Anglia Ruskin University

Course Information Sheet

BEng (Hons) Computer Science

Mode and course length – Full-Time (4 years)

Location – ARU Cambridge Campus

Awarding Body – Anglia Ruskin University. As a registered Higher Education provider Anglia Ruskin University is regulated by the Office for Students.

Overview

Study in the heart of ‘Silicon Fen’, home to firms like ARM, Sony and Microsoft. Explore the key theories and technologies of computing. Develop skills in designing and building systems to the latest specifications. Gain the skills employers are looking for, and choose from a range of exciting career options.

Your course has a new home in Compass House, which extends our campus along East Road. With the latest technology at your fingertips, you'll be able to collaborate with other students on innovative projects to hone your skills.

Computer scientists don’t use computers like most of us do. Instead, they use them as tools to address important scientific questions, and to solve real world-problems. Computing can be amazingly diverse, including computer design, graphics, artificial intelligence, gaming, software engineering, programming and applications development.

Our course has been designed to offer you a wide choice of career options when you graduate. As you study, you can choose to focus on the core elements of computer science, or to specialise in areas such as software development, mobile applications, computer security, cloud computing, network administration and technical support.

You’ll benefit from being based in Cambridge, home to the largest cluster of technology firms in Europe. Recently named the 'Best UK city to work in' you'll have lots of opportunities to gain relevant work experience locally and after graduation can expect an average salary of £35,000 (Glassdoor 2016). You'll also benefit from talks with industry experts (Citrix, ARM, Atom, Jagex, Sony, Compare the Market, Microsoft Research, etc.) who are regularly invited to give guest lectures and seminars.

You’ll spend lots of time in our computing labs, including a Cisco lab with hands-on routing and switching equipment and our virtual Netlab, offering 24/7 remote access to our Cisco equipment. You’ll have access to Microsoft Imagine Premium’s professional developer and designer tools, VMware IT Academy’s virtualisation software and tools, plus mobile devices for testing and developing mobile applications.

It’s not just about technical skills, though. You’ll learn to work effectively as a team member and become an independent thinker and a creative problem-solver who's aware of the social, moral and ethical issues relating to the impact of computers on our lives. You’ll also be given the opportunity to participate in computing related social and educational activities with your peers. Student

s have previously taken a day trip to Bletchley Park as part of their course.

Course Delivery

Our courses are delivered through teaching and learning methods which provide students with the widest possible exposure to a modern and innovative higher education experience.

These methods vary and could include attendance at lectures and seminars, undertaking laboratory exercises or work-based activities, practical work, performances, presentations, field trips, other relevant visits and e-learning through Canvas, our online learning management system.

Each course is divided into a number of ‘modules’ which focus on particular areas, each of which has a specific approach to its delivery. This information is published to students for each module they take via the Module Definition Form (MDF) and Canvas.

Fees

Information about your course fee including any annual fee increases or deposits (if required) can be found in your offer letter.

Additional Costs

Throughout the course we’ll use a range of assessment methods to help measure your progress. Besides exams, these will include group work, presentations, case studies, laboratory tests and projects.

Modules

Core Modules

Year 1: Foundation in Engineering, Computing and Technology

This module will provide students with the necessary skills to begin studying at level 4 in Engineering, Computer Science and related courses.

Students will be introduced to the core skills necessary to succeed in higher education, including thinking critically, researching and referencing appropriately, demonstrating appropriate numeracy and ICT skills, and communicating effectively verbally and in writing.

In addition to these fundamental skills, Students will cover the subjects underpinning the technological disciplines. Fundamental mathematical skills will be covered, alongside pre-calculus, followed by an introduction to calculus and vector and matrix arithmetic. Students will also be introduced to Classical mechanics, and its application to real-world scenarios. Students will be introduced to the fundamentals of computer science, learning about the principles behind programming and applying them through a series of practical coding exercises. Students will undertake a multi-disciplinary group project as they learn about the collaborative nature of engineering, and design from a broader perspective of business.

