

Mathematics and Computer Science with a Year in Industry

BSc (Hons)

COURSE DETAILS

- A level requirements: [AAB](#)
- UCAS code: GG16
- Study mode: Full-time
- Length: 4 years

KEY DATES

- Apply by: [25 January 2023](#)
- Starts: 25 September 2023

Course overview

Mathematicians and computer scientists are amongst the most highly-prized graduates today.

INTRODUCTION

On this programme, you will divide your studies more or less equally between the two subjects, studying modules from Mathematics and Computer Science.

Mathematics is a fascinating, beautiful and diverse subject to study. It underpins a wide range of disciplines; from physical sciences to social science, from biology to business and finance. At Liverpool, our programmes are designed with the needs of employers in mind, to give you a solid foundation from which you may take your career in any number of directions.

From the underlying principles to the very edge of modern technology, this

programme will cover aspects of Computer Science and ensure that when you graduate you will know exactly what is and isn't possible with computers.

On this **year in industry** programme, you will spend year three of this programme on a year-long placement with an approved company/organisation. During this time, you will develop work-based transferrable skills and professional competences leading to enhanced employability which will make you well placed to take up opportunities in project-based, research and management roles.

WHAT YOU'LL LEARN

- Pure mathematics
- Applied mathematics

- Problem solving
- Team work
- How to communicate and present clearly
- Understanding different computer systems

- Building and structuring databases
 - Fundamentals of software engineering
 - Algorithmic foundations
 - Complexity of algorithms and decision
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Course content

Discover what you'll learn, what you'll study, and how you'll be taught and assessed.

YEAR ONE

Year one of the programme has been designed as an even split between

subjects related to computing and mathematics.

In year one students will typically undertake either COMP101 (Introduction to Programming) or COMP105 (Programming Language Paradigms) based on prior exposure to programming (eg Computer Science A level). Students without a computer science background will normally study COMP101, however in some instances may be permitted to enrol on COMP105 instead.

All other year one modules are required.

COMPULSORY MODULES

CALCULUS I (MATH101)

Credits: 15 / Semester: semester 1

At its heart, calculus is the study of limits. Many quantities can be expressed as the limiting value of a sequence of approximations, for example the slope of a tangent to a curve, the rate of change of a function, the area under a curve, and so on. Calculus provides us with tools for studying all of these, and more. Many of the ideas can be traced back to the ancient Greeks, but calculus as we now understand it was first developed in the 17th Century, independently by Newton and Leibniz. The modern form presented in this module was fully worked out in the late 19th Century. MATH101 lays the foundation for the use of calculus in more advanced modules on differential equations, differential geometry, theoretical physics, stochastic analysis, and many other topics. It begins from the very basics – the notions of real number, sequence, limit, real function, and continuity – and uses these to give a rigorous treatment of derivatives and integrals for real functions of one real variable.

CALCULUS II (MATH102)

Credits: 15 / Semester: semester 2

This module, the last one of the core modules in Year 1, is built upon the knowledge you gain from MATH101 (Calculus I) in the first semester. The syllabus is conceptually divided into three parts: Part I, relying on your knowledge of infinite series, presents a thorough study of power series (Taylor expansions, binomial theorem); part II begins with a discussion of functions of several variables and then establishes the idea of partial differentiation together with its various applications, including chain rule, total differential, directional derivative, tangent planes, extrema of functions and Taylor expansions; finally, part III is on double integrals and their applications, such as finding centres of mass of thin bodies. Undoubtedly, this module, together with the other two core modules from Semester 1 (MATH101 Calculus I and MATH103 Introduction to linear algebra), forms an integral part of your ability to better understand modules you will be taking in further years of your studies.

DATA STRUCTURES AND ALGORITHMS (COMP108)

Credits: 15 / Semester: semester 2

This module introduces students to some basic algorithms and data structures. It gives some fundamental concepts of design and analysis of algorithms, and implementation of algorithms by choosing appropriate data structures.

DESIGNING SYSTEMS FOR THE DIGITAL SOCIETY (COMP107)

Credits: 15 / Semester: semester 1

This module will provide students with an all rounded appraisal of what is expected from a computing professional in the current digital society. Students will be introduced to social, legal and ethical aspects on computing and will develop employability skills. As a way to blend both theory and practice, students will be equipped with concepts and techniques for designing digital systems tailored to the needs of the user.

INTRODUCTION TO LINEAR ALGEBRA (MATH103)

Credits: 15 / Semester: semester 1

Linear algebra is the branch of mathematics concerning vector spaces and linear mappings between such spaces. It is the study of lines, planes, and subspaces and their intersections using algebra.

Linear algebra first emerged from the study of determinants, which were used to solve systems of linear equations. Determinants were used by Leibniz in 1693, and subsequently, Cramer's Rule for solving linear systems was devised in 1750. Later, Gauss further developed the theory of solving linear systems by using Gaussian elimination. All these classical themes, in their modern interpretation, are included in the module, which culminates in a detailed study of eigenproblems. A part of the module is devoted to complex numbers which are basically just planar vectors. Linear algebra is central to both pure and applied mathematics. This module is an essential pre-requisite for nearly all modules taught in the Department of Mathematical Sciences.

OBJECT-ORIENTED PROGRAMMING (COMP122)

Credits: 15 / Semester: semester 2

The intention of COMP122 is to introduce students to the concepts and methodology of object-oriented programming using the Java programming language. Topics covered include hierarchical structures, polymorphism, collections and iterators, exception handling, and graphical user interface design. Basic concepts of software design methodology, testing, and version control are also included in the module. It is normally expected that students have prior programming experience.

