAL  
ADVANCEMENT CENTER

## 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**



**Pearson**  
**BTEC**

## Units for HNC Computing (Data Analytics) – HCMB8

SN	U N	UNIT	Code	Type	Level	Credit
1	1	Programming	H/618/7388	Core	4	15
2	2	Networking	M/618/7393	Core	4	15
3	3	Professional Practice	L/618/739	Core	4	15
4	4	Database Design & Development	A/618/7400	Core	4	15
5	5	Security	D/618/7406	Core	4	15
6	6	Planning a Computing Project	H/618/7407	Core	4	15
7	8	Data Analytics	F/618/7415	Core	4	15
8	14	Maths for Computing	R/618/7421	Optional	4	15

## Units for HND Computing (Data Analytics) – HCMC5

SN	U N	UNIT	Code	Type	Level	Credit
9	16	Computing Research Project	K/618/7425	Core	5	30
10	17	Business Process Support	A/618/7428	Core	5	15
11	24	Advanced Programming for Data Analysis	H/618/5723	Core	5	15
12	25	Machine Learning	H/618/7438	Core	5	15
13	26	Big Data Analytics and Visualisation	F/618/5664	Core	5	15
14	18	Discrete Maths	F/618/7429	Optional	5	15
15	32	Information Security Management	J/618/7447	Optional	5	15

# Unit 1: Programming

**Unit code** H/618/7388

**Unit type** Core

**Unit level** 4

**Credit value** 15

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## 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
<b>LO1</b> Define basic algorithms to carry out an operation and outline the process of programming an application		<b>D1</b> Evaluate the implementation of an algorithm in a suitable language and the relationship between the written algorithm and the code variant.
<b>P1</b> Define an algorithm and outline the process in building an application. <b>P2</b> Determine the steps taken from writing code to execution.	<b>M1</b> Analyse the process of writing code, including the potential challenges faced.	
<b>LO2</b> Explain the characteristics of procedural, object-orientated and event-driven programming		<b>D2</b> 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.
<b>P3</b> Discuss what procedural, object-orientated and event-driven paradigms are; their characteristics and the relationship between them.	<b>M2</b> Compare the procedural, object-orientated and event-driven paradigms used in given source code of an application.	
<b>LO3</b> Implement basic algorithms in code using an IDE		<b>D3</b> Evaluate the use of an IDE for development of applications contrasted with not using an IDE.
<b>P4</b> Write a program that implements an algorithm using an IDE.	<b>M3</b> Enhance the algorithm written, using the features of the IDE to manage the development process.	
<b>LO4</b> Determine the debugging process and explain the importance of a coding standard		<b>D4</b> Evaluate the role and purpose of a coding standard and why it is necessary in a team as well as for the individual.
<b>P5</b> Explain the debugging process and the debugging facilities available in the IDE. <b>P6</b> Explain the coding standard you have used in your code.	<b>M4</b> 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.*





## **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

Pass	Merit	Distinction
<b>LO1</b> Examine networking principles and their protocols		
<p><b>P1</b> Discuss the benefits and constraints of different network types and standards.</p> <p><b>P2</b> Explain the impact network topologies have on communication and bandwidth requirements.</p>	<p><b>M1</b> Assess common networking principles and how protocols enable the effectiveness of networked systems.</p>	<p><b>D1</b> Evaluate the topology and protocol suite selected for a given scenario and how it demonstrates the efficient utilisation of a networking system.</p>
<b>LO2</b> Explain networking devices and operations		
<p><b>P3</b> Discuss the operating principles of networking devices and server types.</p> <p><b>P4</b> Discuss the interdependence of workstation hardware and relevant networking software.</p>	<p><b>M2</b> Explore a range of server types and justify the selection of a server for a given scenario, regarding cost and performance optimisation.</p>	
<b>LO3</b> Design efficient networked systems		<p><b>D2</b> Critically reflect on the implemented network, including the design and decisions made to enhance the system.</p>
<p><b>P5</b> Design a networked system to meet a given specification.</p> <p><b>P6</b> Design a maintenance schedule to support the networked system.</p>	<p><b>M3</b> Analyse user feedback on your designs with the aim of optimising your design and improving efficiency.</p>	
<b>LO4</b> Implement and diagnose networked systems		
<p><b>P7</b> Implement a networked system based on a prepared design.</p> <p><b>P8</b> Document and analyse test results against expected results.</p>	<p><b>M4</b> Recommend potential enhancements for the networked systems.</p>	

