UNIVERSITY OF LIVERPOOL

# Actuarial Mathematics BSc (Hons)

### COURSE DETAILS

- A level requirements: AAB
- UCAS code: NG31
- Study mode: Full-time
- Length: 3 years

### KEY DATES

- Apply by: 25 January 2023
- Starts: 25 September 2023

## Course overview

Studying Actuarial Mathematics at Liverpool will allow you to take your career in any number of directions. Choose this programme and you will become an expert, using mathematical models to solve financial problems.

### INTRODUCTION

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 enabling you to take your career in any number of directions.

Actuarial mathematics prepares students to be professionals who use mathematical models to analyse and solve financial problems under uncertainty. Actuaries are experts in the design, financing and operation of insurance plans, annuities, and pension or other employee benefit plans.

This programme is aimed at students who want to work in the world of insurance, financial or governmental services, where actuarial mathematics plays a key role. You will graduate prepared for a career as an actuary, combining financial and actuarial mathematics with statistical techniques and business topics.

You will cover  specialised work in advanced actuarial and financial mathematics. You will then study more advanced ideas in both life and non-life insurance mathematics as well as stochastic modelling, econometrics and finance.

We have accreditation from the Institute and Faculty of Actuaries, the professional body for actuaries in the UK.

## WHAT YOU'LL LEARN

- Core aspects of Mathematics such as finance, algebra, calculus and statistics.
- Teamwork
- Problem solving
- How to present and communicate clearly
- How to analyse and solve financial problems.

# Course content

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

## YEAR ONE

In year one you will study compulsory modules covering economic principles, algebra, calculus, statistics, mathematical IT skills, finance.

## COMPULSORY MODULES

### ECONOMIC PRINCIPLES FOR BUSINESS AND MARKETS (ECON127)

**Credits: 15 / Semester: semester 1**

The aim of this module is to introduce the core principles of economics (both micro and macro), to develop models and economic perspectives relevant to business students and demonstrate how modern economics can illuminate the problems that businesses (both national and international) face on a day-to-day basis.

### 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.

### 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.

**MATHEMATICAL IT SKILLS (MATH111)**

**Credits: 15 / Semester: semester 1**

This module introduces students to powerful mathematical software packages such as Maple and Matlab which can be used to carry out numerical computations or to produce a more complicated sequence of computations using their programming features. We can also do symbolic or algebraic computations in Maple. These software packages have built-in functions for solving many kinds of equations, for working with matrices and vectors, for differentiation and integration. They also contain functions which allow us to create visual representations of curves and surfaces from their mathematical descriptions, to work interactively, generate graphics and create mathematical documents. This module will teach students many of the above-mentioned features of mathematical software packages. This knowledge will be helpful in Years 2, 3 and 4 when working on different projects, for example in the modules MATH266 and MATH371.

**INTRODUCTION TO FINANCE (ACFI103)**

**Credits: 15 / Semester: semester 2**

This module introduces students to fundamental concepts in finance. The course aims to provide a firm foundation for the students to build on later on in the second and third years of their programmes, by covering basic logical and rational analytical tools that underpin financial decisions. The course covers topics such as the structure of firms and time value of money. Building on these notions, we then discuss the valuation of simple securities such as bonds and equities. The course also introduces students to project appraisal techniques.

**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.

#### INTRODUCTION TO STATISTICS USING R (MATH163)

**Credits: 15 / Semester: semester 2**

Students will learn fundamental concepts from statistics and probability using the R programming language and will learn how to use R to some degree of proficiency in certain contexts. Students will become aware of possible career paths using statistics.

#### THEORY OF INTEREST (MATH167)

**Credits: 15 / Semester: semester 2**

This module mainly focuses on the theory of interest rates in financial mathematics. The module provides an understanding of some fundamental concepts of financial mathematics, and how these concepts are applied in calculating present and accumulated values for various streams of cash flows. Students will also be given an introduction to financial instruments, such as derivatives and the concept of no-arbitrage.

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

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## YEAR TWO

In the second and subsequent years of study, there is a wide range of modules. Each year you will choose the equivalent of eight modules. We regularly review our teaching so the choice of modules may change.

Along with the compulsory modules, two modules in Life Insurance and Financial Reporting & Finance must be taken.

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## COMPULSORY MODULES

#### FINANCIAL REPORTING AND FINANCE (NON-SPECIALIST) (ACFI290)

**Credits: 15 / Semester: semester 1**

This module is a non-specialist introduction into the field of accounting and finance. The module aims to give students basic knowledge and skills in a range of financial accounting areas covering 4 main topics – financial reporting and analysis looking at the creation and understanding of financial statements and how to interpret the numbers included in such statements; taxation looking at basic tax calculations covering personal income tax, corporation tax and capital gains tax, along with understanding the tax system in place in the UK; managerial accounting looking at decision making based on financial data; and financial instruments and looking at financial institutions and how businesses can raise finance. Successful students will obtain a good knowledge of basic accounting techniques, the ability to perform accounting calculations and the ability to interpret and understand key financial statements and how to use them in a business scenario. Such skills are essential in the business world and offer students a good foundation on which to build if they are interested in further accounting or business modules. The module is delivered through interactive lectures and seminars involving a high level of question practice with discussion on key topics. It is assessed through a 100% exam. There will be a practice test in Week7 of the Semester. Details will be announced.