OPTIONAL MODULES**NEWTONIAN MECHANICS (MATH122)****Credits: 15 / Semester: semester 2**

This module is an introduction to classical (Newtonian) mechanics. It introduces the basic principles like conservation of momentum and energy, and leads to the quantitative description of motions of bodies under simple force systems. It includes angular momentum, rigid body dynamics and moments of inertia. MATH122 provides the foundations for more advanced modules like MATH228, 322, 325, 326, 423, 425 and 431.

NUMBERS, GROUPS AND CODES (MATH142)**Credits: 15 / Semester: semester 2**

A group is a formal mathematical structure that, on a conceptual level, encapsulates the symmetries present in many structures. Group homomorphisms allow us to recognise and manipulate complicated objects by identifying their core properties with a simpler object that is easier to work with. The abstract study of groups helps us to understand fundamental problems arising in many areas of mathematics. It is moreover an extremely elegant and interesting part of pure mathematics. Motivated by examples in number theory, combinatorics and geometry, as well as applications in data encryption and data retrieval, this module is an introduction to group theory. We also develop the idea of mathematical rigour, formulating our theorems and proofs precisely using formal logic.

INTRODUCTION TO STATISTICS (MATH162)**Credits: 15 / Semester: semester 2**

MATH162 introduces basic concepts and techniques used in probability and statistics. Mathematics does not only deal with precise statements and exact solutions. This module will teach you how to cope with uncertainties associated with incomplete or overwhelming information. Statistics is the science of data. MATH162 presents the most-used methods of basic statistics in a way that emphasizes working with data and mastering statistical reasoning. It is elementary in mathematical level, but conceptually rich in statistical ideas and serious in its aim to help students think about data and use statistical methods with understanding. MATH162 material includes a large set of tutorial/homework problems which widen your view on the use of mathematics for practical problems. The module also includes a set of practical sessions where you solve statistical problems using software packages such as R. MATH162 prepares you for a range of follow-up modules – it is a prerequisite for 22 currently delivered modules."

INTRODUCTION TO PROGRAMMING (COMP101)

Credits: 15 / Semester: semester 1

The module provides an introduction to procedural programming using current language platforms. The module incorporates program design, problem solving, the importance of maintainable, robust software and testing as well as introducing procedural language main programming constructs. Students gain practical experience with program design, programming and testing during weekly laboratory sessions.

PROGRAMMING LANGUAGE PARADIGMS (COMP105)

Credits: 15 / Semester: semester 1

This module is for students that already have some programming skills. Students will learn about the two main programming paradigms: imperative programming and functional programming. Since most introductory programming courses teach imperative programming, this module will focus on the functional paradigm. Students will learn how to program in Haskell, a popular functional programming language. They will learn how to formulate programs in a functional way, and the common techniques and idioms that are used to solve problems in functional programming.

Programme details and modules listed are illustrative only and subject to change.

YEAR TWO

In year two you continue with a mix of modules related to computer science and mathematics but also have the opportunity

to specialise in certain subject areas of your choice.

COMPULSORY MODULES

COMPLEXITY OF ALGORITHMS (COMP202)

Credits: 15 / Semester: semester 2

OPTIONAL MODULES

COMPUTER NETWORKS (COMP211)

Credits: 15 / Semester: semester 1

This module provides an introduction to current computer networks and communications technologies. We will use the architecture and protocols of the Internet as a primary vehicle for studying fundamental computer networking concepts. This will include an in-depth study of the key protocols that enable communications across the Internet. You will become familiar with the various network devices and network addressing schemes. We will identify critical network security issues and study approaches towards addressing these issues.

COMPUTER SYSTEMS (COMP124)

Credits: 15 / Semester: semester 2

This module provides a basic introduction to the important hardware and software components supporting the operation of computer systems. The module presents coverage of how low-level hardware components are organised so as to provide a platform on which complex software systems can be built. Coverage includes the important components of modern operating systems, including abstractions such as processes and concurrency. There is an opportunity to gain some practical awareness of low-level programming and a modern command-line environment.

SOFTWARE ENGINEERING I (COMP201)

Credits: 15 / Semester: semester 1

This module deals with the issues associated with the analysis, design, implementation and testing of significant computing systems (that is, systems that are too large to be designed and developed by a single person).

DATABASE DEVELOPMENT (COMP207)

Credits: 15 / Semester: semester 1

This module introduces students to the problems arising from databases, including concurrency in databases, information security considerations and how they are solved; the integration of heterogeneous sources of information and the use of semi-structured data; non-relational databases and the economic factors involved in their selection and to techniques for analysing large amounts of data, the security issues and commercial factors involved with them.

INTRODUCTION TO THEORY OF COMPUTATION (COMP218)

Credits: 15 / Semester: semester 1

This module aims to introduce formal concepts of automata, grammars and languages; to introduce ideas of computability and decidability, and to illustrate the importance of automata, formal language theory and general models of computation in Computer Science and Artificial Intelligence.

