Mathematics with Ocean and Climate Sciences  BSc (Hons)

COURSE DETAILS
- A level requirements: ABB
- UCAS code: G1F7
- Study mode: Full-time
- Length: 3 years

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

Course overview
Climate change is a major challenge we all currently face. Combining Ocean Sciences with Maths, this programme will equip you with the skills and knowledge to be able to understand some of the most important issues facing the scientific community, providing an excellent foundation for a career in the Ocean Sciences.

INTRODUCTION
Predicting climate and climate change is a major challenge facing the scientific community.

The oceans regulate the climate of the planet through storing and transporting heat and carbon as well as modifying properties of the overlying atmosphere. Complex issues such as climate change and sea level rise can only be understood if the role of the ocean and atmosphere is fully appreciated.

This degree provides an understanding of how the ocean and atmosphere operate in the climate system, as well as offering a strong grounding in mathematics. It is offered in collaboration between the Department of Mathematics in the School of Physical Sciences and the internationally renowned National Oceanography Centre in Liverpool, providing excellent preparation for careers in computer modelling in oceanography, meteorology or environmental monitoring.

You will acquire a broad knowledge of mathematics and the analytical and numerical techniques for solving problems, and the ability to apply those techniques with confidence. You will gain an understanding of how the climate system behaves, how the atmosphere and ocean
transport heat, why jets and eddies emerge on a rotating planet, how tracers are transported and mixed, and how these processes affect the growth of phytoplankton.

The degree in Mathematics with Ocean and Climate Sciences at Liverpool is accredited by the Institute of Marine Engineering, Science and Technology.

A number of the School’s degree programmes involve laboratory and field work. Fieldwork is carried out in various locations, ranging from inner city to coastal and mountainous environments. We consider applications from prospective disabled students on the same basis as all other students, and reasonable adjustments will be considered to address barriers to access.

WHAT YOU’LL LEARN

- Problem solving
- Analytical techniques
- Data management
- Numerical techniques
- How the climate system behaves

- How to monitor and detect change in various environments
- Insights into sustainability and mitigation strategies
Course content
Discover what you'll learn, what you'll study, and how you'll be taught and assessed.

YEAR ONE
Students acquire mathematical skills including calculus and dynamic modelling, as well as obtaining a grounding in ocean and climate sciences.

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.

CLIMATE, ATMOSPHERE AND OCEANS (ENVS111)
Credits: 15 / Semester: semester 1
Climate, Atmosphere and Oceans provides an understanding of how the climate system operates. The module draws on basic scientific principles to understand how climate has evolved over the history of the planet and how the climate system is operating now. Attention is particularly paid to the structure and circulation of the atmosphere and ocean, and how they both interact. The course emphases acquiring mechanistic insight and drawing upon order of magnitude calculations. Students gain quantitative skills by completing a series of coursework exercises. Students address the Net Zero carbon goal via group work involving digital storytelling.

**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.

**MARINE ECOSYSTEMS: DIVERSITY, PROCESSES AND THREATS (ENVS122)**

Credits: 15 / Semester: semester 2

This module introduces the range of diversity of marine ecosystems using example environments from around the world. Each week a new ecosystem will be covered, with the main organisms, key processes and human threats to the ecosystem described and explored. Central to this module are interactive discussion sessions that will build an understanding of how marine ecosystems are expected to respond to the human-induced changes of the anthropocene.

**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.

**STUDY SKILLS (OCEAN SCIENCES) (ENVS103)**

Credits: 15 / Semester: whole session
This module is designed to introduce students to key concepts and skills in Ocean Sciences (e.g. use of specific software, development of laboratory and analytical skills, fieldwork experience) as well as the development of generic skills, specifically communication skills (through writing essay, technical reports, oral and poster presentations), teamwork and time management. The module also comprises introduction to academic integrity, how to access scientific literature and how to use a bibliographic software. Tutorials with an assigned individual tutor take place in groups of typically 6-7 students, typically once every 2 weeks.

**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.

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

**YEAR TWO**

Students develop their mathematical skills including methods of applied mathematics. Students gain skills in processing and manipulating ocean and climate data using an industry standard software (Matlab) and, collect and interpret observations from the open and coastal ocean.