The module is made up of the following 8 constituent elements:

- Interactive Learning Skills and Communication (ILSC)
- Information Communication Technology (ICT)
- Critical Thinking
- Maths for Scientists
- Maths for Engineers
- Physics for Engineers
- Fundamentals of Computing
- Engineering Design

Year 2: Introduction to Programming

This module provides an introduction to high level programming, requiring no prior programming experience. The student will use industry-standard tools and techniques to design, implement, test and document simple programs using a current programming language such as C#, Java or C++.

The module will enable students to understand the principal components of a high-level program, laying the foundation for subsequent modules requiring structured programming ability. It will emphasise the principles of good programming practice and introduce the techniques required to develop software which:

is robust and efficient;

satisfies the needs of the customer;

has a usable and aesthetic interface;

consists of elegant, easy to read code;

is resilient within the cybersecurity context.

Summative assessment will address the student's knowledge of programming theory, syntax and best practice. Formative exercises will be set at intervals through the module for peer review and feedback. By the end of the module, students should have sufficient mastery of a high-level programming language to allow them to design, implement and test simple programs. The skills taught within the module are intended to be directly transferable to the workplace and to provide a suitable foundation for students who will be expected to apply programming skills in their later studies and future career.

Year 2: Fundamentals of Design

In this module the concepts of a software life cycle, system theory, design methodologies and relational data modelling are introduced. The module uses a system methodology to work through a software life cycle looking at analysis, design and implementation. Students will be given the opportunity to apply a design methodology to a case study. Students produce a set of system diagrams requiring them to identify, classify, and represent data, functionality, states and events. The module will introduce students to the essentials of database design and will include implementation. Students will be expected to participate in group work as well as individual contributions.

In addition to studying the above, the module will introduce aspects of employability soft skill development such as problem solving, group working, communication skills and self-evaluation which students will build on in later modules of their course.

Year 2: Computer Systems

This module introduces students to the components present in modern computer systems and networks. On completing this module, students will be able to specify, construct and maintain networked computer systems, and gain an in depth understanding of common computer and network architectures, their function and confidently solve their problems. Theoretical topics include CPU architectures; bus systems; types of memory and data; program execution; number systems; peripheral and network architectures, models and protocols; the importance of standards; network devices and cabling. The module will be delivered in weekly lectures, which should be consolidated through significant self-study. Laboratory sessions will enable students to gain the practical skills needed to construct, maintain and solve problems on networked computer systems. Underpinning the theory students will learn (among other practical skills) how to safely assemble PCs (taking account of health and safety issues); construct (and test) network cables; examine low-level Internet traffic and set up and configure local area networks.

Year 3: Database Design and Implementation

This module guides students through the fundamentals of database design using the software lifecycle as a basis. This grounding enables students to construct industrial quality databases. Students work in small groups emulating real world development teams. They learn the skills of constructing excellent documentation, working in draft, making revisions and delivering work to a deadline. Implicitly they learn the skill of managing a group environment. The module begins with the development of an acceptable approach to industrial clients and their problems. Working within the specification given by an Enterprise, the group learns how to extract data from interviews and documents. Students progress to designing and building a database, querying the database to provide the reports (including statistics) that the Enterprise needs. During this process the current industrial choice database language (SQL) is learned. Specialist resources include availability of Microsoft AccessTM, MySQL, or similar applications.

Year 3: Network Routing

Modern networks continue to evolve to keep pace with the changing way organizations carry out their daily business. Users now expect instant access to company resources from anywhere and at any time. These resources not only include traditional data but also video and voice. There is also an increasing need for collaboration technologies that allow real-time sharing of resources between multiple remote individuals as though they were at the same physical location.

