# University College Dublin
## An Coláiste Ollscoile Baile Átha Cliath

**National University of Ireland, Dublin**
**Ollscoil na hÉireann, Baile Átha Cliath**


# Science

## (Undergraduate Programmes – Second, Third and Fourth Year Science)

**Session 2005/06**

**From September 2005 all first year courses are modularised. Further information is available at www.ucd.ie/horizons**

# Contents

# Science Undergraduate Degree Programmes

The primary degree awarded in Science is the Bachelor of Science (BSc). The BSc Degree is conferred either as a General Degree, after three years of study, or as an Honours Degree on completion of a four-year honours course.

A number of full-time BSc degree programmes are available to students who are offered places in Science. Degree programmes available to 'omnibus' entrants (CAO code: DN008) and 'denominated' entrants (CAO codes: DN030, DN031, DN032) are listed below.

## Bachelor of Science (BSc) Degree Course options Available to 'Omnibus Entry' Students (DN008)

### (i) BSc in a Single Subject

The subject is chosen from the following:

Biochemistry
Botany
Chemistry
Computer Science
Experimental Physics
Geology
Industrial Microbiology
Mathematics
Mathematical Physics
Occupational Safety and Health*
Pharmacology
Physiology
Statistics
Zoology

### (ii) BSc in Two Subjects (Joint Degree)

Two-subject (Joint) degree courses comprised of a pairing of subjects from the above list may be taken by students. The choice of subjects is contingent on the approval of the two Schools concerned.

### (iii) BSc in Genetics and a Biological Subject

This programme entails studying courses in Genetics in addition to courses in one of the following subjects: Biochemistry, Botany, Pharmacology, or Zoology.

### (iv) BSc in a Chosen Topic (Topical Degree)

The following six Topical Degree programmes each encompass more than one subject area:

Applied and Computational Mathematics
Astrophysics
Cell and Molecular Biology
Environmental Biology
Geophysical Science
Environmental Geochemistry
Plant Genetic Engineering

* Available as a Third Year General option following the successful completion of the previous years.

### Bachelor of Science (BSc) Degree Course Options Available to 'Denominated Entry' Students

(i) BSc Computer Science (DN030)
(ii) BSc Theoretical Physics (DN031)
(iii) BSc Mathematical Science (DN032)

### Part-time Bachelor of Science (BSc) Degree Course

**BSc Occupational Safety and Health Management**
Applicants to this part-time BSc Degree course must have completed and achieved a high standard in the NUI Diploma in Safety, Health and Welfare at Work or equivalent.

## Course and Examination Regulations for Undergraduate Science Students

Progression in all of the degree programmes is subject to various requirements and standards being met and in this regard undergraduate students are strongly advised to consult relevant sections in this handbook. Regulations governing all examinations are contained in Marks and Standards. Students should consult this publication, copies of which are available in the Library or at http://www.ucd.ie/exams.

Students taking Science are advised that entry to subjects in all years is dependent on the availability of places. When more students indicate preferences than there are places, allocation of places will be made by each School on the basis of academic performance.

# Second Science

## Science Omnibus DN008

## Computer Science DN030

## Theoretical Physics DN031

## Mathematical Science DN032

# Regulations for Second Year Science Students

## 1. Admission to Second Science

Students must have passed the First University Examination in Science.

Students will be assigned to Second Science subjects based on the results of the First Science Examinations.

While every effort is made to accommodate students in the subjects of their choice, entry to a number of the Second Science subjects is limited owing to laboratory space and staffing restrictions.

## 2. Transferring from other UCD colleges to Second Science

The closing date for applications is 1 July 2006. Students wishing to transfer to Science should make application in writing to the Head of College and also complete an Internal Transfer Application Form (available from the Admissions Office, Michael Tierney Building, UCD, telephone: +353 1 716 1649 /1602 or Email: admissions@ucd.ie). Transfers are dependent on the academic record of the student and on the availability of places in Second Science.

### Actuarial and Financial Studies Students

Actuarial and Financial Studies students wishing to transfer to Second Science in Computer Science, Mathematics and Statistics must have passed their First University Examination. Application for such acceptance must be made via an 'Internal Transfer Application Form'.

### Engineering Students

Engineering students wishing to transfer to Second Science must pass their First University Examination in Engineering and with the necessary permission may proceed to subject combinations that include three of the following: Chemistry, Experimental Physics, Mathematics, Mathematical Physics, Statistics. Application for such acceptance must be made via an 'Internal Transfer Application Form'.

## 3. Selection of Subjects

Students in Second Science study **three subjects.** Each subject consists of **four course units,** i.e. students take a total **of twelve units**. Each unit comprises **forty-eight contact hours** (maximum) made up of lectures, laboratory practicals, field practicals and/or tutorials. Examination papers in any subject may be designed to test integrated knowledge, i.e. a single question may require knowledge drawn from more than one unit in that subject.

Second Science subjects are offered in Sets (**see Table 1**). Some subjects may have prerequisite First Science subjects. Students select three subjects, one from three of these Sets (1 to 6). The prerequisites for admission to certain Second Science subjects are shown on **Table 2** but students should also refer to the tables shown under each Second Science subject heading. Students should also note that certain subjects may not be taken together due to timetable or other restrictions as decided by the Head/Director of Programmes.

**Table 1. Second Science Sets**

| | |
|---|---|
| **Set 1** | Mathematics |
| **Set 2** | Mathematical Physics, Zoology |
| **Set 3** | Botany, Experimental Physics, Pharmacology |
| **Set 4** | Chemistry |
| **Set 5** | Computer Science, Industrial Microbiology, Physiology |
| **Set 6** | Biochemistry, Geology, Statistics |

**Table 2. First Science Prerequisites for Admission to Second Science Subjects**

| **Second Science Subjects** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Biol | Chem | CS | EP/BP | Geol | Maths | MP |
| Biochemistry | • | • | | | | • | |
| Botany | • | • | | | | • | |
| Chemistry | | • | | | | • | |
| Computer Science | | | • | | | • | |
| Experimental Physics | | | | • | | • | |
| Geology | | | | | • | • | |
| Industrial Microbiology | • | • | | | | • | |
| Mathematics | | | | | | • | |
| Mathematical Physics | | | | | | • | • |
| Pharmacology | • | • | | | | • | |
| Physiology | • | • | | | | • | |
| Statistics | | | | | | • | |
| Zoology | • | • | | | | • | |

## 4. Special Requirements for Second Year Students Wishing to Proceed to Some Third Year Courses

In selecting their subjects, students should be aware of additional requirements for entry to some Third Science Honours courses.

**Biochemistry**: Students wishing to pursue an Honours Degree in Biochemistry are recommended, but not required, to take Chemistry in second year.

**Cell and Molecular Biology**: Students wishing to pursue a Topical Degree in Cell and Molecular Biology are required to take two biological subjects and one other subject in second year.

**Computer Science**: Students wishing to pursue an Honours Degree in Computer Science are required to take Mathematics in second year.

**Environmental Biology**: Students wishing to pursue a Topical Degree in Environmental Biology are required to choose two subjects out of Botany, Industrial Microbiology or Zoology and one other subject in second year.

**Experimental Physics**: Students wishing to pursue an Honours Degree in Experimental Physics are required to take Mathematics in second year[1].

**Industrial Microbiology**: Students wishing to pursue an Honours Degree in Industrial Microbiology are recommended, but not required, to take Chemistry in second year.

**Plant Genetic Engineering**: Students wishing to pursue a Topical Degree in Plant Genetic Engineering are required to take Botany in second year.

**Statistics**: Students wishing to pursue an Honours Degree in Statistics are required to take Mathematics in second year.

## 5. Second Science Computer Science (Denominated Entry) Programme

Students in computer science (denominated entry) programme take the prescribed courses in Computer Science and Mathematics.

## 6. Second Science Theoretical Physics Programme

Students in the Theoretical Physics programme take the prescribed courses in Experimental Physics, Mathematics and Mathematical Physics.

## 7. Second Science Mathematical Science Programme

Students in the Mathematical Science programme take the prescribed courses in Mathematics, Mathematical Physics and Statistics.

## 8. Examinations

The Second University Examination in Science is taken in the Summer. A Supplemental Examination is held in the Autumn. (The regulations governing this examination are contained in Marks and Standards, available for consultation in the Library or on the web: http://www.ucd.ie/exams/ ). Schools may hold examinations and continuous assessments throughout the year.

### Award of Honours

Honours are awarded at the Summer Examination of the first year of sitting only. To be eligible for Honours in Mathematics students must take the Honours papers.

[1] Students who take Honours Mathematics with Mathematical Physics in First Science are permitted to substitute the Mathematics requirement for Mathematical Physics.

### Qualifying for Third Honours Courses

Students qualify for admission to a Third Year Honours course on the results of the Second University Examination in Science by passing all three subjects at the same examination (either Summer or Autumn) and reaching a minimum of **50%** in the subject that the student proposes to study at Honours Level. A minimum of **55%** will apply if the examination is passed in an academic year later than the academic year of entry to the courses or if it is passed by compensation. Exemption from this regulation may be granted for grave reasons by the College. For further details please see 'Admission to Third Science Courses' on page 30.

### Exemption

Students who receive a mark of 40% in any subject may be recommended by the Examiners for exemption from further examination in that subject (c.f. Marks and Standards).

Students should be aware that where such exemptions have been awarded, students must present for examination in all three subjects if they wish to be considered for admission to a Third Science Honours course.