**COMPULSORY MODULES**

**KEY SKILLS FOR ENVIRONMENTAL DATA ANALYSIS (ENVS202)**

*Credits: 15 / Semester: semester 1*

The module provides a generic training in manipulating environmental data sets using the industry-standard Matlab software. Skills are provided in reading in data, manipulating and plotting the data, and interpreting the data signals. The assumption is that students have little or no experience in programming. The module begins with an introduction to Matlab – what it is, what it can do, how to operate it – and then develops a series of programming skills, each week using data collected in the staffs’ own research to provide real-world examples of the use of Matlab. The aim is to provide students with sufficient grasp of programming in Matlab to enable its use in subsequent project work, as well as providing the foundations in one of the key tools used in science and industry.

**SAMPLING THE OCEAN (ENVS220)**

*Credits: 15 / Semester: semester 2*
This module provides some of the fundamental skills required for surveying and sampling the ocean, either for research or for commercial environmental surveying work.

The module covers the methods and skills used in oceanography for:

- **Navigation and survey design.**
- The measurement of physical parameters, such as temperature, salinity and currents.
- The measurement of biogeochemical parameters such as nutrients, phytoplankton, dissolved oxygen and particles.
- The importance of assessing data quality and instrument calibration, metadata and data banking.

Laboratory work develops skills in the analyses for key oceanographic parameters (e.g. salinity, chlorophyll, dissolved oxygen and nutrients).

Computer laboratories develop skills in sensor calibration, data quality control and data analysis.

These components are all relevant to the subsequent planning and sampling as part of the ENVS349 Sea Practical.

Assessment is by coursework.

**RESEARCH AND CAREER SKILLS (ENVS204)**

**Credits:** 15 / **Semester:** whole session

This module aims to develop the specific skills required by marine biologists, ocean scientists and environmental scientists as they prepare for their final year of study and the next steps in their careers.

In semester one, students will focus on developing skills in critiquing and reading the scientific literature. Lectures, workshops and tutorials will guide students in developing these skills. This will be assessed through a literature review essay. In the second half of semester one students will be introduced to the process of scientific research through a series of lectures, workshops and tutorials, this will continue in semester two.

In semester two students will continue to learn about scientific research and how to write a research report. Students will analyse and synthesise a real scientific data set, create professional display items and write a research report in standard scientific format. This will be assessed through a written research report. Students will be supported through this via a series of lectures, workshops and tutorials.

Students will also develop knowledge of careers in their field and enhance their employability through a series of lectures, SOES careers week, an assessment centre exercise and job video interview. The video interview will be assessed.

**OCEANOGRAPHY, PLANKTON AND CLIMATE (ENVS245)**

**Credits:** 15 / **Semester:** semester 1
The tiny plankton are the base of marine food chains and also affect the Earth’s climate. If you want to understand how and where these organisms live in the ocean, you need to step out of your own experience as a terrestrial animal. In this module we will get you to think about how the viscosity and flow of water control the different sizes of plants and animals by determining how they can acquire light, nutrients and food. For instance, a copepod zooplankton needs to detect, grab and hold on to tiny food particles in what, to the copepod, feels like a very sticky fluid environment. For us it would be a little like trying to swim through thick honey and reaching out to grab a ping-pong ball. On much larger scales the physics of ocean circulation and mixing controls the distributions and diversity of different plankton species and the availability of the nutrients that they need. Plankton play a key role in Earth’s climate, but this can depend on the plankton species. Plankton also respond to changes in Earth’s climate, with important shifts in species distributions currently being caused by our warming climate. In this module we take you from the micron scales of the tiniest plankton up to the scale of the open ocean to illustrate the fundamental links between the ocean’s physical and biogeochemical processes, plankton communities and Earth’s climate.

**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.

**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.

**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.

**CLIMATOLOGY (ENVS231)**

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

The module covers energy balance and transfer processes at the surface, clouds, rain formation, weather forecasting, monsoons, tropical cyclones, weather in the mid latitudes, and the regional climates. The module has a balance between theory, processes, impacts, and hands-on experimentation and data analysis.

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

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**YEAR THREE**

Students apply their mathematical and ocean sciences skills during an independent research project supervised by an Ocean Scientist at the University or from the National Oceanography Centre. Students have the opportunity to engage in activities at sea during a three day research cruise.