## 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

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### 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
<b>LO1</b> Demonstrate a range of interpersonal and transferable communication skills to a target audience		<b>D1</b> Evaluate the effectiveness and application of interpersonal skills used in the design and delivery of a training event.
<p><b>P1</b> Demonstrate effective design and delivery of a training event for a given target audience, using different communication styles and formats.</p> <p><b>P2</b> Demonstrate effective time-management skills in planning an event.</p>	<p><b>M1</b> Design a professional schedule to support the planning of an event, to include contingencies and justifications of time allocated.</p>	
<b>LO2</b> Apply critical reasoning and thinking to a range of problem-solving scenarios		<b>D2</b> Evaluate the overall success of the event delivered, in terms of how well critical reasoning and thinking were applied to achieve the end goal.
<p><b>P3</b> Demonstrate the use of different problem-solving techniques in the design and delivery of an event.</p> <p><b>P4</b> Demonstrate that critical reasoning has been applied to the design and delivery of the event.</p>	<p><b>M2</b> Research the use of different problem-solving techniques used in the design and delivery of an event.</p> <p><b>M3</b> Justify the use and application of a range of methodologies in the design and delivery of an event.</p>	

Pass	Merit	Distinction
<p><b>L03</b> Discuss the importance and dynamics of working within a team and the impact of team working in different environments</p>		<p><b>D3</b> Critically evaluate your own role and contribution to a group scenario.</p>
<p><b>P5</b> Discuss the importance of team dynamics in the success and/or failure of group work.</p> <p><b>P6</b> Work in a team to achieve a defined goal.</p>	<p><b>M4</b> Analyse team dynamics, in terms of the roles that group members play in a team and the effectiveness in terms of achieving shared goals.</p>	
<p><b>L04</b> Examine the need for Continuing Professional Development (CPD) and its role within the workplace and for higher-level learning</p>		<p><b>D4</b> Evaluate a range of evidence criteria that is used as a measure for effective CPD.</p>
<p><b>P7</b> Discuss the importance of CPD and its contribution to own learning and motivation.</p> <p><b>P8</b> Review different motivational theories and the impact they can have on performance in the workplace.</p> <p><b>P9</b> Produce a development plan that outlines responsibilities, performance objectives and required skills for future goals.</p>	<p><b>M5</b> Justify the role of CPD and development planning in building motivation.</p>	

## 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.

Meggison, 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

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## 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. white box, black box; testing documentation.

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

### LO4 **Produce technical and user documentation**

*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
<b>L01</b> Use an appropriate design tool to design a relational database system for a substantial problem		<b>D1</b> Evaluate the effectiveness of the design in relation to user and system requirements.
<b>P1</b> 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.	<b>M1</b> Produce a comprehensive design for a fully-functional system, which includes interface and output designs, data validations and data normalisation.	
<b>L02</b> Develop a fully-functional relational database system, based on an existing system design		<b>D2</b> Evaluate the effectiveness of the database solution in relation to user and system requirements and suggest improvements.
<b>P2</b> Develop the database system with evidence of user interface, output and data validations, and querying across multiple tables.	<b>M2</b> Implement a fully-functional database system, which includes system security and database maintenance.	
<b>P3</b> Implement a query language into the relational database system.	<b>M3</b> Assess whether meaningful data has been extracted through the use of query tools to produce appropriate management information.	
<b>L03</b> Test the system against user and system requirements		
<b>P4</b> Test the system against user and system requirements.	<b>M4</b> Assess the effectiveness of the testing, including an explanation of the choice of test data used.	