MATH201 – ORDINARY DIFFERENTIAL EQUATIONS (MATH201)

Credits: 15 / Semester: semester 1

Differential equations play a central role in mathematical sciences because they allow us to describe a wide variety of real-world systems and the mathematical techniques encountered in this module are useful to a number of later modules; this is why M201 is compulsory. The module will aim to stress the importance of both theory and applications of ordinary differential equations (ODE), putting a strong emphasis on problem solving and examples. It is an immediate continuation of year 1 so anyone who found MATH101-103 too challenging should start revising them well before starting this course. It has broadly 3 parts and each part contains two types of equations: those that can be solved by specific methods and others that cannot be solved but can only be studied by theories to “know” some properties of the underlying equations and their solutions. Part 1 begins by trying to solve first order differential equations where use of integration techniques is routine. Part 2 studies second order differential equations for both initial value and boundary value problems; in the latter we meet eigenfunctions, orthogonal functions and Fourier series through Sturm–Liouville equations. Part 3 generalizes methods and theories from Parts 1–2 to the case of system of ODEs where eigenvalues, eigenvectors and generalized eigenvectors are extensively used. The module introduces some of the basic concepts of partial differential equations (PDEs) in simple cases where reduction to ODEs is possible. Throughout the module, the technique of separation of variables is used.

INTRODUCTION TO THE METHODS OF APPLIED MATHEMATICS (MATH224)

Credits: 15 / Semester: semester 2

In order to solve problems which arise in nature one invariably encounters differential equations. These can be either ordinary or partial differential equations. Basic techniques to solve both types of differential equations are developed in the module including solution by Fourier series and characteristics. The former allow one to analyse the dominant or resonant modes of a physical system whilst the latter are the foundation for solving partial differential equations. The module therefore lies at the heart of many applied mathematics applications and serves as the foundation for the advanced associated module MATH323 (Further methods of applied mathematics).

VECTOR CALCULUS WITH APPLICATIONS IN FLUID MECHANICS (MATH225)

Credits: 15 / Semester: semester 1

To provide an understanding of the various vector integrals, the operators div, grad and curl and the relations between them. To give an appreciation of the many applications of vector calculus to physical situations. To provide an introduction to the subjects of fluid mechanics and electromagnetism.

MATHEMATICAL MODELS: MICROECONOMICS AND POPULATION DYNAMICS (MATH227)

Credits: 15 / Semester: semester 1

Essentially this module is split into two distinct parts. The first part looks at population dynamics of single and interacting species. The module aims to give an overview of useful solution techniques (both analytic and approximate) to first order non-linear differential equations frequently encountered in evolutionary models where certain quantities are changing with time. The main focus is on biological populations, but the ideas have much wider applications in mechanics, chemical and nuclear physics, and finance. The course also provides a basic introduction to the topic of dynamical systems, explored more deeply in MATH322 (Chaos and dynamical systems).

The second part of the course focuses on the topic of microeconomics, the economics of the small scale consumer and the supplier (e.g. the shop keeper/factory owner) which we all experience – as opposed to the subject macroeconomics which is the preserve of Government policy. Students are introduced to the concepts of marginal Utility Theory, first formulated by British mathematician Alfred Marshall, one of the founders of the neoclassical school of economics. This leads on to ideas of how a consumer should optimize his utility function subject to budgetary constraints. Attention is then turned to the problems facing manufacturers, the need to minimize production costs based on labour and raw materials, whilst at the same time seeking to achieve and maximise their profits. Finally consumers and suppliers are brought together in the market, where a consumer price for a commodity is established, based on the consumer's demand and the manufacturer's ability to supply. The classical approach adopted to the solution of these problems complements the more modern mathematical developments in finance/economics based on stochastic calculus, discussed in modules such as MATH260/MATH262 (Financial Mathematics).

CLASSICAL MECHANICS (MATH228)

Credits: 15 / Semester: semester 2

This module is concerned with the motion of physical bodies both in everyday situations and in the solar system. To describe motion, acceleration and forces you will need background knowledge of calculus, differentiation, integration and partial derivatives from MATH101 (Calculus I), MATH102 (Calculus II) and MATH103 (Introduction to Linear Algebra). Classical mechanics is important for learning about modern developments such as relativity (MATH326), quantum mechanics (MATH325) and chaos and dynamical systems (MATH322). This module will make you familiar with notions such as energy, force, momentum and angular momentum which lie at the foundations of applied mathematics problems.

METRIC SPACES AND CALCULUS (MATH241)

Credits: 15 / Semester: semester 1

This is a foundational module aimed at providing the students with the basic concepts and techniques of modern real Analysis. The guiding idea will be to start using the powerful tools of analysis, familiar to the students from the first-year module MATH101 (Calculus I) in the context of the real numbers, to vectors (multivariable analysis) and to functions (functional analysis). The notions of convergence and continuity will be reinterpreted in the more general setting of metric spaces. This will provide the language to prove several fundamental results that are in the basic toolkit of a mathematician, like the Picard Theorem on the existence and uniqueness of solutions to first order differential equations with an initial datum, and the implicit function theorem. The module is central for a curriculum in pure and applied mathematics, as familiarity with these notions will help students who want to take other subsequent modules such as MATH444 as well as many projects. This module is also a useful preparation (although not a formal prerequisite) for MATH365 (Measure theory and probability), a very useful module for a deep understanding of financial mathematics.

COMPLEX FUNCTIONS (MATH243)

Credits: 15 / Semester: semester 1

This module introduces students to a surprising, very beautiful theory having intimate connections with other areas of mathematics and physical sciences, for instance ordinary and partial differential equations and potential theory.

