

# Physics and Mathematics

 BSc (Hons)

## COURSE DETAILS

- A level requirements: [ABB](#)
- UCAS code: FG31
- Study mode: Full-time
- Length: 3 years

## KEY DATES

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

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## Course overview

Combining the study of Physics and Mathematics in your degree programme will give you a strong foundation for your future career. You will learn mathematical techniques to help you deal with new ideas and will understand new concepts such as quantum mechanics and relativity.

## 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.

Physics is the most fundamental of the sciences. New concepts, such as quantum mechanics and relativity, are introduced at degree level in order to understand nature at the deepest level. These theories have profound philosophical implications because they challenge our view of the everyday world. At the same time they have a huge impact on society since they underpin the technological revolution.

Combining the study of Physics and Mathematics in your degree programme will give you a strong mathematical

training. You will learn mathematical techniques to help you to deal with new ideas that often seem counterintuitive, such as string theory, black holes, superconductors and chaos theory.

Physics and Mathematics degrees are highly prized and our graduates have excellent career opportunities.

With this degree programme you also have the option to spend your third year abroad, an incredible opportunity to spend one academic year at one of our partner universities expanding your academic and cultural horizons.

## WHAT YOU'LL LEARN

- Numeracy
  - Problem solving skills
  - Ability to reason and communicate clearly
  - Teamwork
  - Presentation skills
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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

In Year One you will take three core mathematics modules, a module in Newtonian Mechanics, and four physics modules. After passing the first year, you

have the flexibility of transferring to Mathematics or Physics if you wish, subject to approval.

## 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.

### FOUNDATIONS OF QUANTUM PHYSICS (PHYS104)

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

This module illustrates how a series of fascinating experiments, some of which physics students will carry out in their laboratory courses, led to the realisation that Newtonian mechanics does not provide an accurate description of physical reality. As is described in the module, this failure was first seen in interactions at the atomic scale and was first seen in experiments involving atoms and electrons. The module shows how Newton's ideas were replaced by Quantum mechanics, which has been critical to explaining phenomena ranging from the photo-electric effect to the fluctuations in the energy of the Cosmic Microwave Background. The module also explains how this revolution in physicist's thinking paved the way for developments such as the laser.

## **INTRODUCTION TO COMPUTATIONAL PHYSICS (PHYS105)**

**Credits: 7.5 / Semester: semester 1**

The "Introduction to computational physics" (Phys105) module is designed to introduce physics students to the use of computational techniques appropriate to the solution of physical problems. No previous computing experience is assumed. During the course of the module, students are guided through a series of structured exercises which introduce them to the Python programming language and help them acquire a range of skills including: plotting data in a variety of ways; simple Monte Carlo techniques; algorithm development; and basic symbolic manipulations. The exercises are based around the content of the first year physics modules, both encouraging students to recognise the relevance of computing to their physics studies and enabling them to develop a deeper understanding of aspects of their first year course.

## **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.

## **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.

### **PRACTICAL SKILLS FOR MATHEMATICAL PHYSICS (PHYS156)**

**Credits: 7.5 / Semester: second semester, whole session**

This is a practical-based module exclusively for students taking joint maths and physics degree programmes. In the sessions you will work through progressively more challenging experiments with increasingly complex equipment. You may work alone or in a pair, but you will be supported by a demonstrator who will give you a lot of feedback on your work. In the classes you will be expected to contribute to class discussions and put your results on a whiteboard. There is an assessment associated with each laboratory practical. Again, there will be a variety of activities that will allow you to demonstrate different parts of your learning. You will also have to write at least two full reports for which you will receive written and verbal feedback.

### **THERMAL PHYSICS AND PROPERTIES OF MATTER (PHYS102)**

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

Einstein said in 1949 that "Thermodynamics is the only physical theory of universal content which I am convinced, within the areas of applicability of its basic concepts, will never be overthrown." In this module, different aspects of thermal physics are addressed: (i) classical thermodynamics which deals with macroscopic properties, such as pressure, volume and temperature – the underlying microscopic physics is not included; (ii) kinetic theory of gases describes the properties of gases in terms of probability distributions associated with the motions of individual molecules; and (iii) statistical mechanics which starts from a microscopic description and then employs statistical methods to derive macroscopic properties. The laws of thermodynamics are introduced and applied.

### **WAVE PHENOMENA (PHYS103)**

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

Waves lie at the heart of physics, being phenomena associated with quantum wave mechanics, electromagnetic fields, communication, lasers and, spectacularly, gravitational waves. The course is divided into several major sections. The first, can be viewed as a pre-wave study of oscillations. This teaches the basics of oscillatory systems which form the backbone of an understanding of waves. The second, deals with waves in abstract; solution of the wave equation and the principles of superposition. Finally, we look at examples of wave phenomena. These are the first introduction to what will be covered in the remainder of your degree.