### Pass by Compensation

Students may be allowed to pass their Second Science Examination by passing two subjects (minimum 40%), and achieve 35-39% in the third subject, where the deficiency is compensated by excess marks in the other subjects.

### Two-Year Rule

Students must pass the Second University Examination in Science within two years of entering the courses. Exemption from this regulation may be granted for grave reasons by the Academic Council on the recommendation of the College.

## 9. Re-Attendance at Second Science Courses

Students may re-attend their courses with the approval of the School(s) concerned, provided that places remain available in the relevant subject. Where a student wishes to change a subject, formal permission of the School must be sought.

### Repeating for Honours

If a student wishes to repeat their Second Science Examination to qualify for entry to an Honours Degree programme in Third Science, examinations in all three Second Science subjects must be taken at the same time.

# Syllabus of Second Year Courses in Science

Each unit comprises 48 contact hours (maximum) made up of lectures, laboratory practicals, field practicals and/or tutorials.

## Biochemistry

**Prerequisite:** Biology and Chemistry in First Science

### Available subject groups with Biochemistry:

| | | |
|---|---|---|
| Biochem | Botany | Chem |
| Biochem | Botany | IndMicro |
| Biochem | Botany | Maths |
| Biochem | Botany | Zool |
| Biochem | Chem | IndMicro |
| Biochem | Chem | Maths |
| Biochem | Chem | Pharm |
| Biochem | Chem | Physiol |
| Biochem | Chem | Zool |

| | | |
|---|---|---|
| Biochem | ExpPhys | Maths |
| Biochem | IndMicro | Maths |
| Biochem | IndMicro | Pharm |
| Biochem | IndMicro | Zool |
| Biochem | Maths | Pharm |
| Biochem | Maths | Physiol |
| Biochem | Maths | Zool |
| Biochem | Pharm | Physiol |
| Biochem | Pharm | Zool |

### Second Year Courses

**Biomolecules I** **BIOC 2006**

Cellular architecture; introduction to macromolecules; amino acids and proteins including antibodies, receptors, haemoglobin, molecular motors; associated techniques.

**Biomolecules II** **BIOC 2007**

Enzymes and cofactors; glycoproteins and bacterial cell walls; lipids and membranes; transport mechanisms; signal transduction.

**Metabolism** **BIOC 2008**

Bioenergetics; carbohydrate metabolism; photosynthesis; lipid transport and metabolism; oxidative metabolism; amino acid metabolism; metabolic control.

**Molecular Genetics and Biotechnology** **BIOC 2009**

Structures of nucleotides and nucleic acids; nucleotide metabolism; transcription, translation and DNA sequencing; regulation of gene expression; molecular biotechnology.

## Botany

**Prerequisite:** Biology and Chemistry in First Science

**Available subject groups with Botany:**

| | | |
|---|---|---|
| Botany | Biochem | Chem |
| Botany | Biochem | IndMicro |
| Botany | Biochem | Maths |
| Botany | Biochem | Zool |
| Botany | Chem | Geology |
| Botany | Chem | IndMicro |
| Botany | Chem | Maths |

| | | |
|---|---|---|
| Botany | CompSc | Maths |
| Botany | Geology | Maths |
| Botany | Geology | Zool |
| Botany | IndMicro | Maths |
| Botany | IndMicro | Zool |
| Botany | Maths | Zool |
| | | |

### Second Year Courses

**Biology of Fungi** **BOTN 2001**

A course dealing with growth, development and physiology of fungi. Characteristic and noteworthy features of fungal structure and growth; osmotrophy and extracellular enzymes; nutritional requirements; responses to environment; hyphal tip growth, mycelium, differentiation and reproduction; spore characteristics, dispersal and germination.

**Plant Growth and Anatomy** **BOTN 2003**

Growth of plants and cultured plant cells, growth measurements and evaluation. Anatomical development of plants. The range and distribution of cell types, relationships between structure and function, structural aspects of cell differentiation. The structure and identification of woods.

**Environment, Plants and Vegetation** **BOTN 2004**

Plant/environment interactions: plant ecotoxicology; soil; rhizosphere; nutrients; effects of and tolerance to salt, drought, waterlogging and pollutants. Vegetation and environment: saltmarshes, sand-dunes, heathlands, peatlands, grasslands and woodlands.

**Plant Signalling Molecules in Growth and Development** **BOTN 2005**

Introduction to the five major groups of signalling molecules, auxin, gibberellins, cytokinins, abscisic acid, ethylene and other biologically-active signalling molecules; the influence of signalling molecules on different categories of development such as, apical dominance, differentiation of vascular tissue, embryogenesis, root hair development and senescence.

## Chemistry

**Prerequisite:** First Science Chemistry

### Available subject groups with Chemistry:

| | | |
|---|---|---|
| Chem | Biochem | Botany |
| Chem | Biochem | IndMicro |
| Chem | Biochem | Maths |
| Chem | Biochem | Pharm |
| Chem | Biochem | Physiol |
| Chem | Biochem | Zool |
| Chem | Botany | Geology |
| Chem | Botany | IndMicro |
| Chem | Botany | Maths |
| Chem | CompSc | Maths |
| Chem | ExPhys | Maths |
| Chem | Geology | MPhys |
| Chem | Geology | Maths |

| | | |
|---|---|---|
| Chem | Geology | Zool |
| Chem | IndMicro | Maths |
| Chem | IndMicro | Pharm |
| Chem | IndMicro | Stats |
| Chem | IndMicro | Zool |
| Chem | MPhys | Maths |
| Chem | MPhys | Stats |
| Chem | Maths | Pharm |
| Chem | Maths | Stats |
| Chem | Maths | Zool |
| Chem | Pharm | Physiol |
| Chem | Pharm | Stats |
| | | |

### Second Year Courses

**Organic Chemistry** **CHEM 2101**

*Synthesis and Reactivity of Organic Compounds*. The preparation and reactions of molecules containing double bonds. Reactivity and stereochemistry of ionic and free-radical additions to alkenes and alkadienes; resonance and aromaticity; electrophilic and nucleophilic aromatic substitution. Chemistry of aldehydes and ketones. Chemistry of carboxylic acids and their derived amides, esters, halides and anhydrides including nucleophilic acyl transfer reactions. Acidity of carboxylic acids. Mechanism of Base hydrolysis of an ester. The Grignard synthesis of tertiary alcohols. Chemistry of amines, amino acids.

**Physical Chemistry** **CHEM 2102**

*Bonding*. Quantum mechanics, the Schroedinger equation and atomic wave functions, molecular orbitals, linear combination of atomic orbitals. Interaction of electromagnetic radiation with atoms and molecules.

*Kinetics*. Elementary and complex reactions, molecularity, reaction order and rate equations, elucidation of reaction mechanisms from kinetic studies.

*Solution Chemistry*. Strong and weak electrolytes, conductivity, analytical applications of conductance measurements, electrolysis, redox reactions, Faraday's laws of electrolysis.

**Introductory Inorganic Chemistry** **CHEM 2103**

Origin of the elements, overview of the Periodic Table; introduction to point group symmetry; Werner-type coordination compounds; solid state chemistry – ionic, layer and molecular structures.

**Chemistry and Biology** **CHEM 2104**

The objective of this course is to provide a broader perspective on chemistry by considering the central role that chemistry plays in many important biological processes. Particular attention will be paid to the properties of biomolecules, including amino acids, peptides, proteins and bioinorganic compounds.

## Computer Science

**Prerequisite:** First Year Computer Science and Mathematics

**Available subject groups with Computer Science:**

| | | |
|---|---|---|
| CompSc | Botany | Maths |
| CompSc | Chem | Maths |
| CompSc | ExPhys | Maths |
| CompSc | Geology | MPhys* |
| CompSc | Geology | Maths |

| | | |
|---|---|---|
| CompSc | MPhys | Maths |
| CompSc | MPhys* | Stats |
| CompSc | Maths | Stats |
| CompSc | Maths | Zool |
| | | |

Students must take Mathematics and one other subject.

**Second Year Courses**

**Data Structures and Algorithms I** **COMP 2001**

Object Oriented design, Data abstractions, lists, queues, stacks, trees, graphs and operations on them using Java programming language.

**Data Structures and Algorithms II** **COMP 2011**

Trees; graphs; pattern matching; sorting; specification techniques; complexity analysis; application.

**Software Engineering Project** **COMP 2014**

A project in software engineering building a complete system based on the application of analysis, design and implementation techniques.

**Digital Systems** **COMP 2015**

Boolean logic; gates; multiplexers; decoders; arithmetic circuits; synchronous and asynchronous circuits, clocks, flip-flops, counters, registers, race conditions, glitches; buses; memory elements.

* Those students who took Mathematical Physics and Honours Mathematics in First Science may substitute Mathematical Physics for Mathematics.

## Computer Science (Denominated Entry)
**(SCBDF0015)**

Students follow the Second Science Honours or Pass course in Mathematics.

### Second Computer Science (Denominated Entry) Courses

In Computer Science students take the following courses:

**Datastructures and Algorithms I** **COMP 2001**
Object Oriented design, Data abstractions, lists, queues, stacks, trees, graphs and operations on them using Java programming language.

**Databases and Information Systems** **COMP 2006**
Types of information system; database organisation; data models; the relational model; data definition and manipulation languages; relational algebra and calculus; SQL; database design; normalisation; database systems vs. information retrieval systems.

**Interactive Multimedia and the Web** **COMP 2008**
Introduction to the web, the basic principles of web-page development and design, HTML, XHTML, javascript, graphic formats, cascading style sheets, typography, WAP and WML, future trends, interactive web-based systems.