LINEAR ALGEBRA AND GEOMETRY (MATH244)

Credits: 15 / Semester: semester 1

Linear algebra provides a toolbox for analysing phenomena ubiquitous in many areas of mathematics: linear maps, or linearity in general. In all of these situations it is essential to first identify the kind of objects which are mapped or behave in a linear way. To cover the many different possibilities the concept of an abstract vector space is introduced. It generalizes the real vector spaces introduced in MATH103 (Introduction to Linear Algebra) and the calculational techniques developed there can still be used. Applications of ideas from Linear Algebra appear in Geometry (MATH201, MATH349), in Algebra (MATH247, MATH343), in solving Differential Equations (MATH201, MATH221), which in turn model many physical systems (MATH323, MATH324), in Physics, especially Quantum Mechanics (MATH325, MATH421), in Biology (MATH335, MATH426) and in Statistics (MATH363).

COMMUTATIVE ALGEBRA (MATH247)

Credits: 15 / Semester: semester 2

The module provides an introduction to the theory and methods of the modern commutative algebra (commutative groups, commutative rings, fields and modules) with some applications to number theory, algebraic geometry and linear algebra.

GEOMETRY OF CURVES (MATH248)

Credits: 15 / Semester: semester 2

This module is about plane curves and their geometry. The key question about a curve is: what does it look like? To answer this we have to do calculations, but the answer is not complete until we can draw a picture of the curve based on the calculations. The module is therefore important in many pure and applied mathematics questions. The advanced associated module is MATH349 (Differential geometry).

STATISTICAL THEORY AND METHODS I (MATH263)

Credits: 15 / Semester: semester 2

Analysis of data has become an essential part of current research in many fields including medicine, pharmacology, and biology. It is also an important part of many jobs in e.g. finance, consultancy and the public sector. This module provides an introduction to statistical methods with a strong emphasis on applying and interpreting standard statistical techniques. Since modern statistical analysis of real data sets is performed using computer power, a statistical software package is introduced and employed throughout.

STATISTICAL THEORY AND METHODS II (MATH264)

Credits: 15 / Semester: semester 2

This module provides an introduction to probabilistic methods that are used not only in actuarial science, financial mathematics and statistics but also in all physical sciences. It focuses on discrete and continuous random variables with values in one and several dimensions, properties of the most useful distributions (e.g. geometric, exponential, and normal), their transformations, moment and probability generating functions and limit theorems. This module will help students doing MATH262 (Financial mathematics). This module complements MATH365 (Measure theory and probability) in the sense that MATH365 provides the contradiction-free measure theoretic foundation on which this module rests.

OPERATIONAL RESEARCH: PROBABILISTIC MODELS (MATH268)

Credits: 15 / Semester: semester 1

This module introduces several probabilistic models in operations research, such as queueing systems, simulations, and decision theory under risk. Those topics heavily interact with other subjects such as applied probability, actuarial sciences etc. This module is complementary to MATH261 (Introduction to operational research), which focuses on the mathematical programming aspect of operational research, mainly in a deterministic setup.

FINANCIAL MATHEMATICS (MATH260)

Credits: 15 / Semester: semester 2

Mathematical Finance uses mathematical methods to solve problems arising in finance. A common problem in Mathematical Finance is that of derivative pricing. In this module, after introducing the basic concepts in Financial Mathematics, we use some particular models for the dynamic of stock price to solve problems of pricing and hedging derivatives. This module is fundamental for students intending to work in financial institutions and/or doing an MSc in Financial Mathematics or related areas.

INTRODUCTION TO ARTIFICIAL INTELLIGENCE (COMP111)

Credits: 15 / Semester: semester 1

Artificial intelligence (AI) is the theory and development of machines able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. In the 21st century, AI techniques became an essential part of the technology industry. High-profile examples include autonomous vehicles, medical diagnosis, creating art, proving mathematical theorems, playing games, search engines, and online assistants. This module provides an application driven introduction to AI through studying the basic problems most AI systems have to deal with: search problems, reasoning under uncertainty, knowledge representation, planning, and learning in intelligent systems. The module will also provide a basic introduction to the history and philosophy of AI as well as recent issues in ethics of AI.

CYBER SECURITY (COMP232)

Credits: 15 / Semester: semester 2

The module provides a thorough introduction to the area of Cyber Security, including cryptographic algorithms and protocols, systems vulnerabilities and attacks, computer networks and web security. The main basic concepts and theoretical foundations are presented in the lectures, while extensive practical sessions support the development of skills in practical cybersecurity.

GROUP SOFTWARE PROJECT (COMP208)

Credits: 15 / Semester: semester 2

Software development skills form a fundamental part of the professional expertise of a Computer Scientist. Often the development is a team activity. The module provides the students with the unique opportunity to complete a sizeable software development project working as part of team.

DISTRIBUTED SYSTEMS (COMP212)

Credits: 15 / Semester: semester 2

This module covers the concepts of distributed systems and the underlying principles of distributed computing and discusses the issues and various solutions proposed in the distributed computing community. Specifically, communication and broadcast, election algorithms, synchronization and concurrency, fault-tolerance and security related issues will be discussed in the lectures. Where applicable practical implementations of the concepts will be introduced.

COMPUTER-BASED TRADING IN FINANCIAL MARKETS (COMP226)

Credits: 15 / Semester: semester 2

Programme details and modules listed are illustrative only and subject to change.