Pass	Merit	Distinction
<b>LO4</b> Produce technical and user documentation		
<b>P5</b> Produce technical and user documentation.	<b>M5</b> Produce technical and user documentation for a fully-functional system, including data flow diagrams and flowcharts, describing how the system works.	

## 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

<a href="http://mva.microsoft.com">mva.microsoft.com</a>	Microsoft Virtual Academy Database Development (Training)
<a href="http://mva.microsoft.com/ebooks">mva.microsoft.com/ebooks</a>	Microsoft Virtual Academy Microsoft Press (E-books)
<a href="http://www.lynda.com">www.lynda.com</a>	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

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

Pass	Merit	Distinction
<b>LO4</b> Manage organisational security		
<p><b>P7</b> Design a suitable security policy for an organisation, including the main components of an organisational disaster recovery plan.</p> <p><b>P8</b> Discuss the roles of stakeholders in the organisation in implementing security audits.</p>	<p><b>M5</b> Justify the security plan developed giving reasons for the elements selected.</p>	

## 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](http://www.bcs.org) BCS, The Chartered Institute for IT  
(General Reference)

[www.bsa.org](http://www.bsa.org) Software Alliance  
(General Reference)

[www.fast.org.uk](http://www.fast.org.uk) Federation Against Software Theft  
(General Reference)

[www.ico.org.uk](http://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

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### **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

Pass	Merit	Distinction
<b>LO1</b> Conduct small-scale research, information gathering and data collection to generate knowledge on an identified subject		<b>D1</b> Interpret findings to generate knowledge on how the research theme supports business requirements in the identified sector.
<b>P1</b> Demonstrate qualitative and quantitative research methods to generate relevant primary data for an identified theme. <b>P2</b> Examine secondary sources to collect relevant secondary data and information for an identified theme.	<b>M1</b> Analyse data and information from primary and secondary sources to generate knowledge on an identified theme.	
<b>LO2</b> Explore the features and business requirements of organisations in an identified sector		
<b>P3</b> Discuss the features and operational areas of a businesses in an identified sector. <b>P4</b> Discuss the role of stakeholders and their impact on the success of a business.	<b>M2</b> Analyse the challenges to the success of a business in an identified sector.	

Pass	Merit	Distinction
<p><b>L03</b> Produce project plans based on research of the chosen theme for an identified organisation</p>		<p><b>D2</b> 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.</p>
<p><b>P5</b> Devise comprehensive project plans for a chosen scenario, including a work and resource allocation breakdown using appropriate tools.</p>	<p><b>M3</b> Produce comprehensive project plans that effectively consider aims, objectives and risks/benefits for an identified organization.</p>	
<p><b>L04</b> Present your project recommendations and justifications of decisions made, based on research of the identified theme and sector</p>		
<p><b>P6</b> Communicate appropriate project recommendations for technical and non-technical audiences.</p> <p><b>P7</b> Present arguments for the planning decisions made when developing the project plans.</p> <p><b>P8</b> Discuss accuracy and reliability of the different research methods applied.</p>	<p><b>M4</b> Assess the extent to which the project recommendations meet the needs of the identified organisation, including fully-supported rationales for planning decisions made.</p>	



## 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 (IJQQR)* – EA Journals

*Qualitative Research Journal (QRJ)* – Sage Journals

### Web

[www.apm.org.uk](http://www.apm.org.uk)

Association for Project Management  
(General Reference)

[www.gov.uk/government/publications](http://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](http://www.hesa.ac.uk)

Higher Education Statistics Agency (HESA)  
– data collection and analysis for higher education

[www.ons.gov.uk](http://www.ons.gov.uk)

Office for National Statistics (ONS)  
(General Reference)