**Datastructures and Algorithms II** **COMP 2011**
Trees; graphs; pattern matching; sorting; specification techniques; complexity analysis; application.

**Unix Operating System** **COMP 2012**
Introduction to UNIX Operating System, Unix File System, Unix Shell, Unix Tools, Unix Scripts.

**Software Engineering Project** **COMP 2014**
A project in software engineering building a complete system based on the application of analysis, design and implementation techniques.

**Digital Systems** **COMP 2015**
Boolean logic; gates; multiplexers; decoders; arithmetic circuits; synchronous and asynchronous circuits, clocks, flip-flops, counters, registers, race conditions, glitches; buses; memory elements.

**Mathematics for Computer Science** **COMP 2016**
Introduction to the skills of algorithm development and analysis through an asset of case studies of mathematical problems and the algorithms used to solve them. Problems will be taken from areas such as: Number Theory, Elementary Cryptography, Elementary Graph Theory, Discrete Mathematics, Elementary Numerical Analysis. The course will involve a practical component in which students implement some of these algorithms.

## Experimental Physics

**Prerequisite:** First Science Experimental Physics

**Available subject groups with Experimental Physics:**

| | | |
|---|---|---|
| ExPhys | Biochem | Maths |
| ExPhys | Chem | Maths |
| ExPhys | CompSc | Maths |
| ExPhys | Geology | Maths |

| | | |
|---|---|---|
| ExPhys | MPhys | Maths |
| ExPhys | Maths | Physiol |
| ExPhys | Maths | Stats |
| | | |

Students must take Mathematics and one other subject. Those students who took Mathematical Physics and Honours Mathematics in First Science may substitute the Mathematics requirement with Mathematical Physics.

### Second Year Courses

**Laboratory**

Students work either singly or in pairs, on a range of modern experiments designed to complement the Second Year lecture course syllabus and enhance understanding of topics in optics, solid state physics, quantum and atomic physics and electromagnetism. In addition, measurements of fundamental physical constants are made in classic physics experiments, such as the Cavendish experiment to measure the universal gravitational content and the Millikan oil-drop experiment to determine the charge on the electron. Students become familiar with a variety of practical techniques, e.g. computerised instrument control, scanning tunnelling microscopy and photographic development, while reinforcing their understanding of difficult concepts encountered in the lecture courses. Continuous assessment of the laboratory component is based on students' performance in the laboratory and on written reports.

**Optics and Topics in Modern Physics** **EXPH 2001**

A brief review of geometrical optics. Wave motion. Superposition. Electromagnetic theory of light. Light propagation (reflection, Fermat's principle). Polarisation. Interference. Amplitude splitting and wave front splitting interferometers. Fraunhofer diffraction. Special relativity. Introduction to topics in modern physics, such as applied optics, astrophysics and particle physics.

**Electromagnetism** **EXPH 2002**

Introduction. Electrostatics. Conservative nature of the electric field. Divergence theorem and Stokes' theorem. Faraday's laws of electromagnetic induction. Inductance and eddy currents. Symmetry principles applied to network S and complex circuits. DC and AC circuits. Complex impedance, resonance, power transfer and impedance matching. Effect of electric fields on materials.

**Atomic and Quantum Physics** **EXPH 2003**

Introduction. Distribution functions. Blackbody radiation. Quantisation. The Bohr atom. Wave-particle duality. The wave packet. Heisenberg's uncertainty principle. The Schrödinger wave equation and simple systems. Applications of Quantum Mechanics to

different scale systems, i.e. solids, atoms, nuclei. In addition, The Compton effect, Rutherford scattering and Brownian motion are modelled as exercises.

**Solid State Physics and Devices** **EXPH 2004**

Introduction to the physics of materials in the solid state, with particular reference to electron behaviour. Electronic band structure of conductors, semiconductors and insulators. Intrinsic and extrinsic conductivity and doping in semiconductors. The p-n junction. Practical semiconductor devices, including FET transistors and the solid state laser. Computer modelling of devices. Superconducting properties of materials at low temperatures.

## Geology

**Prerequisite:** First Science Geology

**Available subject groups with Geology:**

| | | |
|---|---|---|
| Geology | Botany | Chem |
| Geology | Botany | Maths |
| Geology | Botany | Zool |
| Geology | Chem | MPhys |
| Geology | Chem | Maths |

| | | |
|---|---|---|
| Geology | Chem | Zool |
| Geology | CompSc | Maths |
| Geology | ExPhys | Maths |
| Geology | MPhys | Maths |
| Geology | Maths | Zool |

### Second Year Courses

GEOL 2101, GEOL 2102 and GEOL 2103 are prerequisites for GEOL 2104.

**Sedimentology and Palaeobiology** **GEOL 2101**

Introduction to the petrological microscope and properties of sedimentary rocks. Texture and composition of clastic sedimentary rocks. Petrology of sandstones. Fluid dynamics and origin of sedimentary structures. Limestone classification, depositional environments and petrology. Major invertebrate fossil groups: preservation, morphologies, modes of life and evolution. Fossils in stratigraphy and palaeoecology.

**Tectonics and Structure** **GEOL 2102**

Plate tectonics and motions. Divergent and convergent margins. Geophysical Techniques in Tectonics. Volcano and earthquake seismology. Brittle, ductile and viscoelastic behaviour. Conditions for brittle failure, faults and joints. Fold classification and mechanisms. Shear zones and transpression. Strain theory, foliations and lineations. Geological and geophysical maps. Structural analysis using the stereonet.

**Mineralogy and Petrology** **GEOL 2103**

Optical properties of rock-forming minerals. Composition and origin of igneous and metamorphic rocks. Experimental petrology. Igneous textures. MORB, OIB and subduction-related magmatism. Tectonic settings of magmatism and metamorphism Metamorphic textures. Metamorphic grade, zones and facies. Metapelite, metabasite and calc-silicate assemblages. Phase Rule. Regional and contact metamorphism.

**Field Studies and Applied Geology** **GEOL 2104**

Approximately half the course consists of lectures and practical classes, the remainder being field courses. Description and interpretation of igneous, sedimentary and metamorphic rocks in the field and subsurface, using field material, maps and seismic sections. Introduction to photogeology. Petroleum geology exploration. Practical examples from Irish onshore and offshore.

## Industrial Microbiology

**Prerequisite:** Biology and Chemistry in First Science

Students are recommended, not required to take Chemistry in Second Science.

**Available subject groups with Industrial Microbiology:**

| | | |
|---|---|---|
| IndMicro | Biochem | Botany |
| IndMicro | Biochem | Chem |
| IndMicro | Biochem | Maths |
| IndMicro | Biochem | Pharm |
| IndMicro | Biochem | Zool |
| IndMicro | Botany | Chem |
| IndMicro | Botany | Maths |
| IndMicro | Botany | Zool |
| IndMicro | Chem | Maths |

| | | |
|---|---|---|
| IndMicro | Chem | Pharm |
| IndMicro | Chem | Stats |
| IndMicro | Chem | Zool |
| IndMicro | Maths | Pharm |
| IndMicro | Maths | Stats |
| IndMicro | Maths | Zool |
| IndMicro | Pharm | Stats |
| IndMicro | Pharm | Zool |
| | | |

**Second Year Courses**

**The Microbial World** **INDM 2001**

An introduction to the biodiversity of microorganisms; contrasts between prokaryotic and microeukaryotic organisms; systems for classifying bacteria and fungi together with the biology of the main groups; an examination of growth, reproduction and survival of microorganisms and their applications.

*Corequisite: INDM 2002.*

**Nutrition and Metabolism** **INDM 2002**

Growth, energy and nutrition; carbon utilisation in aerobic and anaerobic growth; fermentation and respiration; ATP generation and growth rate. Key metabolic intermediates and their relevance in industrial microbiology. Protein structure, classification, quantification and properties of enzymes. Introduction to enzyme technology.

*Corequisite: INDM 2001.*

**Microbial Genetics** **INDM 2003**

Nucleic acid structure and functions. The bacterial chromosome and reproduction. Extrachromosomal genetic elements. Gene transfer in bacteria. Mutagenesis. Control of gene expression. Diploids and merodiploids. Phenotype expression.

*Prerequisites: INDM 2001, INDM 2002.*

**Microbes, Man and Environment** **INDM 2004**

Assessment of microbial activity in the environment with reference to important environmental processes mediated by microorganisms. Microorganisms and the infection cycle. Microorganisms and the food chain. Industrial products of economic significance from microorganisms.

*Prerequisites: INDM 2001, INDM 2002, INDM 2003.*

## Mathematical Physics

**Prerequisite:** First Science Mathematical Physics

**Available subject groups with Mathematical Physics:**

| | | |
|---|---|---|
| MPhys | Chem | Geology |
| MPhys | Chem | Maths |
| MPhys | Chem | Stats |
| MPhys | CompSc | Maths |

| | | |
|---|---|---|
| MPhys | ExPhys | Maths |
| MPhys | Geology | Maths |
| MPhys | Maths | Stats |
| | | |

**Second Year Courses**

**Methods A** **MAPH 2111**

*VectorCalculus:* Vector differentiation (Frenet-Serret formulae). Directional derivatives, Grad, Div, Curl. Vector integration (line, surface, volume integrals). Integral theorems (Divergence and Stokes' theorems). Grad, Div and Curl in orthogonal curvilinear coordinates. Variational problems, Lagrange multipliers.