**COMPULSORY MODULES**

**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.

**GLOBAL CARBON CYCLE (ENVS335)**

**Credits: 15 / Semester: semester 2**
Increasing amounts of carbon dioxide in the atmosphere are having a profound impact on our Earth system. This module will introduce students to the fundamental theory behind the global carbon cycle. It will evaluate how carbon is partitioned between the atmosphere, land and ocean in the contemporary and past system, why the ocean stores 50 times more carbon than the atmosphere and considers the impact of increasing carbon dioxide on the organisms living on land and in the ocean.

**CONTEMPORARY ISSUES IN OCEAN AND CLIMATE SCIENCES (ENVS366)**

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

This research-led module aims to promote interest, awareness and understanding of current important research topic within Ocean and Climate Sciences. It also aims to develop generic skills such as team working and communication skills. The module has the following components:

- Presentation of the IPCC (Intergovernmental Panel on Climate Change) and the 2019 SROCC (Special Report on Oceans and Cryosphere in a Changing Climate) with one of the lead authors, Prof. A. Tagliabue;
- Weekly Ocean Sciences research seminars that are given by international experts on a range of subject (physical, chemical and/or biological) related to the marine system, in the past, currently and/or in the future;
- Individual oral presentations by students of recent research papers or research topic of particular interest to them;
- Group presentations (typically 3 to 4 students per group) on a research topic of current importance (e.g. as highlighted in the latest SROCC report).

**OCEAN DYNAMICS (ENVS332)**

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

Ocean dynamics addresses how the ocean and atmosphere circulate. Fundamental questions are addressed, such as how heat, salt, and dissolved substances are transported, how jets and weather systems emerge on our planet, why there are western boundary currents in the ocean, and how seafloor topography shapes the ocean circulation.

Students will improve their understanding of how the ocean and atmosphere behave, including comparing the importance of different physical processes in the climate system. The module is delivered via lectures and formative workshops to gain skills at problem solving. There is significant mathematical content, requiring familiarity with calculus and algebra. The module is assessed through two online tests (25% each) and an essay (50%).

**SEA PRACTICAL (ENVS349)**

**Credits:** 30 / **Semester:** semester 1
Measurements made at sea are a key activity in oceanographic research and this module provides an introduction to the collection of data and samples including navigation, meteorological parameters, temperature and salinity, currents, dissolved oxygen, nutrients, chlorophyll, and plankton. We will use the Field Studies Council Site at Millport in Scotland. The laboratory phase will take place in Millport and in the Central Teaching Laboratories in Liverpool. The module is assessed by (1) a group presentation on components of the data analysis and quality, (2) a record and laboratory book and (3) a scientific report/paper addressing a key question. The Sea Practical introduces students to the way in which professional ocean scientists work. It involves collecting data and samples at sea, analysing samples in the laboratory, processing and analysing data using computer software, assessing and reporting on the data and its quality, and finally presenting the methods, results and interpretation in an accurate and comprehensive report. By following professional ways of working it provides students with both subject specific and generic employability skills. Research integrity is an integral component of this module.

INDEPENDENT RESEARCH PROJECT (ENVS306)

Credits: 30 / Semester: whole session

This module consists of a two-semester dissertation research project, carried out individually by a student with supervision by a member of academic staff. Projects can be field-, laboratory- or desk-based studies on a predefined project and the student will learn about project design, data collection, analysis and interpretation of results.

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

HOW YOU’LL LEARN

Teaching takes place through lectures, practicals, workshops, seminars, tutorials and computer based learning, with an emphasis on learning through doing.

Students value the learning opportunities provided by field classes, including the rapid feedback on performance. You will typically receive at least 15 hours of formal teaching each week. Between 30 and 100 hours of fieldwork and hands-on activities are provided each year depending on the discipline.

A typical module might involve two or three one-hour lectures each week, and often a three-hour laboratory or computer-based practical as well. Tutorials typically involve groups of 4-7 students meeting with a member of staff at least every two weeks in year one and two.

In year three, you will undertake an Honours project, which is a piece of independent research (field, laboratory or data analysis) on a topic of your choice, supervised by a member of staff. In year three students meet with their project supervisor on a weekly or more frequent basis. As you progress through your degree, you will be increasingly challenged to engage with current debates, to think critically and to study independently.