[www.pmi.org.uk](http://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

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## 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, black box and white box 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
<b>LO1</b> Describe different software development lifecycles		<b>D1</b> Assess the merits of applying the Waterfall lifecycle model to a large software development project.
<b>P1</b> Describe two iterative and two sequential software lifecycle models. <b>P2</b> Explain how risk is managed in software lifecycle models.	<b>M1</b> Discuss using an example, why a particular lifecycle model is selected for a development environment.	
<b>LO2</b> Explain the importance of a feasibility study		<b>D2</b> Assess the impact of different feasibility criteria on a software investigation.
<b>P3</b> Explain the purpose of a feasibility report. <b>P4</b> Describe how technical solutions can be compared.	<b>M2</b> Discuss the components of a feasibility report.	
<b>LO3</b> Undertake a software development lifecycle		<b>D3</b> Evaluate the process of undertaking a systems investigation with regard to its effectiveness in improving a software quality.
<b>P5</b> Undertake a software investigation to meet a business need. <b>P6</b> Use appropriate software analysis tools/techniques to carry out a software investigation and create supporting documentation.	<b>M3</b> Analyse how software requirements can be traced throughout the software lifecycle. <b>M4</b> Discuss two approaches to improving software quality.	
<b>LO4</b> Discuss the suitability of software behavioural design techniques		<b>D4</b> Present justifications of how data-driven software can improve the reliability and effectiveness of software.
<b>P7</b> Discuss, using examples, the suitability of software behavioural design techniques.	<b>M5</b> Analyse a range of software behavioural tools and techniques. <b>M6</b> Differentiate between a finite state machine (FSM) and an extended FSM, providing an application of use for both.	



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

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## 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

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

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

## 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

<a href="http://archive.ics.uci.edu/ml">archive.ics.uci.edu/ml</a>	University of California, Irvine Machine Learning Repository (Data sets) (General reference)
<a href="http://cran.r-project.org">cran.r-project.org</a>	The R Project for Statistical Computing R Archive Network (Development Tool)
<a href="http://cs.waikato.ac.nz">cs.waikato.ac.nz</a>	University of Waikato – Machine Learning Group Data Mining Software in Java (Development Tool)
<a href="http://lfd.uci.edu">lfd.uci.edu</a>	University of California, Irvine – Laboratory for Fluorescence Dynamics (Research)
	Binaries for Python Extension Packages (Development Tool)
<a href="http://knime.org">knime.org</a>	Konstanz Information Miner ‘KNIME’ (Development Tool)
<a href="http://powerbi.microsoft.com">powerbi.microsoft.com</a>	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 14: Maths for Computing

**Unit code** R/618/7421

**Unit level** 4

**Credit value** 15

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## 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
<b>L01</b> Use applied number theory in practical computing scenarios		<b>D1</b> Produce a detailed written explanation of the importance of prime numbers in the field of computing.
<p><b>P1</b> Calculate the greatest common divisor and least common multiple of a given pair of numbers.</p> <p><b>P2</b> Use relevant theory to sum arithmetic and geometric progressions.</p>	<b>M1</b> Identify multiplicative inverses in modular arithmetic.	
<b>L02</b> Analyse events using probability theory and probability distributions		<b>D2</b> Evaluate probability theory to an example involving hashing and load balancing.
<p><b>P3</b> Deduce the conditional probability of different events occurring in independent trials.</p> <p><b>P4</b> Identify the expectation of an event occurring from a discrete, random variable.</p>	<b>M2</b> Calculate probabilities in both binomially distributed and normally distributed random variables.	
<b>L03</b> Determine solutions of graphical examples using geometry and vector methods		<b>D3</b> Construct the scaling of simple shapes that are described by vector co-ordinates.
<p><b>P5</b> Identify simple shapes using co-ordinate geometry.</p> <p><b>P6</b> Determine shape parameters using appropriate vector methods.</p>	<b>M3</b> Evaluate the co-ordinate system used in programming a simple output device.	