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

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## YEAR TWO

In the second and subsequent years, there is a wide range of modules. For the programme that you choose there may be no compulsory modules (although you may have to choose a few from a subset such as Pure Mathematics).

If you make a different choice, you will find that one or more modules have to be taken. Each year you will choose the equivalent of eight modules. To give you an idea of the rich variety, see the titles below. Please note that we regularly review our teaching so the choice of modules may change.

### COMPULSORY MODULES

#### 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.

#### 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.

#### 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.

#### ELECTROMAGNETISM I (PHYS201)

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

The study of classical electromagnetism, one of the fundamental physical theories. Several simple and idealised systems will be studied in detail, developing an understanding of the principles underpinning several applications, and setting the foundations for the understanding of more complex systems. Mathematical methods shall be developed and exercised for the study of physical systems.

## **QUANTUM AND ATOMIC PHYSICS I (PHYS203)**

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

The course aims to introduce 2nd year students to the concepts and formalism of quantum mechanics. The Schrodinger equation is used to describe the physics of quantum systems in bound states (infinite and finite well potentials, harmonic oscillator, hydrogen atoms, multi-electron atoms) or scattering (potential steps and barriers). Basis of atomic spectroscopy are also introduced.

## **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.

## **CONDENSED MATTER PHYSICS (PHYS202)**

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

Condensed matter physics (CMP) is the study of the structure and behaviour of matter that makes up most of the things that surround us in our daily lives, including the screen on which you are reading this material. It is not the study of the very small (particle and nuclear physics) or the very large (astrophysics and cosmology) but of the things in between. CMP is concerned with the "condensed" phases of real materials that arise from electromagnetic forces between the constituent atoms, and at its heart is the necessity to understand the behaviour of these phases by using physical laws that include quantum mechanics, electromagnetism and statistical mechanics. Understanding such behaviour leads to the design of novel materials for advanced technological devices that address the challenges that face modern civilization, such as climate change.

## **NUCLEAR AND PARTICLE PHYSICS (PHYS204)**

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

Introduction to nuclear and particle physics

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## YEAR THREE

If MATH334 is chosen, either PHYS306 or PHYS309 must be taken. Either MATH325 or PHYS361 must be taken.

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## COMPULSORY MODULES

### 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.

### 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).

## OPTIONAL MODULES

### 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.

### **STATISTICAL PHYSICS (MATH327)**

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

Statistical Physics is a core subject in Physics and a cornerstone for modern technologies. To name just one example, quantum statistics is informing leading edge developments around ultra-cold gases and liquids giving rise to new materials. The module will introduce foundations of Statistical Physics and will develop an understanding of the stochastic roots of thermodynamics and the properties of matter. After successfully completing this module students will understand statistical ensembles and related concepts such as entropy and temperature, will understand the properties of classical and quantum gases, will be know the laws of thermodynamics and will be aware of advanced phenomena such as phase transition. The module will also develop numerical computer programming skills for the description of macroscopic effects such as diffusion by an underlying stochastic process.

### **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.

### **NUMERICAL METHODS FOR ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS (MATH336)**

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

Many real-world systems in mathematics, physics and engineering can be described by differential equations. In rare cases these can be solved exactly by purely analytical methods, but much more often we can only solve the equations numerically, by reducing the problem to an iterative scheme that requires hundreds of steps. We will learn efficient methods for solving ODEs and PDEs on a computer.

### **THE MAGIC OF COMPLEX NUMBERS: COMPLEX DYNAMICS, CHAOS AND THE MANDELBROT SET (MATH345)**

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

A “dynamical system” is a system that changes over time according to a fixed rule. In complex dynamics, we consider the case where the state of the system is described by a single (complex) variable, and the rule of evolution is given by a holomorphic function. It turns out that this seemingly simple setting leads to very rich, subtle and intricate problems, some of which are still the subject of ongoing mathematical research, both at the University of Liverpool and internationally. This module will provide an introduction to this fascinating subject, and introduce students to some of these problems. In the course of this study, we will encounter many results about complex functions that may seem “magic” when compared with what might be expected from real analysis. A highlight of this kind is the theorem that every polynomial is “chaotic” on its Julia set. We will also see how this “magic” can help us understand phenomena that at first seem to have no connection with complex numbers at all.