The global Internet is a collection of networks, termed Autonomous Systems (AS), that are linked together via high-speed communication links provided by telecommunication organisations. LAN switches provide the connection point for end users into the enterprise network and are also primarily responsible for the control of information within the LAN environment. Routers facilitate the movement of information between LANs and are generally unaware of individual hosts. Converged traffic, that is traffic comprising both data and voice, is routed through the network based either on policies agreed between ASs or

performance metrics by routers within the ASs. But how should flows through a network be organised, so that the network responds sensibly to failures and overloads? What about network security and scalability ? These questions are closely linked to considerable technological importance in connection with the development of computer and telecommunication over IP networks.

Due to the complexity and dynamic nature of networks, often networks employ dynamic routing protocols to dynamically establish the "best" path for routing the traffic, to achieve the maximum efficiency while maintain the ever-increased demand of reliability and security.

This module focuses on the key concepts and protocols of network routing. It covers basic routing and switching concepts, including static and default routing, Virtual Local Area Networks (VLANs), and inter-VLANs routing. Dynamic protocols such as RIP and OSPF, and will be discussed and explored. Network security using Access Control Lists will be introduced and the wider issues of network and Internet security considered.

The module is delivered as a mixture of theory, delivered through a series of lectures, and practical implementation, delivered through a series of guided laboratory exercises. In the lab sessions students will gain deep understanding on the routing and switching concepts and acquire hands-on-skills using advanced network simulation tools that comply with industry standard router platforms.

Students studying this module will be able to access on-line materials including the Cisco Networking Academy online curriculum and access a specialist laboratory.

Year 3: Software Engineering

Ian Sommerville states that Software Engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software. The aim of this module is to give to students a real-world experience in software engineering. The number, size, and application domains of computer applications have grown to the extent that many organisations and individuals depend on the effectiveness of software development. Therefore software products have to be efficient, of very good quality and to help us to be more efficient and productive. This module will provide students with the intellectual and practical tools required to be able to design, implement and test software systems. The module is built on material covered in Fundamentals of Design and Introduction to Programming, and will cover all the phases of the life cycle by taking case studies and building real software applications based on them. As part of this at least two types of project management, waterfall and agile methodologies will be discussed together with the cost drivers that can influence projects. The students will use computer-aided software engineering (CASE) tools to study topics including analysis and design in UML and managing the OO software development process. Both the automated and manual testing are discussed and the students have to demonstrate the ability to use both of them.

Year 3: Interaction and Usability

Developing effective human-computer interfaces is a vital yet poorly understood area. As such it is necessary to have some understanding of a variety of fields including cognitive psychology and usability theory which has recently become a major issue in web design / effective e-commerce implementation. The user experience (beyond traditional usability) is a key design issue, where the importance of the perceptions and experience of the user is considered. This module seeks to develop understanding of interaction design through the delivery of core theory which is then applied to the analysis, design, implementation and evaluation of a limited functionality horizontal prototype. The student will be introduced to the notion of user mental models (following the approach of Donald Norman) and the extent to which they can be utilized in the design of conceptual models underlying the designed interface. Students will then examine the range of discovery methods used to harvest user, task and environmental data to support user needs analysis comprising user characterisation (including the notion of user personae), task analysis (hierarchical task analysis / action and object taxonomies) and environmental analysis. Following a discussion of visual style / aesthetics, the preceding analysis will then progress to documented design rationale supporting by logical storyboards showing information, action and navigation screen components. The design is then prototyped in an appropriate high level interface prototyping tool and subjected to critical introspective and user evaluation. Note that ideally students will be expected to possess some scripting experience prior to starting the module. Students will document all the above to produce the final assignment. The module would be of considerable benefit to those who intend to design interfaces (including web design), become usability / testing consultants or work within user training / user support roles. Specialist resources required for this module are prototyping and access to the safari online text (Badre A (2002) Shaping Web Usability - Interaction Design in Context Addison-Wesley).