A number of the School’s degree programmes involve laboratory and field work. The field work is carried out in various locations, ranging from inner city to coastal and mountainous environments. We consider applications from prospective students with disabilities on the
same basis as all other students, and reasonable adjustments will be considered to address barriers to access.

HOW YOU’RE ASSESSED

Assessment matches the learning objectives for each module and may take the form of written exams, coursework submissions in the form of essays, scientific papers, briefing notes or lab notebooks, oral and poster presentations and contributions to group projects. Coursework is designed around the types of problems encountered, and the skills needed, in commercial, research and public sector jobs. Emphasis is placed on good laboratory practice and maintaining useful lab notebooks in the context of scientific integrity and scientific data management.

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

Graduates of the Climate Science degree programme will have sound knowledge of the fundamental science behind climate change, skills to detect and monitor change in a range of environments and insight into sustainability and mitigation strategies. Together, these skills will help tackle our ability to detect and respond to our changing climate.

89.5% OF ENVIRONMENTAL SCIENCES STUDENTS ARE IN WORK AND/OR FURTHER STUDY 15 MONTHS AFTER GRADUATION.

Discover Uni, 2018-19.

The employability options after graduating from this programme are extensive and include:

- Government agencies (Environment Agency, Met Office)
- Environmental consultancy and management
- Climate research
- Accountancy and insurance brokers
- Education
- Renewable energy industries

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.

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<tr>
<th>UK fees</th>
<th>Also applies to Channel Islands, Isle of Man and Republic of Ireland</th>
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<tr>
<td>Full-time place, per year</td>
<td>£9,250</td>
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<tr>
<td>Year in industry fee</td>
<td>£1,850</td>
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<tr>
<td>Year abroad fee</td>
<td>£1,385</td>
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<th>International fees</th>
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<td>Full-time place, per year</td>
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Fees stated are for the 2023-24 academic year.

ADDITIONAL COSTS
We understand that budgeting for your time at university is important, and we want to make sure you understand any course-related costs that are not covered by your tuition fee. This includes the cost of a lab coat, food and drink during compulsory field courses, and dissertation expenses.

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.

<table>
<thead>
<tr>
<th>Your qualification</th>
<th>Requirements</th>
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<tbody>
<tr>
<td>About our typical entry requirements</td>
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## A levels

ABB

Applicants with the Extended Project Qualification (EPQ) are eligible for a reduction in grade requirements. For this course, the offer is **BBB** with **A** in the EPQ.

You may automatically qualify for reduced entry requirements through our [contextual offers scheme](#).

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.

Available foundation years:

- Earth Sciences entry route leading to BSc (Hons) (4 year route including a Foundation Year at Carmel College)

## GCSE

4/C in English and 4/C in Mathematics

## Subject requirements


For applicants from England: where a science has been taken at A level (Chemistry, Physics or Biology), a pass in the science practical of each subject will be required.
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<tr>
<th>Your qualification</th>
<th>Requirements</th>
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<tbody>
<tr>
<td></td>
<td><em>About our typical entry requirements</em></td>
</tr>
<tr>
<td>BTEC Level 3 National Extended Diploma</td>
<td>D*DD in relevant diploma</td>
</tr>
<tr>
<td>International Baccalaureate</td>
<td>33 points including 5 at Higher Level in Mathematics and one other science, no score below 4.</td>
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<tr>
<td>Irish Leaving Certificate</td>
<td>H1, H2, H2, H2, H3, H3 including H2 or above in Mathematics and a second science</td>
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<tr>
<td>Scottish Higher/Advanced Higher</td>
<td>Not accepted without Advanced Highers at ABB including Mathematics and 1 other science</td>
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<tr>
<td>Welsh Baccalaureate Advanced</td>
<td>Accepted at Grade B with AB at A levels including Mathematics and 1 other science</td>
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<tr>
<td>Access</td>
<td>45 Level 3 credits in graded units in a relevant Diploma, including 30 at Distinction and a further 15 with at least Merit. 15 Distinctions are required in each of Mathematics and a second science. GCSE Mathematics and English at grade C/4 also required.</td>
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<tr>
<td></td>
<td>Select your country or region to view specific entry requirements.</td>
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<tr>
<td>International qualifications</td>
<td>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.</td>
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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.