YEAR IN INDUSTRY (YEAR THREE)

Year three of the programme is taken up with a placement in a professional software industry environment.

COMPULSORY MODULES

INDUSTRIAL PLACEMENT Y3 (COMP299)

Credits: 120 / Semester: whole session

Programme details and modules listed are illustrative only and subject to change.

YEAR FOUR

OPTIONAL MODULES

KNOWLEDGE REPRESENTATION AND REASONING (COMP304)

Credits: 15 / Semester: semester 1

This module presents formal ways to reason about knowledge and uncertain or partial information.

BIOCOMPUTATION (COMP305)

Credits: 15 / Semester: semester 1

Biology inspired adaptive algorithms such as Artificial Neural Networks (ANNs) and Genetic Algorithms (GAs) play an important role in modern computing, information processing, and machine learning. The latest increase in computer power ensured broad use of the algorithms to solve problems in science and engineering previously considered impossible to tackle. ANNs are now broadly used in pattern recognition, including speech recognition and classification problems, statistics, functional analysis, modelling financial series with considerable stochasticity, etc. GAs are search procedures based on the mechanics of natural selection and natural genetics. They provide effective solutions to a variety of optimisation problems in economics, linguistics, engineering, and computer science. Both ANNs and GAs can exploit massively parallel architectures to speed up problem solving and provide further understanding of intelligence and adaptation. The main goals of the module are to introduce students to some of the established work in the field of Artificial Neural Networks and Genetic Algorithms and their applications, particularly in relation to multidisciplinary research. To equip students with a broad overview of the field, placing it in a historical and scientific context. The module provides students with the knowledge and skills necessary to keep up-to-date in actively developing areas of science and technology and be able to make reasoned decisions.

EFFICIENT SEQUENTIAL ALGORITHMS (COMP309)

Credits: 15 / Semester: semester 1

This module aims to teach students some advanced topics in the design and analysis of efficient sequential algorithms, and a few key results related to the study of their complexity.

MULTI-AGENT SYSTEMS (COMP310)**Credits: 15 / Semester: semester 2****FORMAL METHODS (COMP313)****Credits: 15 / Semester: semester 2****TECHNOLOGIES FOR E-COMMERCE (COMP315)****Credits: 15 / Semester: semester 2****SOFTWARE ENGINEERING II (COMP319)****Credits: 15 / Semester: semester 1**

The overall aim of this module is to introduce students to a range of advanced, near-research level topics in contemporary software engineering. The actual choice of topics will depend upon the interests of the lecturer and the topics current in the software engineering research literature at that time. The course will introduce issues from a problem (user-driven) perspective and a technology-driven perspective where users have new categories of software problems that they need to be solved, and where technology producers create technologies that present new opportunities for software products. It will be expected that students will read articles in the software engineering research literature, and will discuss these articles in a seminar-style forum.

INTRODUCTION TO COMPUTATIONAL GAME THEORY (COMP323)**Credits: 15 / Semester: semester 1**

This module is an introduction to the area of algorithmic game theory, which is a novel area in the intersection of economics and computer science. It provides tools for dealing with and analysing problems related to applications motivated by the Internet. Examples involve various Internet auctions and e-commerce systems, like, Google's sponsored search, Ebay auctions, recommendation systems, etc.

COMPUTATIONAL GAME THEORY AND MECHANISM DESIGN (COMP326)**Credits: 15 / Semester: semester 2**

In this module we introduce and study games that have some underlying network structure or that appear in auctions. A focus will be on scheduling and routing, as well as on the computational aspects in the design of mechanisms and auctions.

OPTIMISATION (COMP331)

Credits: 15 / Semester: semester 1

This module is an indepth tour over optimisation methods applied for various optimisation models. These methods are extensively used in both academic and industrial practices.

CHAOS AND DYNAMICAL SYSTEMS (MATH322)**Credits: 15 / Semester: semester 1**

Math322 introduces the novel findings concerning the solving techniques and nature of solutions occurring in nonlinear difference and differential equations. The (counterpart) theory of linear equations is covered in Math122 (Dynamic Modelling) and Math201 (Differential Equations). The modern theory of fractals (occurred only in 1970s) is delivered and many examples of fractal objects, including the Mandelbrot set, are demonstrated. The classification of possible solutions occurring in dynamical systems together with the bifurcation theory is provided. The emphasis is made to the bifurcations leading to chaotic solutions. Detailed analysis of chaotic solutions (their nature and impact in understanding the universe) is provided. The qualitative analysis technique for solving nonlinear systems of difference/differential equations is introduced.

FURTHER METHODS OF APPLIED MATHEMATICS (MATH323)**Credits: 15 / Semester: semester 1**

Ordinary and partial differential equations (ODEs and PDEs) are crucial to many areas of science, engineering and finance. This module addresses methods for, or related to, their solution. It starts with a section on inhomogeneous linear second-order ODEs which are often required for the solution of higher-level problems. We then generalize basic calculus by considering the optimization of functionals, e.g., integrals involving an unknown function and its derivatives, which leads to a wide variety of ODEs and PDEs. After those systems of two linear first-order PDEs and second-order PDES are classified and reduced to ODEs where possible. In certain cases, e.g., 'elliptic' PDEs like the Laplace equation, such a reduction is impossible. The last third of the module is devoted to two approaches, conformal mappings and Fourier transforms, which can be used to obtain solutions of the Laplace equation and other irreducible PDEs.