### **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).

### **MATHEMATICAL PHYSICS PROJECT (MATH334)**

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

This is one of the choices for students in Year 3 of the FGH1 Mathematical Physics MMath or F344 Theoretical Physics MPhys degree programmes, the other choice being the Physics project module PHYS488/PHYS305 (Modelling physical phenomena). Research is performed in an interesting topic in Mathematical Physics 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.

One of MATH432 or PHYS488/PHYS305 is a pre-requisite to year 4 Mathematical Physics Project MATH420.

### **PRACTICAL PHYSICS III (PHYS306)**

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

Year 3 Laboratory.

### **PHYSICS INTERNSHIP (PHYS309)**

**Credits: 15 / Semester: summer**

The physics internship module is designed to give students the experience of working in a STEM related working environment or setting that is different from any project work that they undertake in the Department of Physics. It should provide an insight into how students may apply skills and experiences later in their career; whether working abroad or in any other non-UoL, off-campus scientific or secondary school setting.

### **SOLID STATE PHYSICS (PHYS363)**

**Credits: 7.5 / Semester: semester 1**

Condensed Matter Physics (CMP) is the largest subfield of physics with practical applications that has changed our everyday life such as semiconductor devices, magnetic recording disks, Magnetic resonance imaging. It deals with the study of the structure and physical properties of large collection of atoms that compose materials, which are found in nature or synthesized in laboratory. This particular module aims to advance and extend the concepts on solids introduced in Year 1 and Year 2 modules. Especially, it focuses on the atomic structure and behaviour of electrons in crystalline materials, which are essential for understanding of physical phenomena in complex systems.

### **NUCLEAR PHYSICS (PHYS375)**

**Credits: 7.5 / Semester: semester 1**

This module gives an introduction to nuclear physics. Starting from the bulk properties of atomic nuclei different modes of radioactivity are discussed, before a closer look at the nucleon-nucleon interaction leads to the development of the shell model. Collective models of the nucleus leading to a quantitative understanding of rotational and vibrational excitations are developed. Finally, electromagnetic decays between excited states are introduced as spectroscopic tools to probe and understand nuclear structure.

### **MATERIALS PHYSICS AND CHARACTERISATION (PHYS387)**

**Credits: 7.5 / Semester: semester 1**

Preparation and characterisation of a range of materials of scientific and technological importance.

## **SEMICONDUCTOR APPLICATIONS (PHYS389)**

**Credits: 7.5 / Semester: semester 1**

This module develops the physics concepts describing semiconductors in sufficient details for the purpose of understanding the construction and operation of common semiconductor devices.

## **STATISTICS FOR PHYSICS ANALYSIS (PHYS392)**

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

Statistical Methods in Physics Analysis: Understanding Statistics and its application to data analysis

## **STATISTICAL PHYSICS (PHYS393)**

**Credits: 7.5 / Semester: semester 1**

The problem to understand blackbody radiation opened the door to modern physics. In this module an understanding of thermodynamics is developed from a quantum mechanical and statistical description of the three fundamental gases: The Maxwell-Boltzmann ideal gas in the classical limit, and the Fermi-Dirac and Bose-Einstein gases in the quantum limits for fermions and bosons, respectively. A statistical understanding of thermodynamic quantities will be developed together with a method of deriving thermodynamic potentials from the properties of the quantum system. Applications are shown in solid state physics and the Planck blackbody radiation spectrum.

## **QUANTUM AND ATOMIC PHYSICS II (PHYS361)**

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

This module concerns the study of quantum mechanics and its application to atomic systems. The description of simple systems will be covered before extending to real systems. Perturbation theory will be used to determine the detailed physical effects seen in atomic systems.

## **ACCELERATORS AND RADIOISOTOPES IN MEDICINE (PHYS246)**

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

This module provides an introduction to applications of accelerators and radioisotopes in medical imaging and tumour therapy. Concepts are developed from a simple physics perspective to provide an insight into the principles and practices of these modern medical applications. The lectures are complemented by workshops in which students can work collaboratively on problems to solve set problems. Experimental demonstrations to reinforce concepts also take place in the workshops. As well as being of interest to students considering careers in medical physics or nuclear-related industries, this module should also appeal to those curious to see how physics can be applied in a multidisciplinary approach to other areas of science.

## **COMPUTATIONAL MODELLING (PHYS305)**

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

Computational methods are at the heart of many modern physics experiments and mastering these techniques is invaluable also beyond fundamental research. In this module we introduce students to object-oriented concepts of a modern programming language (Python) and employ this to model experiments. A combination of Monte Carlo methods (based on random trials) and deterministic methods to solve differential equations are used. Students will then apply their knowledge in a small-group project connected to the state-of-the-art research done in the department. The project topics are taken from different areas of particle, nuclear or accelerator physics and range from analyses situated at the Large Hadron Collider to medical applications of proton beams.