*Calculus of Variations*: Euler's equation, geometric examples, extension to higher number of variables, conditional variation.

**Mechanics and Special Relativity** **MAPH 2120**

*Mechanics*: Dynamics of rigid bodies, rotating earth, spinning top, moments of inertia, principal axes, Euler's equations of motion.

*Special Relativity*: Inertial frames, Lorentz transformations, space-time, tensors, relativistic mechanics, energy-momentum conservation.

**Analytical and Quantum Mechanics** **MAPH 2130**

*Analytical Mechanics*: Lagrange's equation, variational principles. Small oscillations, normal modes. Hamilton's equations, canonical transformations, Poisson brackets.

*Quantum Mechanics*: Introduction, Postulates of Quantum Mechanics, One-dimensional examples: Potential well and harmonic oscillator, the Heisenberg uncertainty principle, Quantum tunnelling.

**Ordinary Differential Equations** **MAPH 2140**

*Analytical methods*: Existence of solutions. Linear differential equations: linearly independent solutions, dimension of solution space, Wronskians, Green's functions. Singular points. Solution in series.

*Numerical methods*: Runge-Kutta methods. Adaptive techniques. Applications to satellite motion, the three-body problem and the Lorenz model.

## Mathematical Science
**(SCBDF0014)**

Students take the following courses.

### Mathematics

| | |
|---|---|
| MATH 2101 | Vector Spaces and Linear Transformations |
| MATH 2105 | Number Theory and Group Theory |
| MATH 2106 | Introduction to Analysis |
| MATH 2104 | Functions of Several Variables |

### Mathematical Physics

| | |
|---|---|
| MAPH 2111 | Methods A |
| MAPH 2120 | Mechanics and Special Relativity |
| MAPH 2130 | Analytical and Quantum Mechanics |
| MAPH 2140 | Ordinary Differential Equations |

In addition, students study:

### Euclidean Spaces

Convergence, Bessel's inequality, Parseval's equality. Fourier series (Piecewise continuous functions, Riemann-Lebesgue lemma, Weierstrass approximation theorem, Pointwise convergence). Orthogonal series of polynomials (Legendre polynomials, Hermite polynomials, Laguerre polynomials, Bessel functions).

### Statistics

| | |
|---|---|
| STAT 2205 | Statistical Theory I: Probability |
| STAT 2206 | Statistical Theory II: Statistical Inference |
| STAT 2207 | Statistical Theory III: Bayesian Statistics and Stochastic Processes |
| STAT 2221 | Introduction to Statistical Methods |

## Mathematics

### Available subject groups with Mathematics:

| | | |
|---|---|---|
| Maths | Biochem | Botany |
| Maths | Biochem | Chem |
| Maths | Biochem | ExPhys |
| Maths | Biochem | IndMicro |
| Maths | Biochem | Pharm |
| Maths | Biochem | Physiol |
| Maths | Biochem | Zool |
| Maths | Botany | Chem |
| Maths | Botany | CompSc |
| Maths | Botany | Geology |
| Maths | Botany | IndMicro |
| Maths | Botany | Zool |
| Maths | Chem | CompSc |
| Maths | Chem | ExPhys |
| Maths | Chem | Geology |
| Maths | Chem | IndMicro |
| Maths | Chem | MPhys |
| Maths | Chem | Pharm |
| Maths | Chem | Stats |
| Maths | Chem | Zool |

| | | |
|---|---|---|
| Maths | CompSc | ExPhys |
| Maths | CompSc | Geology |
| Maths | CompSc | MPhys |
| Maths | CompSc | Stats |
| Maths | CompSc | Zool |
| Maths | ExPhys | Geology |
| Maths | ExPhys | MPhys |
| Maths | ExPhys | Physiol |
| Maths | ExPhys | Stats |
| Maths | Geology | MPhys |
| Maths | Geology | Zool |
| Maths | IndMicro | Pharm |
| Maths | IndMicro | Stats |
| Maths | IndMicro | Zool |
| Maths | MPhys | Stats |
| Maths | Pharm | Physiol |
| Maths | Pharm | Stats |
| Maths | Pharm | Zool |
| Maths | Physiol | Stats |
| Maths | Stats | Zool |

### Second Year General Courses

**Linear Algebra** **MATH 2202**

Vector Spaces and subspaces. Linear independence, spanning sets, basis, dimension. Linear mappings, kernel and image, rank-nullity theorem. Correspondence between linear mappings and matrices. Change of basis matrices. Matrices for orthogonal projections, reflections and rotations. Eigenvalues and eigenvectors, characteristic polynomials. Determinant and trace – relation to eigenvalues. Eigenvalues of symmetric matrices. Diagonalization of matrices.

**Probability and Statistics** **MATH 2204**

Probability spaces. Conditional probability and Bayes' theorem. Enumeration techniques. Binomial theorem. Discrete random variables – cumulative distribution functions, normal distribution. Estimation – random samples, sample mean and variance, confidence intervals.

**Calculus I** **MATH 2205**

Functions of several variables: examples, graphs, contours. Limits and continuity of real-valued functions of several variables. Partial derivatives. The gradient vector field. The chain rule. Second–order partial derivatives. Directional derivatives, direction of steepest ascent. Local optimisation, classification of critical points. Lagrange multipliers. Vector fields, div and curl. Double Integrals, iterated integrals.

**Calculus II** **MATH 2206**

Complex numbers and de Moivre's theorem. Second order differential equations. Infinite series. Power series, radius of convergence. Differentiation and integration of power series functions. Taylor's theorem, Taylor series, examples. Series of differential equations. Improper integrals.

**Second Year Honours Courses**

**Vector Spaces and Linear Transformations** **MATH 2101**

The internal structure of a vector space. Vector spaces homomorphisms. Matrices and linear transformations.

**Functions of Several Variables** **MATH 2104**

Partial and directional derivatives. Taylor series. Critical points and Lagrange multipliers. Implicit function theorem. Line integrals and multiple integrals.

**Number Theory and Group Theory** **MATH 2105**

Euclid's algorithm. The algebra of congruences. Groups, subgroups and homomorphisms. Lagrange's theorem. The Fermat-Euler theorem.

**Introduction to Analysis** **MATH 2106**

The supremum axiom, sequences and series. Properties of continuous functions. Power series.

## Pharmacology

Prerequisite: Biology and Chemistry in First Science

**Available subject groups with Pharmacology:**

| | | |
|---|---|---|
| Pharm | Biochem | Chem |
| Pharm | Biochem | IndMicro |
| Pharm | Biochem | Maths |
| Pharm | Biochem | Physiol |
| Pharm | Biochem | Zool |
| Pharm | Biochem | Physiol |
| Pharm | Chem | IndMicro |
| Pharm | Chem | Maths |
| Pharm | Chem | Physiol |

| | | |
|---|---|---|
| Pharm | Chem | Stats |
| Pharm | IndMicro | Maths |
| Pharm | IndMicro | Stats |
| Pharm | IndMicro | Zool |
| Pharm | Maths | Physiol |
| Pharm | Maths | Stats |
| Pharm | Maths | Zool |
| Pharm | Physiol | Stats |
| | | |

**Second Year Courses**

**Introduction to Pharmacological Principles** **PHAR 2001**

Membrane structure and transport of drugs across cell membranes. Drug disposition including drug routes of administration, absorption, distribution, metabolism and excretion. Pharmacokinetics. Drug receptors and receptor theory. Introduction to nerve and muscle pharmacology.

**Neuropharmacology I** **PHAR 2002**
Structure and function of autonomic nervous system. Autonomic pharmacology. Cholinergic and adrenergic drugs. Structure and function of central nervous system. Introduction to CNS pharmacology: Membrane stabilizing drugs and neurotransmitter modulators with CNS activity.

**Cardiovascular, Respiratory, Renal and Gut Pharmacology** **PHAR 2003**
Body fluids. Cardiovascular system. Introduction to therapy of hypertension, congestive cardiac failure, ischemic heart disease, myocardial infarction and stroke. Respiratory system. Antiasthmatic drugs. Renal pharmacology. Diuretics. Alimentary tract, gut movements, digestion and absorption.

**Introductory Endocrine Pharmacology and Immunopharmacology PHAR 2004**
Chemotherapy. Introduction to endocrinology, insulin and cortisol. The immune system: Immunopharmacology. Inflammation. Anti-inflammatory drugs. Introduction to chemotherapeutic agents.

## Physiology

**Prerequisite:** Biology and Chemistry in First Science

**Available subject groups with Physiology:**

| | | |
|---|---|---|
| Physiol | Biochem | Maths |
| Physiol | Biochem | Pharm |
| Physiol | Chem | Pharm |
| Physiol | ExPhys | Maths |

| | | |
|---|---|---|
| Physiol | Maths | Pharm |
| Physiol | Maths | Stats |
| Physiol | Pharm | Stats |
| | | |

**Second Year Courses**

**General Physiology** **PHYS 2004**
Cell structure, intracellular organelles. Body fluids. Cell membrane receptors, second messenger systems. Connective tissue. Epithelia: absorption, secretion, mucosa, skin. Muscle: skeletal, cardiac, smooth. Neural structure and function. Intercellular communication; synaptic transmission, hormones, chemical messengers.

**Circulation and Respiration** **PHYS 2005**
Blood; structure and function. Introduction to mechanisms of immunity. Organisation of the circulation. Heart as a pump. Structure and function of blood vessels. Capillary exchange. Structure of the respiratory system. Mechanics of breathing. Gas exchange and transport.