Year 3: Digital Security

'Digital Security' is essentially about giving individuals the freedom to embrace the digital lifestyle, confidently engaging in everyday interactions across all digital devices with a certainty that the accessibility and integrity of the data is ensured. Digital security affects all aspects of the digital lifestyle, which, among others, comprises computers and the internet, telecommunications, financial transactions, transportation, healthcare, secure access and the IT professional's legal and moral obligations when practicing their trade. This module essentially covers these broad topic areas: - Computer Security Principles covers security objectives such as authentication, authorization, access control, confidentiality, data integrity, and non-repudiation. The module also introduces fundamental software design principles such as that of least privilege, fail-safe stance, and defense-in-depth. - Introduction to Cryptography covers both symmetric encryption and public-key cryptography, discussing how they are used to achieve security goals and build PKI (Public-Key Infrastructure) systems. Technologies covered are typically DES, 3DES, AES, RC4, RSA, ECC, MD5, SHA-1, X.509, digital signatures, and all cryptographic primitives necessary to understand PKI. Diffie-Hellman key exchange and man-in-the-middle attacks will also be discussed. - Secure Programming Techniques discusses the threats that worms and hackers present to software and the programming techniques that developers can use to defend against software vulnerabilities such as buffer overflows, SQL injection, and off-line dictionary attacks.

Year 3: Computing Research Methodologies

The main aim of this module is to provide students with experience of topic specific research and the analysis and application of that work in order to carry out a computer science based project in their final year. It does this by showing the scientific principles, research methodologies and theoretical underpinnings from an engineering context. Students will apply this knowledge in the selection of a suitable project demonstrating their research into the context and theory of the topic. The module also covers essential skills in project management and planning so that students can develop a viable project plan, identifying appropriate technology, experimental process and any limitations of their approach. Data collection and analysis including statistical concepts dealing with evaluation and the significance of experimental results are covered so that students can provide a realistic plan for the evaluation and critical analysis of their proposal. Finally we ensure that students appreciate and implement strategies to avoid problems with risk assessment and the ethical and legal considerations of the work to be undertaken.

Year 4: Professional Issues: Computing and Society

It is essential to ensure that a professional engineer has an in depth understanding of professional ethics, law and the impact of what they do on society. This module aims to provide an understanding of the issues, opportunities and problems which have arisen as a result of the computerisation of wide areas of human activity. It is designed to enhance advanced computer reflective thinking in both computer science specialists and others, and is a key part of the programme of professional development for computer scientists and others seeking to embody professional values and approaches in the IT and computing fields. The course covers relevant and current topics in Computer Law (e.g. Data Protection; Intellectual Property Law; Computer Misuse) and other social, ethical and legal topics such as considering the causes and effects of systems failures (including but not limited to computer systems failure). Other aspects such as the ethical and professional responsibilities of graduates - particularly those from IT and Computing disciplines - will be critically appraised. Topics may also cover the technical development and social effects of computer technology from c1936 to the present day, as the basis for an informed discussion of the issues and whether lessons have been learnt from the past. A high level of in class student participation is expected; non attendance/non-contribution may be penalised.

Year 4: Final Project

The individual Final Project module allows students to engage in a substantial piece of individual research and / or product development work, focused on a topic relevant to their specific discipline. The topic may be drawn from a variety of sources including: Anglia Ruskin research groups, previous / current work experience, the company in which they are currently employed, an Anglia Ruskin lecturer suggested topic or a professional subject of their specific interest (if suitable supervision is available). The project topic will be assessed for suitability to ensure sufficient academic challenge and satisfactory supervision by an academic member of staff. The chosen topic will require the student to identify / formulate problems and issues, conduct literature reviews, evaluate information, investigate and adopt suitable development methodolgies, determine solutions, develop hardware, software and/or media artefacts as appropriate, process data, critically appraise and present their finding using a variety of media. Regular meetings with the project supervisor should take place, so that the project is closely monitored and steered in the right direction. The project developed in this module is the most substantial piece of work that the student is

producing during their undergraduate studies. Thus, the choice of project topic and the quality of the work is likely to bear a great influence on the student's career / employability. Therefore, the module will also include aspects of Personal Development Plan and CV preparation. The students are strongly advised to allocate appropriate attention, time and effort to this module. The successful completion of the module will increase students' employability, as they will acquire skills directly applicable to real world projects.