## **ELECTROMAGNETISM II (PHYS370)**

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

The module builds on first and second year modules on electricity, magnetism and waves to show how a wide variety of physical phenomena can be explained in terms of the properties of electromagnetic radiation. The module will also explore how these properties follow from the relationships between electric and magnetic fields (and their interactions with matter) expressed by Maxwell's equations, and how electromagnetism fits into the theory of Special Relativity.

## **RELATIVITY AND COSMOLOGY (PHYS374)**

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

The course covers the concepts required to connect special relativity, Newtonian gravity, general relativity, and the cosmological metrics and dynamical equations. The main part of the course is focussed on cosmology, which is study of the content of the universe, structure on the largest scales, and its dynamical evolution. This is covered from both a theoretical and observational perspective.

## **PARTICLE PHYSICS (PHYS377)**

**Credits: 7.5 / Semester: semester 2**

Introduction to Particle Physics. To build on the second year module involving Nuclear and Particle Physics. To develop an understanding of the modern view of particles, of their interactions and the Standard Model.

## **SURFACES AND INTERFACES (PHYS381)**

**Credits: 7.5 / Semester: semester 2**

This module gives a brief introduction into the physics of solid surfaces their experimental study. Surfaces and interfaces are everywhere and many surface-related phenomena are common in daily life (texture, friction, surface-tension, corrosion, heterogeneous catalysis). Here we are concerned with understanding the microscopic properties of surfaces, asking questions like: what is the atomic structure of the surface compared to that of the bulk? What happens to the electronic properties and vibrational properties upon creating a surface? What happens in detail when we adsorb an atom or a molecule on a surface? This module will mostly concentrate on simple model systems like the clean and defect-free surface of a single-crystal substrate.

### **NUCLEAR POWER (PHYS376)**

**Credits: 7.5 / Semester: semester 2**

This module focuses on nuclear reactors as a source of energy for use by society. After reviewing the underlying physics principles, the design and operation and nuclear fission reactors is introduced. The possibility of energy from nuclear fusion is then discussed, with the present status and outlook given.

### **PROJECT (BSC) (PHYS379)**

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

This module involves the student engaging in a detailed final year project undertaken individually. The project work is typically based in one of the research groups within the Department of Physics. There is also the option to pursue individual projects in cooperation with an industrial partner. The student will be planning, managing and accomplishing an extended investigation of a physics-based or physics-related problem under the supervision of one or more academic staff members. In case of an industry-based project, there are two supervisors required, one academic and one from industry. BSc projects may be experimental, observational, computational or theoretical. The output of the project will be written up in a project report and presented in the form of a talk. Industry-based projects can be related to any in-house developments but not to an actual product release. The programme is to develop graduates to acquire skills in: development of solving new complex tasks; initiative and creativity; communication and cooperation with others; project organisation and self management. Quantitative scientific skills will be emphasized so as to make graduates of the course gain a wider experience of report writing displaying high standards of composition and production.

### **ENERGY GENERATION AND STORAGE (PHYS372)**

**Credits: 7.5 / Semester: semester 2**

Producing sufficient energy to meet the demands of an expanding and increasingly power-hungry society, whilst striving not to exacerbate the impacts of climate change, is a significant challenge. This module looks at the key physical concepts which underpin a range of energy generation sources, from traditional fossil fuel fired turbine generation to photovoltaic solar cells. This builds on prior knowledge of thermodynamics, fluid behaviour and semiconductors to show how these concepts can be practically applied to power generation and storage systems.

## **MAGNETIC PROPERTIES OF SOLIDS (PHYS399)**

**Credits: 7.5 / Semester: semester 2**

The magnetic properties of solids are exploited extensively in a wide range of technologies, from hard disk drives, to sensors, to magnetic resonance imaging, and the development of magnetic materials is a multi-billion pound industry. Fundamentally, magnetism in condensed matter also represents one of the best examples of quantum mechanics in action, even at room temperature and on a macroscopically observable scale. In this module we will explore how the interactions between electrons in solids can result in the magnetic moment, and how this relates to the quantum mechanical property of spin. We will use these tools to probe the complicated processes that allow spontaneous magnetism to exist within certain select materials, and their implications for future technologies and our theoretical understanding of the nature of solids.

## **MATHEMATICAL BIOLOGY (MATH335)**

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

In the current age of big data, mathematics is becoming indispensable in order for us to make sense of experimental results and in order to gain a deeper understanding into mechanisms of complex biological systems. Mathematical models can provide insights that cannot be gained through experimental work alone. This module will focus on teaching students how to construct and analyse models for a wide range of biological systems. Mathematical approaches covered will be widely applicable.