**Digestion and Excretion** **PHYS 2006**
Structure and functions of the alimentary tract; movement, secretion, digestion, absorption, excretion. Structure and functions of the pancreas and liver. Kidneys; homeostatic functions, structure, blood vascular system. Glomerular filtration, tubular reabsorption and secretion, concentration of urine, micturition.

**Nervous and Endocrine Systems** **PHYS 2007**

Structure of the nervous system. Sensation. Spinal reflexes and reflex arcs. Hormonal control of physiological function, metabolism, growth and reproduction.

## Statistics

There are no prerequisites for students wishing to take Statistics

**Available subject groups with Statistics:**

| | | |
|---|---|---|
| Stats | Chem | IndMicro |
| Stats | Chem | MPhys |
| Stats | Chem | Maths |
| Stats | Chem | Pharm |
| Stats | CompSc | Maths |
| Stats | ExPhys | Maths |
| Stats | IndMicro | Maths |

| | | |
|---|---|---|
| Stats | IndMicro | Pharm |
| Stats | MPhys | Maths |
| Stats | Maths | Pharm |
| Stats | Maths | Physiol |
| Stats | Maths | Zool |
| Stats | Pharm | Physiol |
| | | |

**Second Year Courses**

**Concepts in Data Collection and Analysis** **STAT 10010**

Statistics: the science of data. Data sources: sampling and opinion polls, experiments and observational studies. Descriptive statistics: summarising data and the relationships between variables. Inferential statistics: the Normal distribution, simple linear regression with applications. How to interpret hypothesis tests and confidence intervals. Computer simulation in statistics.

**Exploratory Data Analysis and Introduction to Statistical Inference STAT 10020**

Types of variables and data, graphical techniques for displaying data, samples and populations, transforming data, numerical summary measures, summarising bivariate data. Introduction to statistical programming. Probability concepts. Random variables and probability distributions. Binomial and Normal distributions. The distribution of a sample mean and the Central Limit Theorem. Confidence interval estimation using a single sample.

**Statistical Inference and Goodness-of-fit** **STAT 10030**

Hypothesis testing procedures. Errors in hypothesis testing. Test for population means and proportions in a single sample. P-Values. Hypothesis tests and confidence intervals for the difference between two population means or proportions using independent samples and using paired data. Distribution free procedures. One and two way frequency tables. Hypothesis testing for proportions and independence. Testing the fit for a population model.

**Linear Regression and Analysis of Variance** **STAT 10040**

The simple linear regression model. Inferences based on the estimated regression line. Inferences on the population correlation. Checking model adequacy. Single factor Analysis of Variance. Multiple comparisons. Randomized block experiment. Two-factor Analysis of Variance.

*The following four units may only be taken by Second Mathematical Science students:*

**Statistical Theory I: Probability** **STAT 2205**
Probability Theory. Combinatorics. Random Variables: univariate, bivariate and multivariate. Moment Generating Functions. Functions of a random variable. Standard Probability Laws.

**Statistical Theory II: Statistical Inference** **STAT 2206**
(a) Estimation Theory: Chebyshev Inequality. Law of Large Numbers. Central Limit Theorem. Methods of moments and maximum likelihood. Point estimation and interval estimation.

(b) Hypothesis Testing: Neyman Pearson Lemma. Likelihood ratio tests.

**Statistical Theory III: Bayesian Statistics and Stochastic Processes** **STAT 2207**
Bayesian statistical inference. Stochastic processes. Poisson processes. Birth and death processes. Branching processes.

**Introduction to Statistical Methods** **STAT 2221**
Data reduction and representation. Probability distributions. Sampling. Confidence intervals. Hypothesis testing. Independent and paired samples. Sample size calculations. Design of experiments. Correlation. Linear regression.

## Theoretical Physics
**(SCBDF0012)**

### Second Year Courses
Students follow the Second Year Honours course in Mathematics and Second Year course in Experimental Physics. In Mathematical Physics students take the following courses:

**MAPH 2111** Methods A
**MAPH 2120** Mechanics and Special Relativity
**MAPH 2130** Analytical and Quantum Mechanics
**MAPH 2140** Ordinary Differential Equations

In addition, students study:

### Computational Physics
*Monte-Carlo Methods:* Uniform and non-uniform deviates. Integration. Random walks.

*Computational Methods in Quantum Mechanics:* Shooting and matching methods. Energy levels of one-dimensional potentials.

Also:
**Theoretical Physics students attend seminars in Experimental Physics.**

## Zoology

**Prerequisite:** Biology and Chemistry in First Science

**Available subject groups with Zoology:**

| | | |
|---|---|---|
| Zool | Biochem | Botany |
| Zool | Biochem | Chem |
| Zool | Biochem | IndMicro |
| Zool | Biochem | Maths |
| Zool | Biochem | Pharm |
| Zool | Botany | Geology |
| Zool | Botany | IndMicro |
| Zool | Botany | Maths |

| | | |
|---|---|---|
| Zool | Chem | Geology |
| Zool | Chem | IndMicro |
| Zool | Chem | Maths |
| Zool | CompSc | Maths |
| Zool | IndMicro | Maths |
| Zool | IndMicro | Pharm |
| Zool | Maths | Pharm |
| Zool | Maths | Stats |

### Second Year Courses

**Animal Form and Function 1** **ZOOL 2005**

Comparative anatomy and physiology of invertebrate and vertebrate systems (digestion; respiration/circulation; excretion/osmoregulation; reproduction). Enzymology and metabolism. Correlation between form and function. Adaptation to environment.

**Cell and Molecular Zoology** **ZOOL 2006**

Topics covered include chromosome organisation and genome stability; mutation, repair and recombination; genetic linkage and chromosome mapping; gene expression and its regulation; protein targeting; cytoskeleton and extracellular matrix (ECM); cell-cell and cell-ECM interactions; cell-cycle regulation, apoptosis and cancer.

**Animal Ecology** **ZOOL 2007**

Biotic and abiotic determinants and limiting factors in growth and control of animal populations/communities. Food webs, decomposition processes, nutrient cycling. Features, habitats and fauna of terrestrial, freshwater and marine ecosystems.

**Invertebrate Diversity** **ZOOL 2008**

The Bauplan concept, constraints in body design and comparative biology of the following invertebrate phyla: Protista, Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca and Echinodermata. Species of economic and medical importance.

## Third Science

**BSc (General) One-Subject: SCBDF0003**

**BSc (General) Two-Subject: SCBDF0004**

**BSc (Honours) One-Subject: SCBDF0005**

**BSc Joint Honours: SCBDF0006**

**BSc Topical: SCBDF0007/8**

**BSc Theoretical Physics: SCBDF0012**

**BSc Occupational Safety and Health: SCBDF0013**

**BSc Mathematical Science: SCBDF0014**

**BSc Computer Science: SCBDF0015**

# Regulations for Third Year Science Students

## Application for Honours or Topical Degrees

Students will be offered places in Third Science courses by the relevant School Head/Programme Director based on the results of the Second Science Examinations in Summer. Students interested in pursuing a Topical Degree should note that they must register their interest with the Programme Director before the Summer Examinations as well as fill out a subject choice form.

Students reaching the qualifying standard at the repeat Autumn Examinations will be accommodated in an Honours/Topical course provided places are still available. Such students should contact the relevant School Head/Programme Director.

## Special Requirements for Admission to some Third Science Courses

### Availability of Places in Some Third Science Honours Courses

The number of places available in some Third Science Honours courses is limited by the availability of laboratory space, staffing and facilities. Qualification in a particular subject will not necessarily guarantee a place. Students should consult with the Heads of the programmes regarding the availability of places.

### Single Honours

Students qualify for admission to a Third Year Honours course on the results of the Second University Examination in Science by passing all three subjects at the same examination (either Summer or Autumn) and reaching a minimum of 50% in the subject that the student proposes to study at Honours Level. A minimum of 55% will apply if the examination is passed in an academic year later than the academic year of entry to the courses or if it is passed by compensation. Exemption from this regulation may be granted for grave reasons by the College.

### Single or Joint Honours – Mathematics

To qualify for admission to the Honours course in Mathematics students must have taken the Honours paper in this subject at the Second Science Examination and attained at least 50% in the subject.

### Mathematical Science

In order to gain admission to the Third Year of the Mathematical Science Degree programme, students must, at the Second Science Examination have attained a qualifying mark (50%) in at least two of the subjects, Mathematical Physics, Mathematics and Statistics, and, in addition, must obtain a minimum of 45% in the other subject. These qualifying standards must be gained at a single sitting, at either the Summer or Autumn Examination. Students passing the examinations but gaining marks less than the requirements may continue in either a one/two-subject Degree course in Mathematical Physics, Mathematics or Statistics.

### Theoretical Physics

To qualify for admission to the Third Year of the Theoretical Physics Degree, students must attain a qualifying standard of 50% in each of their three Second Science subjects: Experimental Physics, Mathematical Physics and Mathematics. These qualifying standards must be gained at a single sitting, at either the Summer or Autumn Examination. Students passing the examinations but gaining marks less than the requirements may continue to a one/two-subject Degree course in Experimental Physics, Mathematical Physics or Statistics.

### Joint Honours Degrees

Students wishing to proceed to a Joint Honours Degree course must at a single sitting of the Second Science Examination, Summer or Autumn, pass the examination and reach a qualifying standard (50%) in each of the two subjects in which they wish to pursue a Joint Honours Degree programme. The approval of the Heads of the relevant programmes must be obtained.