Year 4: Data Structures and Algorithms

The concept of the algorithm is a central pillar of computer science, and is closely related to the concept of the data structure: the storage mechanism that algorithms are used to manipulate. The aim of this module is to raise awareness of efficient programming practice by critically appraising the core data structures and algorithms available to the computer scientist. A range of algorithm analysis techniques will be employed to quantitatively evaluate the performance of common data structures and algorithms in order that prudent choices may be made in the assembly of non-trivial software artefacts with specific performance targets or constraints. In addition to empirical and cyclomatic techniques, asymptotic analysis (in space and time) will be particularly emphasised, and the student will learn how to categorise algorithms into specific complexity classes, enabling them to select from among multiple possible approaches to a given computational problem. The focus of data structures and algorithms is largely theoretical, and requires some experience of elementary topics in algebra and discrete mathematics, such as roots, linear, exponential and quadratic growth functions, limits, summation notation, probability, sets and graph theory.

Year 4: Image Processing

Image processing is a rapidly growing area of computer science, with applications as diverse as entertainment, manufacturing/robotics, forensics, security, broadcasting, cognitive psychology, computer graphics, and medicine. The range of underpinning techniques relevant to the image processing discipline is similarly diverse, and include image acquisition and digital representation, visual perception, image statistics, transformation, enhancement, restoration, compression, and higher level analyses such as feature recognition and object tracking. The input to an image processing operation is typically a two dimensional signal (i.e., an image matrix), and the output may be a modified signal (for instance, an enhanced image), or a set of descriptors or interpretations, produced by an image processing operation. This module will introduce students to a set of core image processing operations in weekly lectures in which their theoretical and mathematical foundations will be emphasised. Students will be expected to implement a range of image processing algorithms using real datasets in structured weekly laboratory sessions.

Optional Modules

(Subject to availability)

Year 2: Operating Systems

This module will introduce students to the fundamental features of modern operating systems, their components and their use. It will look at key concepts including the kernel and its modes; memory and resource management; file systems, security and authentication; single and multi-tasking; interrupts, hardware and device drivers and command line and graphical user interfaces (GUI). The module will also introduce students to the command line interface (CLI) commands and scripting in both the Windows CLI and a Linux shell and allow them to develop simple scripts to automate activities in both operating system environments. It will also explain how each operating system stores configuration information and how (particularly in Linux/Unix) scripts can be used to modify the system configuration. No specific knowledge is needed before undertaking the module, however a basic user level familiarity with a GUI based operating system (such as Windows) will be useful. The skills acquired in the module will enable students to go on to study modules which involve topics such as system administration, network and server configuration and technical support all of which are key skills graduates need when working in the systems and network support industries.

Year 2: Core Mathematics for Computing

This module will equip students embarking on a degree in Computer Science with the core mathematical skills necessary to succeed. The module will begin by refreshing students’ arithmetic and algebra skills, including basic notation, variables and constants, number types (real and natural numbers, integers, irrational/rational numbers, and so on), ratios, percentages and fractions, bases, exponents, roots/surds, order of operations, product and summation notation, factorising, rationalising, scientific form, decimal places and significant figures, floors/ceilings, rounding, modular arithmetic, the interpretation and manipulation of algebraic expressions, simultaneous and quadratic equations and scientific calculator use. Probability and

statistic analysis methods will be introduced, including histograms, uniform and Gaussian distributions, accuracy and precision, descriptive measures of central tendency and dispersion, correlation, and basic (parametric) inferential techniques for hypothesis testing. Good practice in data plotting will be emphasized, including axis labelling and scaling, error bars, and the placement of dependent/independent variables, which will be strengthened by laboratory exercises using a graphing-capable software package, such as MATLAB. Basic notation in set theory and discrete mathematics will be introduced, along with number bases, permutations, combinations and combinatorial logic, including truth tables, which will be related to conditional logic statements in computing. Exponential, logarithmic, and linear functions will be discussed in detail; limits and the generation of recursive/non-recursive sequences and series will be related to the computational growth of elementary algorithms involving simple computational structures. Throughout the module, wherever possible, theory will be explicitly related to computer science topics, and general reusable skills will be favoured over more esoteric topics. Weekly classroom exercises will completed to reinforce learning and give the student the opportunity to work through (and receive formative feedback on) many example problems prior to summative assessment.