## **NETWORKS IN MATHEMATICAL BIOLOGY (MATH338)**

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

Networks are familiar to us from many real-world systems such as the internet, power grids, transportation and biological networks. The underpinning mathematical concept is called a graph and it is no surprise that the same issues arise in each area, whether this is to identify the most important or influential individuals in the network, or to prevent dynamics on the network (e.g. epidemics) or to make the network robust to the dynamics it supports (e.g. power grids and transportation). In this module, we learn about different classes of networks and how to quantify and describe them including their structures and their nodes. Much of our detailed understanding of networks and their features will come from analysis of idealised random networks which nevertheless are often good representations of those seen in the real world. We will consider real-world biological applications of network theory, in particular focusing on epidemics.

## **PHYSICAL SCIENCES GROUP PROJECT (SOPS300)**

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

By participating in a team project with either an industrial or academic focus students will learn the importance of communication, cooperation and reliability. They will also have an opportunity to develop imaginative solutions to problems and to test them out on a real problem.

The problem is specified by the client, who may be an external sponsor or a University academic. The team of students will then discuss their approach to solving the problem and decide who is going to tackle the various aspects of the problem. The group meets regularly (weekly) with the academic supervisor, who offers advice and may suggest approaches to tackling the problem.

At the end of the project the group writes a group report, which is assessed by the academic supervisor and a second supervisor. An individual's contribution to the project is assessed by the academic supervisor, self-reflection and peer review. The team presents a poster which is assessed by academics.

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## **HOW YOU'LL LEARN**

Your learning activities will consist of lectures, tutorials, practical classes, problem classes, private study and supervised project work.

In year one, lectures are supplemented by a thorough system of 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. 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.

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# Careers and employability

Physics and Mathematics degrees are highly prized and our graduates have excellent career opportunities in industrial research and development, computing, business, finance and teaching.

**87.5% OF 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

## 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	
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	£23,500

*Fees stated are for the 2022-23 academic year and may rise for 2023-24.*

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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.

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# Entry requirements

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

Your qualification	Requirements <a href="#">About our typical entry requirements</a>
A levels	<p>ABB</p> <p>Applicants with the Extended Project Qualification (EPQ) are eligible for a reduction in grade requirements. For this course, the offer is <b>ABC</b> with <b>A</b> in the EPQ.</p> <p>You may automatically qualify for reduced entry requirements through our <a href="#">contextual offers scheme</a>.</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"><li>• <a href="#">Mathematical Sciences BSc (Hons) (Foundation, 4 year route with Carmel College)</a> BSc (Hons)</li><li>• <a href="#">Physical Sciences entry route leading to BSc (Hons) (4 year route including a</a></li></ul> <p><a href="#">Foundation Year at Carmel College</a></p>
GCSE	4/C in English and 4/C in Mathematics

<b>Your qualification</b>	<b>Requirements</b> <a href="#">About our typical entry requirements</a>
Subject requirements	<p>Mathematics A level at grade A and Physics A level at grade B. Applicants must have studied Mathematics at Level 3 within 2 years of the start date of their course.</p> <p>For applicants from England: Where a science has been taken at A level (Chemistry, Biology or Physics), a pass in the Science practical of each subject will be required.</p>
BTEC Level 3 National Extended Diploma	D*DD in relevant diploma, when combined with A Level Mathematics grade A
International Baccalaureate	33 including 6 at higher level in Physics and Mathematics.
Irish Leaving Certificate	H1, H2, H2, H2, H3, H3 including H1 in Mathematics and H2 in Physics
Scottish Higher/Advanced Higher	Advanced Highers accepted at grades ABB including grade A in Mathematics. Relevant language required for advanced level.
Welsh Baccalaureate Advanced	Acceptable at grade B alongside AB at A level including grade A in Mathematics and grade B in Physics.
Access	45 Level 3 credits in graded units in a relevant Diploma, including 39 at Distinction and a further 6 with at least Merit. 15 Distinctions are required in each of Mathematics and Physics

Your qualification	Requirements <a href="#">About our typical entry requirements</a>
International qualifications	<div data-bbox="491 499 927 633" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">           Select your country or region to view specific entry requirements.         </div> <p data-bbox="1002 499 1417 577">guaranteed a place on your chosen course.</p> <p data-bbox="491 667 927 1081">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 <a href="#">University of Liverpool International College</a>, means you're</p>

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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.
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**THE ORIGINAL**

**REDBRICK**