### Genetics and a Biological Subject

Students seeking admission to the Joint Honours Degree in Genetics and a Biological Subject, select one of the following biological subjects: Biochemistry, Botany, Pharmacology and Zoology. They must: -

- Have followed a Second Science programme including at least two biological subjects, one of which must be Biochemistry or Industrial Microbiology or Zoology and
- Pass the Second Science Examination attaining the qualifying standard (50%) for admission to the Honours course in their chosen biological subject.

### Topical Degrees

Students wishing to proceed to a Topical Degree Course follow the Second Science programme outlined in the relevant Course Syllabus for that Topical Degree.

Admission to the Third Year of the Topical Degrees is granted by the Programme Director. Admission is based on academic merit, subject to space and number restrictions in the Schools concerned. Students must show a clear ability at the Second Science University Examination in the two subjects that form the core of the Topical Degree in Third Science.

## Description of Third Science Degree Programmes

In Third Science, students study ten course units. Each unit comprises 48 contact hours (maximum) made up of lectures, laboratory practicals, field practicals and/or tutorials.

### BSc Single Honours Degree (SCBDF0005)

#### 1. Selection of Units

Students admitted to Honours courses must attend, for one academic year, eight units in their major subject and two other units. The choice of optional units is at the discretion of the Honours subject Programme Director. These optional units may be

Third Year units from the Honours subject or from other Third Year units offered in the Colleges, including language units.

A list of recommended optional units for their courses is available in this booklet under the heading of each programme. Please note that these units are included for guidance purposes only and should a student wish to take alternative units, they may do so subject to the agreement of the Programme Director/Head concerned.

## 2. Examinations

The examination is taken in ten units.
The examination must be passed at the first attempt.

### Honours Standards:

- First Class Honours 70%
- Second Class Honours (Grade I) 60%
- Second Class Honours (Grade II) 50%

Honours may be awarded at the Summer Examination of the first year of sitting only.

### Minimum required to continue in Honours Courses

The pass standard in each unit is 40%. In units including written and practical assessment candidates may be rejected or debarred from passing by compensation on grounds of extreme weakness in one or other part of the examination, in which case a pass mark for the unit will not be granted.

To continue in the Honours course, students must obtain an overall average of at least 45% in their ten units and reach the pass mark in at least eight units. Students who have passed the examination but obtain an average of less than 45% will be graduated with a BSc (General) Degree.

Candidates who attain a mark of 40% overall but who do not attain at least 45% overall will not be permitted to continue in the Honours course but will be graduated with the BSc (General) Degree, provided they have passed at least seven units.

### Beneficial Aggregation of Marks

The grade of all Honours Degrees in the Science will be determined by beneficial aggregation of marks where aggregation operates to the benefit of the student, as follows:

**Either:**

Aggregation of 25% of the Third Science Examination results with 75% of the Final Year Examination result

**Or:**

100% of the Final Year Examination result

Beneficial Aggregation of marks will also be applied to the grade of all Joint Honours and Honours Topical Degree programmes.

### 3. Theoretical Physics

Students following the Theoretical Physics Degree programme will take a combination of Third and Fourth year courses as set out in the syllabus. The choice of courses is approved by the Heads of the Experimental Physics and Mathematical Physics programmes.

### 4. Mathematical Science

Students following the Mathematical Science Degree programme will take ten units from the Third year Honours programme of the three subjects with at least two units from each subject. The choice of courses must be approved by the Programme Director.

## BSc Joint Honours Degree (SCBDF0006)

### 1. Approval of Subjects and Units for Joint Honours Degrees

The combination of two subjects for a Joint Honours Degree must have the approval of the Heads of the two programmes concerned. Students should pursue five units in each of the two subjects with an overall maximum total of ten units. The selection of units must be approved by the two programmes concerned.

### 2. Award of Honours

Honours are awarded at the Summer Examination of the first year of sitting only.

## BSc Topical Degree Programmes (SCBDF0007/8)

### 1. Definition of a Topical Degree

The BSc Topical Degree may be defined as a Degree programme encompassing more than one subject area. Students need to qualify for the Honours Degree at the end of Third Science.

### 2. Degrees Awarded from Topical Programmes

The BSc Topical Degree may be awarded as a BSc (General) Topical Degree, following three years of study, or as a BSc (Honours) Topical Degree, following four years of study.

### 3. Selection of Units

The BSc (General) Topical Degree will be taken in ten units made up of eight core units and an additional two units. The Programme Directors will advise students on their choice of units.

### 4. Examinations

The BSc (General) Topical Degree Examination will be held in the ten selected units in Summer. A Supplemental Examination will be held in Autumn. The pass standard in each unit is 40%. In units including written and practical assessment candidates may be rejected or debarred from passing by compensation on grounds of extreme

weakness in one or other part of the examination, in which case a pass mark for the unit will not be granted. Candidates who attain an average mark of 40% overall and reach the pass mark in at least seven units will graduate with a BSc (General) Topical Degree.

### 5. Distinction

Candidates can be awarded the BSc (General) Topical Degree with Distinction if, at the Summer Examination of the first year of sitting the examination, they attain an average of 62.5% or more over ten units.

### 6. Qualification for Final Honours Year

Students wishing to proceed to a BSc (Honours) Topical Degree must pass the BSc General Topical Degree Examination at the first attempt, obtaining an overall average of 50% in six of the eight core units and passing at least eight units. Students who fail to reach this standard but pass the examination, with passes in at least seven units will be awarded the BSc (General) Topical Degree.

## BSc General Degree – One *OR* Two Subject Programme (SCBDF0003/4)

### 1. Selection of Units

Students taking the BSc General Degree study *ten units* as part of either (a) a one subject programme made up of *eight units in one subject* together with *two optional units* or (b) a two subject programme consisting of *four units from each of two subjects* together with *two optional units*.

The two optional units must be taken at the Third Science level. The Programme Director/Head of the core subject will advise students on the choice of units and must approve the students' ten units before they can be registered.

### 2. Examinations

The Final Examination for the BSc General Degree will be held in the ten selected units in the Summer. A Supplemental Examination will be held in the Autumn. (The regulations governing this examination are contained in Marks and Standards, available for consultation in the Library or on the web: http://www.ucd.ie/exams/).

#### Pass Standard

The pass standard in each unit is 40%. In units including written and practical assessment candidates may be rejected or debarred from passing by compensation on grounds of extreme weakness in one or other part of the examination, in which case a pass mark for the unit will not be granted. Candidates who attain an average mark of 40% overall and reach the pass mark in at least seven units will be graduated with a BSc (General) Degree.

### Distinction

Candidates can be awarded the BSc (General) Degree with distinction if, at the Summer Examination of the first year of sitting the examination, they attain an average of 62.5% or more over ten units.

### Exemption

Students who receive a mark of 40% in any unit may be recommended by the Examiners for exemption from further examination in that unit (c.f. Marks and Standards http://www.ucd.ie/exams/).

## 3. Re-Attendance at Courses

Permission to re-attend courses may be granted on application to the relevant School or Programme Office.

## 4. Admission to Honours Courses based on the BSc (General) Degree

Students who complete the BSc (General) Degree Examination at their first sitting and reach specified standards may be admitted to Honours courses, subject to the availability of places. Science regulations do not allow admission to Honours courses based on supplemental or repeat BSc General Examinations.

### From a One-Subject Programme

Students who obtain an average mark of 50% in six of the major subject units and reach the pass mark in at least eight units may be admitted to a Fourth Science Honours course, subject to the approval of the School/Programme concerned.

### From a Two-Subject Programme

Students who obtain an average mark of 50% in four of the major subject units and reach the pass mark in at least eight units may be admitted to a Third Science Honours course, subject to the permission of the Director/Head of Programme. Students so admitted to a Third Science Honours course must attend a minimum of six units as recommended by the major subject.

In the case of Botany and Computer Science, students who obtain an average of 50% in six appropriate units from the major subject and pass the examination may be admitted to a Fourth Science Honours course. Permission of the Director/Head of Programme is required.

# Syllabus of Third Year Courses in Science

## Applied and Computational Mathematics

Core units are marked with the letter **C.** Descriptions of the units may be obtained from the Third Year courses in Mathematical Physics, Mathematics and Statistics. Students must include the eight core units as stated and two of the optional units, as recommended by the Programme Director.

**Core Units:**

| | | |
|---|---|---|
| MATH 3201 | Complex Analysis | **C** |
| MATH 3204 | Groups and Vector Spaces | **C** |
| MATH 3223 | Differential Equations | **C** |
| MAPH 3071 | Numerical Methods | **C** |
| MAPH 2111 | Methods A | **C** |
| STAT 3205 | Statistical Theory I | **C** |
| STAT 3206 | Statistical Theory II | **C** |
| STAT 3207 | Statistical Theory III | **C** |

**Students choose 2 optional units as recommended by the Programme:**

| | |
|---|---|
| STAT 3221 | Biostatistics |
| STAT 3224 | Statistics and Visualisation |
| MATH 3207 | Graph Theory |
| MAPH 3180 | Dynamical Systems and Chaos |

## Astrophysics

**Courses for General and Honours Degrees**

Admission to third year is granted by the course directors, following consultation with the relevant School. Admission is based on academic merit, subject to space and number restrictions in the Schools concerned. Students must show a clear ability at the second science university examination in the two subjects that form the core of the topical degree in third science, normally reaching honours standards in both EXPH and MAPH.

Laboratory: Students will take suitable experiments from the EXPH Honours laboratory commensurate with the number of EXPH units taken.