Year 3: Digital Data Storage and Transmission

This module investigates the way in which data is stored within a computer system and also how it is transmitted between devices at a packet and physical level. Building on the basic understanding of memory data types and file systems covered in earlier modules this module looks in more detail at how data is stored on disk (and backed up!) and in memory and how at a raw signalling and packet level it is passed from device to device and is verified. Students will be introduced to a range of tools for examining memory and file systems, for recovering data and repairing file systems and the law relating to doing so. A range of case studies will be considered which might include (but not be limited to) the Windows Registry, the FAT and Linux based file systems and Ethernet/IP packets and their transmission. Studying this module will enhance the employability of students in the computer science subject discipline as graduates with a strong technical knowledge of the underlying ways in which data is stored and transmitted and can advise on its protection, backup, analysis and recovery when damaged/lost are in demand by companies.

Year 3: Object Oriented C++

C++ (and its language precursor, C) is arguably the most common programming language in industry, and graduates who are good C/C++ programmers are often much sought after in the IT sector (systems programming, embedded software, graphics and games programming). The reason for the popularity of C++ is partly historical, partly because the programmer can produce fast, memory-efficient programs, and partly because of its flexibility to support different programming styles. This module provides an introduction to C++ for those already with some programming experience in another language such as Java or C#. Following a procedural introduction students will learn an object-oriented style of programming including some design considerations. Code will be written using an appropriate development environment (such as VisualC++, DevC++, or C++Builder) and mainly confined to ANSI/ISO C++ and use of the standard library so as to promote source code portability to other platforms. Students will learn how explicit types of memory allocation can be used to manipulate data and how this can influence computer resources, and thus will gain an understanding of the underlying architecture behind how other high level programming languages manage their data.

Year 3: Network Services Engineering and the Internet of Things

The concept of the Internet of Things is that using micro-sensors, we can make almost any everyday object 'intelligent' and connect them to the Internet, and therefore we are not restricted to just our computers, mobiles and tablet devices. The module will explore the potential and impact of the IoT and the environment the devices connect to - the Internet of Everything (IoE).

Students will gain a deep understanding of the concepts and technologies that underpin the IoT and IoE framework and be able to use and apply the information from lectures and technical literature in practice, making them more attractive to employers in the networking and innovative technology sectors.

The module will also introduce system and network-related services. Internet connectivity (including email and the World Wide Web), network printing, firewalls, VoIP (Voice over IP) and VPNs (Virtual Private Networks) are just a few examples of common network services and their applications. They are essential for computers to communicate with each other, and are therefore extremely important in modern computer systems.

Key concepts and principles of network services and the standards used by modern computer networks will be discussed in-depth, considering both theoretical and applied aspects. In the practical sessions for this module, students will be able to

experiment with the configuration and implementation of common network services such as FTP, e-mail and web services. Internet-of-Things programming or scripting languages will be introduced where students will learn how to program ever-increasing affordable Internet-of-Things devices. Prior programming experience will be assumed: students taking this module are expected to quickly pick up the programming or scripting languages introduced.

Most of the scheduled class time will be spent in the Linux laboratory where students have full administrator-level privileges.

Outside of scheduled class times students will have remote access to the LMS where they will be able to access notes and participate in discussions. The skills gained via the practical labs and knowledge of cutting-edge developments in network technologies, including the IoT and IoE, will aid students' employability in any field relating to computer networking and entrepreneurship.