Pass	Merit	Distinction
<b>LO4</b> Evaluate problems concerning differential and integral calculus		
<p><b>P7</b> Determine the rate of change in an algebraic function.</p> <p><b>P8</b> Use integral calculus to solve practical problems involving area.</p>	<p><b>M4</b> Analyse maxima and minima of increasing and decreasing functions, using higher order derivatives.</p>	

## **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 16: Computing Research Project (Pearson-set)

**Unit code** K/618/7425

**Unit type** Core

**Unit level** 5

**Credit value** 30

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## 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

Pass	Merit	Distinction
<b>LO1</b> Examine appropriate research methodologies and approaches as part of the research process		<b>D1</b> Critically evaluate research methodologies and processes in application to a computing research project to justify chosen research methods and analysis.
<b>P1</b> Produce a research proposal that clearly defines a research question or hypothesis, supported by a literature review.	<b>M1</b> Analyse different research approaches and methodology and make justifications for the choice of methods selected based on philosophical/theoretical frameworks.	
<b>P2</b> Examine appropriate research methods and approaches to primary and secondary research.		
<b>LO2</b> Conduct and analyse research relevant to a computing research project		
<b>P3</b> Conduct primary and secondary research using appropriate methods for a computing research project that consider costs, access and ethical issues.	<b>M2</b> Discuss merits, limitations and pitfalls of approaches to data collection and analysis.	
<b>P4</b> Apply appropriate analytical tools, analyse research findings and data.		

Pass	Merit	Distinction
<b>LO3</b> Communicate the outcomes of a research project to identified stakeholders		<b>D2</b> Evaluate outcomes and make valid, justified recommendations.
<b>P5</b> Communicate research outcomes in an appropriate manner for the intended audience.	<b>M3</b> Analyse the extent to which outcomes meet set research objectives and communicate judgements effectively for the intended audience	
<b>LO4</b> Reflect on the application of research methodologies and concepts		<b>D3</b> Demonstrate reflection and engagement in the resource process, leading to recommended actions for future improvement.
<b>P6</b> Discuss the effectiveness of research methods applied, for meeting objectives of the computing research project.  <b>P7</b> Discuss alternative research methodologies and lessons learnt in view of the outcomes.	<b>M4</b> Analyse results in recommended actions for improvements and future research considerations.	

## 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

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## 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
<b>LO1</b> Discuss the use of data and information to support business processes and the value they have for an identified organisation		<b>D1</b> Evaluate the wider implications of using data and information to support business processes in an identified organisation.
<b>P1</b> Discuss how data and information support business processes and the value they have for organisations. <b>P2</b> Discuss how data is generated and the tools used to manipulate it to form meaningful data to support business operations.	<b>M1</b> Assess the value of data and information to individuals and organisations in relation to real-world business processes.	
<b>LO2</b> Discuss the implications of the use of data and information to support business processes in a real-world scenario		
<b>P3</b> Discuss the social legal and ethical implications of using data and information to support business processes. <b>P4</b> Describe common threats to data and how they can be mitigated at on a personal and organisational level.	<b>M2</b> Analyse the impact of using data and information to support business real-world business processes.	

Pass	Merit	Distinction
<b>LO3</b> Explore the tools and technologies associated with data science and how it supports business processes		<b>D2</b> Evaluate the use of data science techniques against user and business requirements of an identified organisation.
<b>P5</b> Discuss how tools and technologies associated with data science are used to support business processes and inform decisions.	<b>M3</b> Assess the benefits of using data science to solve problems in real-world scenarios.	
<b>LO4</b> Demonstrate the use of data science techniques to make recommendations to support real-world business problems		
<b>P6</b> Design a data science solution to support decision making related to a real-world problem. <b>P7</b> Implement a data science solution to support decision making related to a real-world problem.	<b>M4</b> 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](http://gartner.com/en)

Research and Advisory  
(General Reference)

[datascience.codata.org](http://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