**Core Units:**

| | | |
|---|---|---|
| MAPH 3232 | The Formation and Evolution of Stars | **C** |
| EXPH 3211 | General Relativity and Cosmology | **C** |
| MAPH 3120 | Methods C: Differential Equations | **C** |
| MAPH 3130 | Thermal and Statistical Physics | **C** |
| MAPH 3171 | Fluid Mechanics | **C** |
| MAPH 3151 | Electromagnetic Theory *(required for MAPH 4171)* | **C** |
| ***Or*** EXPH 3008 | Electromagnetism | **C** |
| EXPH 3009 | Optics | **C** |
| EXPH 3012 | Nuclear Physics | **C** |
| EXPH 3013 | Quantum Mechanics | **C** |
| EXPH 3017 | Space and Planetary Science | **C** |

## Biochemistry

### Courses for General and Honours Degrees

**Third Year Honours and Single Subject General Degree** share the same core and optional units. Core units are marked with the letter **C.** Students must include the eight core units as stated and two of the optional units, as recommended by the Head/Director of Programme. Details of the optional units are given under the relevant subject headings.

**Core Units:**

| | | |
|---|---|---|
| BIOC 3001 | The Role of Nitrogen Compounds in Health and Disease | **C** |
| BIOC 3002 | Biochemical Catalysis | **C** |
| BIOC 3003 | Biochemist's Toolkit | **C** |
| BIOC 3004 | Gene Manipulation & Regulation | **C** |
| BIOC 3005 | Disease and Disease Resistance | **C** |
| BIOC 3006 | Cell Communication and Immunology | **C** |
| BIOC 3009 | Bioinformatics and Proteomics | **C** |
| BIOC 3010 | Structure-Based Drug Design | **C** |

**Students choose two optional units as recommended by the School:**

| | |
|---|---|
| CHEM 3110 | Chemistry of Biomolecules |
| STAT 3221 | Biostatistics |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |

**Third Year 2-Subject General Degree** take ten units. Core units are marked with the letter **C.** Students must include the eight core units as stated (four Biochemistry units and four units from one other subject) and two of the optional units, as recommended by the Head of Subject.

**Core Units:**

| | | |
|---|---|---|
| BIOC 3001 | The Role of Nitrogen Compounds in Health and Disease | **C** |
| BIOC 3002 | Biochemical Catalysis | **C** |
| BIOC 3003 | Biochemist's Toolkit | **C** |
| BIOC 3004 | Gene Manipulation & Regulation | **C** |

**Plus four units from one other subject, plus one other optional unit nominated by the other subject and one unit from the following optional units:**

| | |
|---|---|
| BIOC 3005 | Disease and Disease Resistance |
| BIOC 3006 | Cell Communication and Immunology |
| BIOC 3009 | Bioinformatics and Proteomics |
| BIOC 3010 | Structure-Based Drug Design |

**Third Year Joint Honours Degree** take ten units, five from Genetics and five from Biochemistry. Core units are marked with the letter **C.** Students must include the eight core units as stated and two of the optional units, as recommended by the Course Co-ordinator. Details of the Genetics units may be obtained under the heading Genetics.

**Core Units:**

| | | |
|---|---|---|
| BIOC 3001 | The Role of Nitrogen Compounds in Health and Disease | **C** |
| BIOC 3002 | Biochemical Catalysis | **C** |
| BIOC 3003 | Biochemist's Toolkit | **C** |
| BIOC 3004 | Gene Manipulation & Regulation | **C** |
| BIOC 3009 | Bioinformatics and Proteomics | **C** |
| GENE 3001 | Genetics | **C** |
| GENE 3002 | Genome Structure | **C** |
| GENE 3003 | Gene Expression | **C** |

**Students choose 2 optional units as recommended by the Head of Subject:**

| | |
|---|---|
| BIOC 3005 | Disease and Disease Resistance |
| BIOC 3006 | Cell Communication and Immunology |
| BIOC 3010 | Structure-Based Drug Design |

## Description of Biochemistry Units

**The Role of Nitrogen Compounds in Health and Disease** **BIOC 3001**
Protein digestion, amino acid and nucleotide metabolism, diseases resulting from enzyme deficiencies, role of ATP in biosynthesis reactions, nitrogen cycle and protein nutritional requirements in humans.

**Biochemical Catalysis** **BIOC 3002**
Enzyme assays, kinetics and inhibition. Specificity and mechanisms of biocatalysts. Methods for determining catalytic properties.

**Biochemist's Toolkit** **BIOC 3003**
Survey of techniques and methods required for a modern biochemical approach to problems of biology, including absorption and emission spectroscopy such as NMR and fluorescence; separation techniques; techniques for analysis and manipulation of nucleic acids and proteins, etc.

**Gene Manipulation & Regulation** **BIOC 3004**
DNA replication; control of gene expression in prokaryotes and eukaryotes; recombinant DNA technology in industry and medicine; cloning and expression of heterologous genes; generation of transgenic organisms; PCR and DNA fingerprinting.

**Disease and Disease Resistance** **BIOC 3005**
Discussion of the biochemical basis of selected diseases such as prion-related diseases, AIDS, cancer, immune disorders; the cardiovascular system in health and disease. Discussion of inherited disorders and approaches to gene therapy.

**Cell Communication and Immunology** **BIOC 3006**
Membranes, signal transduction and signalling cascades; hormones and the integration of metabolism; neurotransmission; immunology.

**Bioinformatics and Proteomics** **BIOC 3009**
Computational molecular biology. Introduction to genomics (studying the entire genome of an organism) and proteomics (the study and analysis of all proteins in a pathway, organ or organism). Extracting information from biological databases; application of genome biology to evolution, anthropology and medicine; drug target identification and validation; pharmacogenomics.

**Structure-Based Drug Design** **BIOC 3010**
Structure-based Drug Design uses knowledge of the 3-dimensional structures of proteins to design and optimise small-molecule inhibitors which can be used to treat a range of diseases. Both theoretical and experimental approaches are described and several examples are presented which illustrate the use of these approaches.

# Botany

## Courses for General and Honours Degrees

Students must take the following eight core units and choose from an optional list of units, available from the School of Biological and Environmental Science. Core units are marked with the letter **C.** Details of the optional units are given under the relevant subject headings.

**Core Units:**

| | | |
|---|---|---|
| BOTN 3001 | Diversity and Ecology of Fungi | **C** |
| BOTN 3002 | Plant Population Biology | **C** |
| BOTN 3003 | Plant/Soil Interactions in Wetlands | **C** |
| BOTN 3004 | Growth & Nutrient Assimilation | **C** |
| BOTN 3006 | Seed Plant Reproduction | **C** |
| BOTN 3007 | Vegetation Ecology and Biogeography | **C** |
| BOTN 3008 | Plant Biotechnology | **C** |
| BOTN 3011 | Plant Cell Growth and Signalling | **C** |

**Students also choose two optional units to be decided in consultation with the Head/Director of Programme:**

| | |
|---|---|
| CELB 3001 | Cytoskeletons |
| GENE 3001 | Genetics |
| STAT 3221 | Biostatistics |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |

## Description of Botany Units

**Diversity and Ecology of Fungi** **BOTN 3001**

Life cycles, morphology, and ecology of fungi. Examples of important fungal pathogens causing diseases of plants and animals along with aspects of host/pathogen relationships and control. Ecology of soil fungi including those associated with roots of plants.

**Plant Population Biology** **BOTN 3002**

Plant census – origins and development. Modular nature of plant growth and its demographic consequence. Life history – birth, growth, death; varieties of life history, including clonal growth. Population structure and dynamics. Demography and conservation of rare populations.

**Plant/Soil Interactions in Wetlands** **BOTN 3003**

Geochemistry of wetland soils: oxidation/reduction processes, chemical speciation and availability of nutrients. The rhizosphere: root/soil interactions, rhizosphere oxidation by wetland plants. Nutrient cycling. Behaviour of heavy metals and metalloids in soil and plants: uptake and translocation in plants, turnover by vegetation.

**Growth & Nutrient Assimilation** **BOTN 3004**

Growth measurement, patterns of growth in response to the environment. Plant growth regulators: assays, synthesis, transport and metabolism. Tropisms, problems with mechanics. Photosynthetic metabolism: interaction with light and nutrient supply. Nitrogen assimilation of plants; nitrogen fixation.

**Seed Plant Reproduction** **BOTN 3006**

Breeding systems of gymnosperms and angiosperms. Genetic control of flower formation. Development of female gametophytes and pollen grains. Pollination, pollen tube growth mechanisms, gamete formation, fertilization and zygote development. Incompatibility systems and male sterility. Sexual selection, pre- and post-zygotic. Species isolation mechanisms and their breakdown (hybridisation). Rates of speciation.

**Vegetation Ecology and Biogeography** **BOTN 3007**

Vegetation description and analysis: field methods; the Braun-Blanquet (Zürich-Montpellier) approach to phytosociology; ordination – principles and computer-based techniques. Biogeography – studying plant distributions, Irish biogeography, ecology of the Burren.

**Plant Biotechnology** **BOTN 3008**

Commercial exploitation of biosynthetic capacities of plants. Seed and gene plasma banks. Tissue and organ culture and its use in propagation and production of secondary metabolites: plant cell transformation, molecular probes in study of plant differentiation and development. Micro organisms as biofertilisers and biocontrol agents. Basic aspects of business administration.