CARTESIAN TENSORS AND MATHEMATICAL MODELS OF SOLIDS AND VISCOUS FLUIDS (MATH324)**Credits: 15 / Semester: semester 1**

This module provides an introduction to basic concepts and principles of continuum mechanics. Cartesian tensors are introduced at the beginning of the module, bringing simplicity and versatility to the analysis. The module places emphasis on the importance of conservation laws in integral form, and on the fundamental role integral conservation laws play in the derivation of partial differential equations used to model different physical phenomena in problems of solid and fluid mechanics. Some knowledge of Vector Calculus (e.g. MATH225 Vector calculus with applications in fluid mechanics) is useful.

QUANTUM MECHANICS (MATH325)

Credits: 15 / Semester: semester 1

The development of Quantum Mechanics, requiring as it did revolutionary changes in our understanding of the nature of reality, was arguably the greatest conceptual achievement of all time. The aim of the module is to lead the student to an understanding of the way that relatively simple mathematics (in modern terms) led Bohr, Einstein, Heisenberg and others to a radical change and improvement in our understanding of the microscopic world.

GROUP THEORY (MATH343)**Credits: 15 / Semester: semester 1**

The module provides an introduction to the modern theory of finite non-commutative groups. Group Theory is one of the central areas of Pure Mathematics. Being part of Algebra, it has innumerable applications in Geometry, Number Theory, Combinatorics and Analysis, but also plays a very important role in Theoretical Physics, Mechanics and Chemistry. The module starts with basic definitions and some well-known examples (the symmetric group of permutations and the groups of congruence classes modulo an integer) and builds up to some very interesting and non-trivial constructions, such as the semi-direct product, which makes it possible to construct more complicated groups from simpler ones. In the final part of the course, the Sylow theory and its applications to the classification of groups are considered.

COMBINATORICS (MATH344)**Credits: 15 / Semester: semester 2**

Combinatorics is a part of mathematics in which mathematicians deal with discrete and countable structures by means of various combinations, such as permutations, ordered and unordered selections, etc. The seemingly simple methods of combinatorics can raise highly non-trivial mathematical questions and lead to deep mathematical results, which are, in turn, closely related to some fundamental phenomena in number theory

APPLIED PROBABILITY (MATH362)**Credits: 15 / Semester: semester 1**

To give examples of empirical phenomena for which stochastic processes provide suitable mathematical models. To provide an introduction to the methods of probabilistic model building for dynamic events occurring over time. To familiarise students with the usual techniques in the area of probability modelling.

LINEAR STATISTICAL MODELS (MATH363)**Credits: 15 / Semester: semester 1**

This module follows on directly from MATH263 (Statistical Theory and Methods I), extending the work there on linear regression and analysis of variance, and then going beyond these to generalised linear models. The module emphasises applications of statistical methods, while the companion module MATH361 (Theory of Statistical Inference) focuses on more theoretical aspects. Statistical software is used throughout as familiarity with its use is a valuable skill for those interested in a career in a statistical field. It is helpful, though not essential, to have taken MATH264 (Statistical Theory and Methods II).

NETWORKS IN THEORY AND PRACTICE (MATH367)

Credits: 15 / Semester: semester 2

MATH367 aims to develop an appreciation of optimisation methods for real-world problems using fundamental tools from network theory; to study a range of 'standard problems' and techniques for solving them. Thus, network flow, shortest path problem, transport problem, assignment problem, and routing problem are some of the problems that are considered in the syllabus. MATH367 is a decision making module, which fits well to those who are interested in receiving knowledge in graph theory, in operational research, in economics, in logistics and in finance.

ADVANCED ARTIFICIAL INTELLIGENCE (COMP219)

Credits: 15 / Semester: semester 1

This module will provide students with an introduction to the machine learning. It will contain traditional machine learning algorithms, deep learning algorithms, and probabilistic graphical models. Both theoretical knowledge and practical skills will be offered.

FINAL YEAR SECOND SEMESTER 15 CREDIT PROJECT (COMP392)

Credits: 15 / Semester: semester 2

COMPLEX INFORMATION NETWORKS (COMP324)

Credits: 15 / Semester: semester 2

Complex network structures are ubiquitous: the world-wide web, the internet, mobile phone networks, social communities, network structures in biology are just a few popular examples. The module shows how simple combinatorial and algorithmic techniques can be exploited to obtain useful information about these (often) massive structures. The content is delivered through a mixture of lectures on core topics and more informal presentations on various application areas. A series of interactive tutorials and on-line tools in VITAL complete the support offered by this module.

COMMUNICATING COMPUTER SCIENCE (COMP335)

Credits: 15 / Semester: whole session

This module spans both semesters in the final year, with a small number of teacher training lectures in the first semester, followed by delivery of a lesson in the second semester as part of the department's outreach activities. Students will consider the issues associated with teaching STEM subjects in schools, and learn how to create a lesson plan that delivers a computer science topic within the context of the National Curriculum in Computing. They will then deliver this lesson several times in a real classroom setting, and reflect on its effectiveness in a written report. There is a significant amount of private study, with the majority of the time spent in the first semester, so students must manage their time effectively.

DATA MINING AND VISUALISATION (COMP337)

Credits: 15 / Semester: semester 2

To provide an in-depth, systematic and critical understanding of some of the current research issues at the forefront of the academic research domain of data mining. Google search framework and IBM Watson QA system and various other industrial level data mining applications are discussed.