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

Pass	Merit	Distinction
<b>L03</b> Investigate solutions to problem situations using the application of Boolean algebra		<b>D3</b> Design a complex system using logic gates.
<p><b>P5</b> Diagram a binary problem in the application of Boolean algebra.</p> <p><b>P6</b> Produce a truth table and its corresponding Boolean equation from an applicable scenario.</p>	<p><b>M3</b> Simplify a Boolean equation using algebraic methods.</p>	
<b>L04</b> Explore applicable concepts within abstract algebra		<b>D4</b> Explore, with the aid of a prepared presentation, the application of group theory relevant to your given example.
<p><b>P7</b> Describe the distinguishing characteristics of different binary operations that are performed on the same set.</p> <p><b>P8</b> Determine the order of a group and the order of a subgroup in given examples.</p>	<p><b>M4</b> Validate whether a given set with a binary operation is indeed a group.</p>	

## 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 24: **Advanced Programming for Data Analysis**

**Unit code** H/618/5723

**Unit level** 5

**Credit value** 15

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## **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

Pass	Merit	Distinction
<b>LO1</b> Explore the tools a programmer can use to manipulate large data sets for data analysis		<b>D1</b> 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.
<b>P1</b> Investigate the functions of a data analysis language. <b>P2</b> Prepare a proposal for analysing a large dataset, including the method of analysis and the outcomes to be achieved.	<b>M1</b> Examine the ways that general programming languages can interact with a data analysis language.	
<b>LO2</b> Design a software tool to analyse a large data set for a given scenario		
<b>P3</b> Design a software tool to carry out a specific analysis on a chosen large dataset. <b>P4</b> Create a detailed test plan for a software tool, identifying expected outcomes of the analysis.	<b>M2</b> Apply program code from both a general programming language and a data analysis-based language in designing the software tool.	
<b>LO3</b> Develop a software tool to analyse a large data set for a given scenario		<b>D2</b> Analyse the output of the data analysis process with focus on the quality of information produced from the dataset and identify possible improvements.
<b>P5</b> Build a software tool for analysing a large dataset according to a developed design.	<b>M3</b> Modify the program to include code from both a general programming language and a data analysis-based language in building the software tool.	
<b>LO4</b> Test a software tool used to analyse a large data set for quality of information produced		
<b>P6</b> Implement a detailed test plan on a data analysis software tool. <b>P7</b> Present the results of the analysis on the chosen data set.	<b>M4</b> Review the outcomes, utilising the software tool and the results of testing.	

## 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

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## 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

Pass	Merit	Distinction
<b>LO1</b> Analyse the theoretical foundation of machine learning to determine how an intelligent machine works		<b>D1</b> Critically evaluate why machine learning is essential to the design of intelligent machines.
<b>P1</b> Analyse the types of learning problems. <b>P2</b> Demonstrate the taxonomy of machine learning algorithms.	<b>M1</b> Evaluate the category of machine learning algorithms with appropriate examples.	
<b>LO2</b> Investigate the most popular and efficient machine learning algorithms used in industry		
<b>P3</b> Investigate a range of machine learning algorithms and how these algorithms solve learning problems. <b>P4</b> Demonstrate the efficiency of these algorithms by implementing them using an appropriate programming language or machine learning tool.	<b>M2</b> Analyse these algorithms using an appropriate example to determine their power.	

Pass	Merit	Distinction
<p><b>LO3</b> Develop a machine learning application using an appropriate programming language or machine learning tool for solving a real-world problem</p>		<p><b>D2</b> Critically evaluate the implemented learning solution and its effectiveness in meeting end user requirements.</p>
<p><b>P5</b> Prepare training and test data sets in order to implement a machine learning solution for an appropriate learning problem.</p> <p><b>P6</b> Implement a machine learning solution with a suitable machine learning algorithm and demonstrate the outcome.</p>	<p><b>M3</b> Test the machine learning application using a range of test data and explain each stage of this activity.</p>	
<p><b>LO4</b> Evaluate the outcome or the result of the application to determine the effectiveness of the learning algorithm used in the application</p>		
<p><b>P7</b> Discuss whether the result is balanced, underfitting or overfitting.</p> <p><b>P8</b> Analyse the result of the application to determine the effectiveness of the algorithm.</p>	<p><b>M4</b> Evaluate the effectiveness of the learning algorithm used in the application.</p>	