Year 4: Internet Services, Data Analytics and the Cloud

The Internet and the emerging cloud-computing paradigm provide an opportunity to design and implement a wide range of effective analytical and distributed applications that can be accessed via various types of devices. The success of such applications involve skilful use of data science and several programming techniques, requiring professionals in the field to confidently deliver solutions in a fast-paced and time-constrained environment. An in-depth knowledge of prototyping, through coding, testing and deployment, is the key to delivering such applications. This module is specifically designed to provide the knowledge and skills to enable students to confidently implement effective analytics applications using technologies that underpin the Internet and the Cloud. Cloud Computing security is also discussed and explored.

A significant proportion of the module will involve writing and testing code using current industry standard programming and scripting languages. Prior coding and programming experience will be assumed: students taking this module are expected to quickly pick up the programming languages introduced. An important part of developing effective cloud/web-based distributed analytics applications is the understanding of current database management systems. Prior knowledge of and experience with simple database design and implementation is therefore a pre-requisite for this module and will be assumed.

Using a blend of theoretical discussion, laboratory sessions and remote access to class servers, this module will cover the necessary skills to understand, evaluate, implement and apply good practice in prototyping effective cloud/web based distributed applications.

Year 4: Artificial Intelligence

Artificial Intelligence (AI) covers a broad range of disciplines ranging from cognitive science and philosophy to more pragmatic engineering subjects. It takes its inspiration from human and other biological behaviour that exhibit intelligence, such as problem solving, planning, decision making and optimization, and seeks to create systems that can perform similar intelligent tasks. The module covers all the main areas of AI such as behaviour, genetic algorithms, neural networks, fuzzy logic and other topics. The course is intended to be quite practical with an emphasis on interactivity in terms of code development and within a wider context of game development. This reflects that whilst a mainstream approach to the subject is taken some content will have a gaming emphasis. The module assumes a basic level of mathematical ability and physics background (e.g. equations, trigonometry, vectors, equations of force) and whilst no expertise in any particular language is presumed some familiarity in one common high-level programming language is expected (eg C#, C++ or Java). The practical sessions will mainly involve code development and exploration of basic AI principles through using various software learning tools. The assessment will require students to develop an AI solution to a given problem providing suitable documentation for the development process.

Year 4: Mobile Technology

This module investigates in detail the technology of "next generation" mobile devices from mobile phones to media centres. The basic communication infrastructure will be covered to establish the context of data transmission to devices including environmental issues of base station location, components and testing. The full range of current and near production devices will be evaluated, in the context of services that can be rendered to users. Extensive use of case study materials will be used to evaluate services: video, conferencing, gaming, internet rich applications and voice over IP among other applications. Practitioners will present these examples of actual and future applications wherever possible and students will be able to practically compare alternative technologies particularly for enterprise deployment. Students will be encouraged to develop their own ideas within the technology and prepare content of whatever form to be rendered and tested on mobile devices using the latest software packages. This material may be for entertainment, games, e-learning/training, conferencing, or applications of

existing services: e-mail, Instant messaging, news etc.

Year 4: Ethical Hacking and Countermeasures

The aim of this module is to give students a rounded introduction to the principles of ethical hacking from theoretical and technical perspectives and to provide a contextual setting for ethical hacking by an examination of the issues associated with systems security, computer crime and the criminal justice system i.e. Computer Misuse Act. Students will be introduced to the basic principles of ethical hacking and the role ethical hacking plays in providing more secure and robust information to support computer systems and networks (including wireless networks). Students will be exposed to, and use, the basic tools and techniques of ethical hacking, particularly in regard to penetration testing and systems security. Students will be provided with opportunities to develop academic skills in report writing and reflective practice presentations. By research and application students will develop the skills to manage the particular legal, ethical and professional challenges, facing the Information Security practitioner with particular reference to the criminal justice system in England and Wales and the Computer Misuse Act.