RELATIVITY (MATH326)

Credits: 15 / Semester: semester 1

Einstein's theories of special and general relativity have introduced a new concept of space and time, which underlies modern particle physics, astrophysics and cosmology. It makes use of, and has stimulated the development of modern differential geometry. This module develops the required mathematics (tensors, differential geometry) together with applications of the theory to particle physics, black holes and cosmology. It is an essential part of a programme in theoretical physics. Together with MATH325 (Quantum mechanics) it covers the basics of modern theoretical physics. Possible follow up modules in theoretical physics are MATH423 (Introduction to string theory), MATH425 (Quantum field theory) and MATH431 (Introduction to modern particle theory). MATH326 is essential for students who consider doing a project on black holes or cosmology. Students following a pure mathematics or applied mathematics pathway might be interested in MATH326 because of its applications of differential geometry, and take it together with MATH349 (Differential geometry).

DIFFERENTIAL GEOMETRY (MATH349)

Credits: 15 / Semester: semester 1

Differential geometry studies distances and curvatures on manifolds through differentiation and integration. This module introduces the methods of differential geometry on the concrete examples of curves and surfaces in 3-dimensional Euclidean space. The module MATH248 (Geometry of curves) develops methods of differential geometry on examples of plane curves. This material will be discussed in the first weeks of the course, but previous familiarity with these methods is helpful. Students following a pathway in theoretical physics might find this module interesting as it discusses a different aspect of differential geometry, and might take it together with MATH326 (Relativity). MATH410 (Manifolds, homology and Morse theory) and MATH446 (Lie groups and Lie algebras).

GAME THEORY (MATH331)

Credits: 15 / Semester: semester 2

In this module you will explore, from a game-theoretic point of view, models which have been used to understand phenomena in which conflict and cooperation occur and see the relevance of the theory not only to parlour games but also to situations involving human relationships, economic bargaining (between trade union and employer, etc), threats, formation of coalitions, war, etc.

MATHEMATICAL RISK THEORY (MATH366)

Credits: 15 / Semester: semester 2

To provide an understanding of the mathematical risk theory used in practise in non-life actuarial depts of insurance firms, to provide an introduction to mathematical methods for managing the risk in insurance and finance (calculation of risk measures/quantities), to develop skills of calculating the ruin probability and the total claim amount distribution in some non - life actuarial risk models with applications to insurance industry, to prepare the students adequately and to develop their skills in order to be exempted for the exams of CT6 subject of the Institute of Actuaries (MATH366 covers 50% of CT6 in much more depth).

MEDICAL STATISTICS (MATH364)

Credits: 15 / Semester: semester 2

NUMBER THEORY (MATH342)

Credits: 15 / Semester: semester 1

Number theory begins with, and is mainly concerned with, the study of the integers. Because of the fundamental role which integers play in mathematics, many of the greatest mathematicians, from antiquity to the modern day, have made contributions to number theory. In this module you will study results due to Euclid, Euler, Gauss, Riemann, and other greats: you will also see many results from the last 10 or 20 years. Several of the topics you will study will be familiar from MATH142 (Numbers, groups, and codes). We will go into them in greater depth, and the module will be self-contained from the point of view of number theory. However, some background in group theory (no more than is in MATH142) will be assumed.

POPULATION DYNAMICS (MATH332)

Credits: 15 / Semester: semester 2

Understanding the behaviour of populations is essential for understanding extinctions, population growth, maintaining the security of our food supplies as well as controlling invasive species and the spread of infectious diseases. Many aspects of dynamical systems theory arise in the study of population dynamics, making the mathematics in this module widely applicable. We will take a deterministic approach to populations and will construct simple models to represent the essential controlling features. By analysing these models, significant insights can be obtained with implications for real-world population dynamics.

PROJECTS IN MATHEMATICS (MATH399)

Credits: 15 / Semester: whole session

Research is performed in an interesting topic in a particular area of Mathematics under the supervision of a member of staff, which is followed by preparation of a report and an oral presentation. It is hoped that this will provide insights into more advanced subjects and experience in handling specialist literature.

THEORY OF STATISTICAL INFERENCE (MATH361)

Credits: 15 / Semester: semester 2

This module introduces fundamental topics in mathematical statistics, including the theory of point estimation and hypothesis testing. Several key concepts of statistics are discussed, such as sufficiency, completeness, etc., introduced from the 1920s by major contributors to modern statistics such as Fisher, Neyman, Lehmann and so on. This module is absolutely necessary preparation for postgraduate studies in statistics and closely related subjects.

Programme details and modules listed are illustrative only and subject to change.

HOW YOU'LL LEARN

Teaching is by a mix of formal lectures, small group tutorials and supervised laboratory-based practical sessions. Students also undertake individual and group projects. Key problem solving skills and employability skills, like presentation and teamwork skills, are developed throughout the programme.

HOW YOU'RE ASSESSED

The main modes of assessment are through a combination of coursework and examination, but depending on the modules taken you may encounter project work, presentations (individual or group), and specific tests/tasks focused on solidifying learning outcomes.

LIVERPOOL HALLMARKS

We have a distinctive approach to education, the Liverpool Curriculum Framework, which focuses on research-connected teaching, active learning, and authentic assessment to ensure our students graduate as digitally fluent and confident global citizens.

Careers and employability

A mathematically-based degree opens up a wide range of career opportunities, including some of the most lucrative professions.