## 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

<a href="http://archive.ics.uci.edu/ml">archive.ics.uci.edu/ml</a>	University of California, Irvine Machine Learning Repository (Data sets)
<a href="http://azure.microsoft.com">azure.microsoft.com</a>	Microsoft Azure (Development Tool)
<a href="http://accord-framework.net">accord-framework.net</a>	Accord.NET Framework (Development Tool)
<a href="http://codechef.com">codechef.com</a>	CodeChef educational initiative List of Compilers (Wiki)
<a href="http://cran.r-project.org">cran.r-project.org</a>	The R Project for Statistical Computing R Archive Network (Development Tool)
<a href="http://cs.waikato.ac.nz">cs.waikato.ac.nz</a>	University of Waikato – Machine Learning Group Data Mining Software in Java (Development Tool)
<a href="http://julia-lang.org">julia-lang.org</a>	Julia Programming Language (Development Tool)
<a href="http://knime.org">knime.org</a>	Konstanz Information Miner – KNIME (Development Tool)
<a href="http://lfd.uci.edu">lfd.uci.edu</a>	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

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## 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 combining 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
<b>LO1</b> Examine data visualisation for decision making of complex data sets		<b>D1</b> Predict the potential impact of using complex data sets on both users and organisations for decision making.
<b>P1</b> Explain the fundamental concepts of big data and its value in decision making for end users and organisations. <b>P2</b> Examine the processes of data driven decision making (DDDM) when using complex data sets.	<b>M1</b> Discuss the advantages and challenges to an organisation of using complex data sets for decision making.	
<b>LO2</b> Discuss statistical and graphical tools and techniques used to present big data for a given use case		<b>D2</b> 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.
<b>P3</b> Discuss statistical and graphical tools and techniques used in industry for big data manipulation and visualisation.	<b>M2</b> Assess the suitability of industry leading tools and software solutions for analysing and visualising data for the given use case.	
<b>LO3</b> Demonstrate statistical and graphical techniques used to present big data as a visualisation.		
<b>P4</b> Demonstrate the use of data manipulation and automation to present a visualisation for a given user case.	<b>M3</b> Interpret the findings derived from the data manipulation to support conclusions made.	
<b>LO4</b> Investigate the challenges faced by data professionals in carrying out their role.		<b>D3</b> Evaluate the impact of the key issues faced by data specialists when working in a data-driven culture.
<b>P5</b> Investigate the different roles, responsibilities and key issues faced by data specialists in their day-to-day role.	<b>M4</b> Review the different strategies used by data specialists to ensure data compliance.	

## 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 32: Information Security Management

**Unit code** J/618/7447

**Unit level** 5

**Credit value** 15

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## 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
<b>LO1</b> Explore the basic principles of information security management		<b>D1</b> Critically analyse what is required to establish and maintain an ISMS for a selected organisation, ensuring that the key principles are met.
<b>P1</b> Examine the key principles of an ISMS and its relevance to the successful operation of an organisation.	<b>M1</b> Analyse the benefits an effective ISMS can have on an organisation.	
<b>LO2</b> Critically assess how an organisation can implement and maintain an Information Security Management System (ISMS)		
<b>P2</b> Assess the elements and processes required to establish and maintain an ISMS.	<b>M2</b> Justify the steps required for implementing an ISMS for a selected organisation.	
<b>LO3</b> Appraise an ISMS and describe any weaknesses it may contain		<b>D2</b> Critically examine the advantages and disadvantages of the planned ISMS against the key ISO and international standards.
<b>P3</b> Plan the design of an ISMS for a selected organisation, including an implementation map.	<b>M3</b> Justify the planned ISMS design for a selected organisation by following the stages of audit.	
<b>P4</b> Appraise the planned ISMS designed, against the organisational requirements.		
<b>LO4</b> Examine the strengths and weaknesses of implementing ISMS standards		
<b>P5</b> Recognise the purpose of the key ISO and international ISMS standards.	<b>M4</b> 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](http://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.*