Year 4: Advanced Network Solutions

Modern IT infrastructures are constantly advancing and expanding to meet the needs of dynamically changing business requirements. The driving force that underpins this comes from many aspects, ranging from the requirement for the adaptation of user mobility, to the advancing computer device and network technologies. Network designers must design and build an enterprise network that is both scalable and highly available.

The first part of the module introduces strategies that can be used to systematically design a highly functional network. It also covers network design concepts, principles, models, architectures and the benefits that are obtained by using a systematic design approach. Students will gain not only a deep understanding of the concept of network designs that underpin reliable and scalable networks but also the ability to apply the knowledge in practice.

Wide-area networks (WANs) are used to connect remote LANs together. The second part of the module introduces WAN standards, technologies, and purposes. It covers selecting the appropriate WAN technologies such as protocols, services, and devices to meet the changing business requirements of an evolving enterprise. . In addition to IPv4, the latest IPv6 protocols and the addressing scheme will also be covered.

The module is based on the new R&S CCNA 3 & 4 curriculum offered by The Cisco Networking Academy Program (CNAP), a well-established partnership between academia and industry, to provide the most up-to-date knowledge and skills required by industry and commerce. Students studying this module will need to undertake a significant amount of directed self-study for Packet Tracer based lab exercises in their own time. The additional optional module Digital and Network Security Forensics helps compliment the skills and knowledge learnt in this module towards achieving the external CCNA certification if required.

Year 4: Digital & Network Security Forensics

Digital evidence features in just about every part of our personal and business lives. Law enforcement and forensic companies rely heavily on digital forensic skills and tools to acquire that evidence. Legal and business decisions hinge on having timely data about what people have actually done. This module will help the student understand how to conduct investigations to correctly gather, analyse and present digital evidence to both business and legal audiences. Students will also learn how to use tools to locate and analyse digital evidence on a variety of devices, including mobile phones, and how to keep up to date with changing technologies, laws and regulations in digital forensics.

The importance of Network Security in modern connected organisations cannot be understated as increasingly data processing and storage are interconnected. Network forensics has had a major impact on analysing the activities of threat actors in compromised networks. Consequently, a thorough understanding and knowledge of both Network Security and Network Forensics is a necessity. This module aims to develop the student's skills and knowledge associated with Network Security and Network Forensics.

The additional optional module Advanced Network Solutions helps compliment the skills and knowledge learnt in this module towards achieving the external CCNA certification if required.

Year 4: Computer Graphics Programming

Computer graphics is a branch of computer science which studies methods for digitally creating and modifying visual content, specifically in two and three dimensions. It has many applications including the development of computer games, the design (and implementation) of engineering tasks, and in medical diagnostics and treatment. Note for this module the definition of computer graphics does not extend to include image processing.

Computer Graphics Programming introduces some of the programming techniques used to construct primitive lines and shapes through an understanding and implementation of the drawing algorithms that underpin the subject. Some of the fundamental graphics algorithms are introduced such as Line and Curve drawing, 2D transformations, 3D perspective transformations, Hidden Line and Surface Removal and Ray Tracing Algorithms.

Some of these algorithms will be implemented using a major software development environment and an appropriate programming language that utilises the graphics capability of the underlying computer hardware.

Year 4: Distributed Programming

Distributed Programming is the development of software applications that utilise the distributed functionality of an intranet or the internet. These applications are vital to the banking sector, commercial organisations and governmental institutions as they involve the fundamental technologies underpinning Cloud Computing and On-Line Multi-Player Gaming environments.

The module covers the key principles of low-level distributed programming to manage the communication of data between computers. The language of implementation will be one whose libraries support Socket programming, such as Java, C# or C++. Students will learn how to develop applications that share out, or 'farm' large computing operations to smaller interconnected nodes thus implementing a kind of virtual parallel processing.

A variety of practical exercises will illustrate these programming techniques and components in an Intranet environment. Examples of programming language support for some of the more common application and communication network protocols will be covered. Threads and multi-threading is introduced as a technique to manage concurrency and the marshalling of data between processes.