87% OF COMPUTER SCIENCE STUDENTS FIND THEIR MAIN ACTIVITY AFTER GRADUATION MEANINGFUL.

Graduate Outcomes, 2018-19.

Recent employers of our graduates are:

- Barclays Bank plc
- Deloitte
- Forrest Recruitment
- Marks and Spencer
- Mercer Human Resource Consulting Ltd.
- Venture Marketing Group.
- BAE Systems
- BT
- Guardian Media Group
- Royal Bank of Scotland
- Siemens
- Unilever

PREPARING YOU FOR FUTURE SUCCESS

At Liverpool, our goal is to support you to build your intellectual, social, and cultural capital so that you graduate as a socially-conscious global citizen who is prepared for future success. We achieve this by:

- Embedding employability within your curriculum, through the modules you take and the opportunities to gain real-world experience offered by many of our courses.
- Providing you with opportunities to gain experience and develop connections with people and organisations, including

student and graduate employers as well as our global alumni.

- Providing you with the latest tools and skills to thrive in a competitive world, including access to Handshake, a platform which allows you to create your personalised job shortlist and apply with ease.
 - Supporting you through our peer-to-peer led [Careers Studio](#), where our career coaches provide you with tailored advice and support.
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Fees and funding

Your tuition fees, funding your studies, and other costs to consider.

TUITION FEES

Tuition fees cover the cost of your teaching and assessment, operating facilities such as libraries, IT equipment, and access to academic and personal support. [Learn more about tuition fees, funding and student finance.](#)

| UK fees Also applies to Channel Islands, Isle of Man and Republic of Ireland | |
|----------------------------------------------------------------------------------------|--------|
| Full-time place, per year | £9,250 |
| Year in industry fee | £1,850 |
| Year abroad fee | £1,385 |

| International fees | |
|---------------------------|---------|
| Full-time place, per year | £24,550 |

Fees stated are for the 2023-24 academic year.

ADDITIONAL COSTS

Your tuition fee covers almost everything but you may have [additional study costs](#) to consider, such as books.

Find out more about the [additional study costs](#) that may apply to this course.

SCHOLARSHIPS AND BURSARIES

We offer a range of scholarships and bursaries to help cover tuition fees and help with living expenses while at university.

[Scholarships and bursaries you can apply for from the United Kingdom](#)

Select your country or region for more scholarships and bursaries.

Entry requirements

The qualifications and exam results you'll need to apply for this course.

| Your qualification | Requirements About our typical entry requirements |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A levels | <p>AAB with grade A in Maths</p> <p>Applicants with the Extended Project Qualification (EPQ) are eligible for a reduction in grade requirements. For this course, the offer is ABB with A in the EPQ.</p> <p>You may automatically qualify for reduced entry requirements through our contextual offers scheme.</p> <p>If you don't meet the entry requirements, you may be able to complete a foundation year which would allow you to progress to this course.</p> <p>Available foundation years:</p> <ul style="list-style-type: none">• Computer Science BSc (Hons) (Foundation) (4 year route with Carmel College) |
| GCSE | 4/C in English and 4/C in Mathematics |
| Subject requirements | <p>Grade A in Mathematics is required.</p> <p>For applicants from England: For science A levels that include the separately graded practical endorsement, a "Pass" is required.</p> |

| Your qualification | Requirements About our typical entry requirements |
|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BTEC Level 3 Subsidiary Diploma | Acceptable at grade Distinction* (any subject) alongside AB at A level, including A Level Mathematics grade A. |
| BTEC Level 3 Diploma | Distinction Distinction in BTEC considered alongside A Level Mathematics grade A. |
| BTEC Level 3 National Extended Diploma | D*D*D plus A level Maths grade A. |
| International Baccalaureate | 35 including 6 in Higher Level Mathematics. |
| Irish Leaving Certificate | H1,H1,H2,H2,H2,H3, including H1 in Higher Maths. We also require a minimum of H6 in Higher English or O3 in Ordinary English |
| Scottish Higher/Advanced Higher | Pass Scottish Advanced Highers with grades AAB including A Level Mathematics grade A. |
| Welsh Baccalaureate Advanced | Acceptable at grade B or above alongside AA at A level including A Level Mathematics grade A. |
| Cambridge Pre-U Diploma | D3 in Cambridge Pre U Principal Subject is accepted as equivalent to A-Level grade A M2 in Cambridge Pre U Principal Subject is accepted as equivalent to A-Level grade B Global Perspectives and Short Courses are not accepted. |
| Access | Considered if taking a relevant subject. 45 Level 3 credits at Distinction, including 15 Level 3 credits in Mathematics is required. GCSE English and Mathematics grade C/grade 4 or above also required. |

| Your qualification | Requirements About our typical entry requirements |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| International qualifications | <div data-bbox="1003 329 1439 465" style="border: 1px solid #ccc; padding: 10px; text-align: center;"> Select your country or region to view specific entry requirements. </div> <p>Many countries have a different education system to that of the UK, meaning your qualifications may not meet our direct entry requirements. Although there is no direct Foundation Certificate route to this course, completing a Foundation Certificate, such as that offered by the University of Liverpool International College, can guarantee you a place on a number of similar courses which may interest you.</p> |

ALTERNATIVE ENTRY REQUIREMENTS

- If your qualification isn't listed here, or you're taking a combination of qualifications, [contact us](#) for advice
 - [Applications from mature students](#) are welcome.
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THE ORIGINAL

REDBRICK