**PRINCIPLES OF ECONOMICS II (ECON210)**

**Credits: 15 / Semester: semester 1**

This course will explore and apply mathematically the core economics principles learned in ECON127 Principles of Economics in order to better understand Economic decision making and behaviour. Microeconomic analysis will illuminate the interactions and outcomes of individual agents while the Macroeconomic analysis will illuminate how the collective economics system operates.

**STATISTICS AND PROBABILITY I (MATH253)**

**Credits: 15 / Semester: semester 1**

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.

**LIFE INSURANCE MATHEMATICS I (MATH273)**

**Credits: 15 / Semester: semester 1**

Actuarial science is the discipline that assesses the impact of risks. The aim of this module is to provide a solid grounding and quantitative tools of actuarial science pertaining to individuals. This module develops skills of calculating the premium for a certain life insurance contract and analyses insurance problems adequately. The module also explains the concept of reserve for insurances and annuities contracts and analyses the annual loss or profit in different types of policies. This module can contribute to getting a CM1 exemption by The Institute and Faculty of Actuaries.

### FINANCIAL MATHEMATICS (MATH262)

**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.

### STATISTICS AND PROBABILITY II (MATH254)

**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 MATH260 and 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.

## OPTIONAL MODULES

### DIFFERENTIAL EQUATIONS (MATH221)

**Credits: 15 / Semester: semester 2**

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 MATH201 is compulsory for a number of degree programmes. The module will aim to stress the importance of both theory and applications of ordinary differential equations (ODEs) and partial differential equations (PDEs), putting a strong emphasis on problem solving and examples. It has broadly 5 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 to understand some properties of the underlying equations and their solutions. The main topics are first order ODEs, second order ODEs, systems of ODEs, first-order PDEs and some of the most well-known second-order PDEs, namely the wave, heat and Laplace equations.

### METRIC SPACES AND CALCULUS (MATH242)

**Credits: 15 / Semester: semester 2**

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 several other subsequent modules 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.

**NUMERICAL METHODS (MATH256)**

**Credits: 15 / Semester: semester 2**

Most problems in modern applied mathematics require the use of suitably designed numerical methods. Working exactly, we can often reduce a complicated problem to something more elementary, but this will often lead to integrals that cannot be evaluated using analytical methods or equations that are too complex to be solved by hand. Other problems involve the use of 'real world' data, which don't fit neatly into simple mathematical models. In both cases, we can make further progress using approximate methods. These usually require lengthy iterative processes that are tedious and error prone for humans (even with a calculator), but ideally suited to computers. The first few lectures of this module demonstrate how computer programs can be written to handle calculations of this type automatically. These ideas will be used throughout the module. We then investigate how errors propagate through numerical computations. The focus then shifts to numerical methods for finding roots, approximating integrals and interpolating data. In each case, we will examine the advantages and disadvantages of different approaches, in terms of accuracy and efficiency.

**OPERATIONAL RESEARCH (MATH269)**

**Credits: 15 / Semester: semester 2**

The term "Operational Research" came in the 20th century from military operations. It describes mathematical methods to achieve the goal (or to find the best possible decision) having limited resources. This branch of applied mathematics makes use of and has stimulated the development of optimisation methods, typically for problems with constraints. This module can be interesting for any student doing mathematics because it concentrates on real-life problems.

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

## YEAR THREE

In addition to the compulsory modules, you can choose one module from the optional module list below.

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## COMPULSORY MODULES

### 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.

### LIFE INSURANCE MATHEMATICS II (MATH373)

**Credits: 15 / Semester: semester 1**

This module covers life contingencies for multiple-life, and in the subject of the analysis of life assurance, life annuities, pension contracts, multi-state models and profit testing. It is delivered through a series of lectures with supporting formative tutorials and is assessed by one formal examination.

### STOCHASTIC MODELLING IN INSURANCE AND FINANCE (MATH375)

**Credits: 15 / Semester: semester 1**

This module covers stochastic modelling and its applications in different actuarial/financial problems. This module can contribute to getting a CM2 exemption by The Institute and Faculty of Actuaries.

### 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).

### STATISTICAL METHODS IN INSURANCE AND FINANCE (MATH374)

**Credits: 15 / Semester: semester 2**

This module covers the application of statistical methodologies and technique into actuarial sets of data. This module can contribute to getting CS1 and CS2 exemptions by The Institute and Faculty of Actuaries.

#### ACTUARIAL MODELS (MATH376)

**Credits: 15 / Semester: semester 2**

#### FINANCIAL AND ACTUARIAL MODELLING IN R (MATH377)

**Credits: 15 / Semester: semester 2**

This module focuses on the applications of actuarial and financial mathematics using the programming language R. It provides the students with an introduction to the basic principles of programming in R. Students will practice various computational aspects of actuarial science and finance. The module focuses on the implementation of the theoretical models, learned in other modules, using R code. Students will develop a background in the practical applications of Statistics, Reserving, Portfolio management, Option pricing, and others. This module will enhance the employability skills for students in Financial and Actuarial Mathematics.

## OPTIONAL MODULES

#### MATHS SUMMER INDUSTRIAL RESEARCH PROJECT (MATH391)

**Credits: 15 / Semester: semester 1,summer**

The research internship module is designed to give students the experience of working in a research environment or setting that is quite different from any project work that they undertake in the Department of Mathematics. It should provide an insight into how students may apply skills and experiences later in their career; whether working abroad, in industry or in a scientific setting.

#### APPLIED STOCHASTIC MODELS (MATH360)

**Credits: 15 / Semester: semester 1**

Stochastic processes are ways of quantifying the dynamic relationships of sequences of random events. Stochastic models play an important role in elucidating many areas of the natural and engineering sciences. They can be used to analyse the variability inherent in biological and medical processes, to deal with uncertainties affecting managerial decisions and with the complexities of psychological and social interactions, and to provide new perspectives, methodology, models and intuition to aid in other mathematical and statistical studies. This module is intended as a beginning course in introducing continuous-time stochastic processes for students familiar with elementary probability. The objectives are: (1) to introduce students to the standard concepts and methods of stochastic modelling; (2) to illustrate the rich diversity of applications of stochastic processes in the science; and (3) to provide exercises in the applications of simple stochastic analysis to appropriate problems. The module is complementary to MATH362 (Applied probability), in which discrete-time processes are studied. Those who plan to go on to MSc study in financial mathematics will find this module a very useful preparation for modules such as MATH481 (Interest rate theory), MATH482 (Stochastic modelling in finance), MATH483 (Stochastic analysis and its applications) and MATH484 (Advanced numerical analysis for financial mathematics).

**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.

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

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## HOW YOU'LL LEARN

You will be taught through a mixture of lectures, tutorials, practical classes, problem classes, private study and supervised project work. In year one, lectures are supplemented by group tutorials and computing work is carried out in supervised practical classes.

Key study skills, presentation skills and group work start in first-year tutorials and are developed later in the programme. The emphasis in most modules is on the development of problem solving skills, which are regarded very highly by employers. Project supervision is on a one-to-one basis, apart from group projects in year two.

## HOW YOU'RE ASSESSED

Most modules are assessed by a two and a half hour examination in January or May, but many have an element of coursework assessment too. This might be through homework, class tests, mini-project work or key skills exercises.

## 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.

**87.5%** **OF MATHEMATICAL SCIENCES GRADUATES GO ON TO WORK OR FURTHER STUDY WITHIN 15 MONTHS OF GRADUATION.**

*Discover Uni, 2018-19.*

Typical types of work our graduates have gone onto include:

- An actuarial trainee analyst
- A graduate management trainee risk analyst
- A trainee chartered accountant.

Recent employers of our graduates are:

- Barclays Bank plc
- Deloitte
- Forrest Recruitment
- Marks and Spencer
- Mercer Human Resource Consulting Ltd
- Venture Marketing Group.

## 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.

# 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**<br>**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 | £23,300 |

*Fees stated are for the **2023-24** academic year.*

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## 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.

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## 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**<br>About our typical entry requirements |
|---|---|
| A levels | AAB<br>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.<br>You may automatically qualify for reduced entry requirements through our contextual offers scheme. |
| GCSE | 4/C in English and 4/C in Mathematics |
| Subject requirements | Mathematics A level grade A.<br>Applicants must have studied Mathematics at Level 3 within 2 years of the start date of their course.<br>For applicants from England: For science A levels that include the separately graded practical endorsement, a "Pass" is required. |
| BTEC Level 3 National Extended Diploma | Applications considered when combined with A level Maths grade A |
| International Baccalaureate | 35 including 6 in Higher Mathematics |
| Irish Leaving Certificate | H1, H1, H2, H2, H2, H3 including Mathematics at H1 |

| Your qualification | Requirements<br>About our typical entry requirements |
|---|---|
| Scottish Higher/Advanced Higher | Advanced Highers accepted at grades AAB including grade A in Mathematics. |
| Welsh Baccalaureate Advanced | Acceptable at grade B or above alongside AA at A level including grade A in Mathematics. |
| Access | Considered |
| International qualifications | Select your country or region to view specific entry requirements.<br><br>Many countries have a different education system to that of the UK, meaning your qualifications may not meet our entry requirements. Completing your Foundation Certificate, such as that offered by the University of Liverpool International College, means you're guaranteed a place on your chosen course. |

## 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.

THE ORIGINAL REDBRICK