**Plant Cell Growth and Signalling** **BOTN 3011**

The course explores the activities and processes underlying cell growth and responses to internal and external signals. Cell wall structure is reviewed as an introduction to cell wall synthesis and growth in response to the osmotic uptake of water. Cytoplasmic elements are shown to govern organ shape through their roles in wall formation and shaping. Cellulose synthase enzymes and ion channels are key components of the plasma membrane. The spatial organization of ion channels is a determinant of cell polarity in systems as diverse as *Fucus* zygotes, pollen tubes and root hairs. Cell signalling involves plasma membrane events that interact with cytoplasmic components. Signalling networks exist which facilitate cross-talk between cells.

## Cell and Molecular Biology

Core units are marked with the letter **C.** Students must include the eight core units as stated and two of the optional units, as recommended by the Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| BOTN 3011 | Plant Cell Growth and Signalling | **C** |
| GENE 3001 | Genetics | **C** |
| GENE 3002 | Genome Structure | **C** |
| GENE 3003 | Gene Expression | **C** |
| PHAR 3001 | Chemotherapeutic Agents | **C** |
| ZOOL 3010 | Animal Development | **C** |
| ZOOL 3012 | Immunology | **C** |
| CELB 3001 | Cytoskeletons | **C** |

**Students choose two of the following optional units as recommended by the Head/Director of Programme:**

| | |
|---|---|
| BIOC 3003 | Biochemist's Toolkit |
| BIOC 3004 | Gene Manipulation & Regulation |
| BIOC 3005 | Disease and Disease Resistance |
| BIOC 3008 | Biochemistry and Environment |
| BIOC 3009 | Bioinformatics and Proteomics |
| BOTN 3004 | Growth & Nutrient Assimilation |
| BOTN 3008 | Plant Biotechnology |
| ZOOL 3015 | Evolutionary Biology |
| STAT 3208 | Statistical Methods I |
| STAT 3221 | Biostatistics |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |

### Description of Cell and Molecular Biology Units

**Cytoskeletons** **CELB 3001**

Cytoskeletons proteins: microtubules, actin, intermediate filaments, motor proteins, microbtubule and actin-associated proteins. Synthesis of tubulin and G-actin. Expression of cytoskeleton genes. Evolution of cytoskeleton genes. Assembly of cytoskeletons. Functioning of cytoskeleton assemblages: cilia, flagella, muscle, cell extension and cell locomotion.

# Chemistry

## Courses for General and Honours Degrees

**Third Year Honours and Single Subject General Degree** are required to take eight core units. Core units are marked with the letter **C.** Students also take one of the additional Chemistry units and one other unit as recommended by the Head/Director of Programme.

The Third Year Chemistry course is semesterised. Units taken in the first and second semester will be examined at the end of the semester in which the unit is given.

**Core Units: 1st Semester**

| | | |
|---|---|---|
| CHEM 3101 | Transition Metal and Organometallic Chemistry | **C** |
| CHEM 3103 | Synthesis and Reactivity of Organic Compounds | **C** |
| CHEM 3104 | Structure Determination by Spectroscopic Methods | **C** |
| CHEM 3113 | Quantum Mechanics and Molecular Spectroscopy | **C** |

**Additional Unit: 1st Semester**

| | |
|---|---|
| CHEM 3109 | Chemistry of Materials |

**Optional Unit: 1st Semester**

| | |
|---|---|
| MATH 3202 | Mathematical Techniques |

**Core Units: 2nd Semester**

| | | |
|---|---|---|
| CHEM 3105 | Chemistry of the Main Group Elements | **C** |
| CHEM 3107 | Stereochemistry and Mechanism in Organic Chemistry | **C** |
| CHEM 3114 | Electrochemistry, and Colloid and Surface Chemistry | **C** |
| CHEM 3115 | Thermodynamics and Reaction Kinetics | **C** |

**Additional Units: 2nd Semester**

| | |
|---|---|
| CHEM 3110 | Chemistry of Biomolecules |
| CHEM 3112 | Instrumental Analysis |

**Optional Unit: 2nd Semester**

| | |
|---|---|
| CHEN 3025 | Process Engineering |

**Third Year 2-Subject General Degree.** Students take ten units and will normally take CHEM 3101, CHEM 3104, CHEM 3105 as Core Units.

**Transition Metal and Organometallic Chemistry** **CHEM 3101**

Chemistry of the d-block elements, metal complexes and bioinorganic chemistry. Introduction to organometallic chemistry, metal carbonyls, sandwich compounds, alkene and alkyne complexes.

**Synthesis and Reactivity of Organic Compounds** **CHEM 3103**

Introduction to the philosophy and practice of organic synthesis with emphasis on the disconnection approach. Carbonyl reactions, including aldol and Claisen condensations. The Michael, Wittig and Mannich reactions; the alkylation of enolates under thermodynamic or kinetic control. Heterocyclic compounds: formation and substitution reactions; their importance in biology. Syntheses of target molecules, including naturally occurring compounds, pharmaceuticals and fine chemicals.

**Structure Determination by Spectroscopic Methods** **CHEM 3104**

Applications of Spectroscopy. The use of mass spectrometry, ultraviolet/visible spectroscopy, infrared spectroscopy and, in particular, advanced methods of nuclear magnetic resonance spectroscopy for determining the structure of organic compounds.

Introduction to group theory. Applications of group theory to spectroscopy.

**Chemistry of the Main Group Elements** **CHEM 3105**

Structure and bonding of the main group elements and their compounds. Bonding in ionic solids, metals, semiconductors and insulators with reference to the Born-Haber cycle, Born-Landé and band theory. An introduction to X-ray methods and heterogeneous catalysis will follow. Chemical applications of Group Theory. Structure and bonding in transition metal elements, term symbols and energy states.

**Stereochemistry and Mechanism in Organic Chemistry** **CHEM 3107**

Properties and analysis of stereoisomers. Stereoselectivity in organic reactions. Comparative discussion of the structure, preparation and reactivity of alicyclic compounds. Aspects of organic reaction mechanisms.

**Quantum Mechanics and Molecular Spectroscopy** **CHEM 3113**

*Quantum Mechanics*. Failures of classical mechanics, particle-wave duality. Uncertainty principle, particle in a box, tunnelling. Harmonic oscillator and vibraional motion. Angular momentum and rotational motion. Pauli principle. Born-Oppenheimer approximation.

*Molecular Spectroscopy*. Electromagnetic radiation, the interactions between electromagnetic radiation and atoms and molecules. Rotational spectra, rigid and non-rigid rotors, rotational spectra of molecules. Vibrational spectra, harmonic and anharmonic oscillators, vibrational-roational spectra of molecules. Electronic spectra, atomic and molecular absorption and emission spectra, vibrational-electronic spectra, Franck-Condon principle.

**Electrochemistry and Colloid and Surface Chemistry** **CHEM 3114**

*Electrochemistry*. Pontentiometry (zero-current electrochemistry), channelling spontaneous chemical reactions through electrochemical cells, chemically reversible electrodes, electromotive force (EMF), free energy, electrode changes, electrodes potentials, standard states, the standard hydrogen electrode (SHE) as arbitrary reference point, the Electrochemical Series concentration dependence of the EMF, the Nernst equation, sample calculations. Batteries.

*Colloid and Surface Chemistry*. Dispersions, emulsions, gels, solutions of polymers and bipolymers, surfactants. Interfaces and surface tension. Colloidal interaction. Brownian motion. Stability and self-organisation of colloid systems. Monomolecular films. Applications in biotechnology, food, pharmaceutical and other industries.

**Thermodynamics and Reaction Kinetics** **CHEM 3115**

*Thermodynamics*. Partial molar quantities, chemical potential, the Gibbs-Duhem relationshipo, ideal and real solutions, activity and the activity coefficient. Gibbs phase rule, liquid-vapour equilibrium and phase diagrams.

*Reaction Kinetics*. Consecutive, parallel and opposing reactions. Steady state assumption and numerical integration. Linear and branched chain reactions, explosion limits. Photophysical and photochemical processes. Diffusion controlled reactions, reactions involving ions, solvent effects.

## Additional Units

**Chemistry of Materials** **CHEM 3109**

The Preparation and Properties of polymers. Characterization and applications of polymers. The chemistry of new functional materials. Nanostructored materials with emphasise on their use in electronics and drug delivery technology.

**Chemistry of Biomolecules** **CHEM 3110**

Structure, preparation and chemical reactivity of biomolecules, including carbohydrates, amino acids, peptides and bioinorganic compounds. Biopolymers and their chemical interactions with small molecules, including mechanisms of drug-target interaction. Drug discovery and development.

**Instrumental Analysis** **CHEM 3112**

This course introduces how spectroscopy and chromatography are used together for chemical analysis. Main topics include high performance liquid chromatography (HPLC), the major technique in pharmaceutical analysis and nuclear magnetic resonance (NMR) spectroscopy. The course will assist students in how to interpret data and assess its quality.

**Optional Units**

**Mathematical Techniques** **MATH 3202**

Functions of one and several variables. Partial derivatives and differential equations. Elgenvactors and elgen values. Applications to chemistry. ***This course is not available to students who have taken Second Year Mathematics.***

**Process Engineering** **CHEN 3025**

Introduction to industrial processes; description of typical processes, flow sheets, flow and batch systems, general concepts of unit operations, stoichiometry. Principles of analysis of distillation units and crystallisers and of chemical reactors.

## Computer Science

### Courses for General and Honours Degrees

Core units are marked with the letter **C.** Students must include the eight core units as stated and two of the optional units in agreement with the Head/Director of Programme.

Students are reminded that choice of Third Year options may constrain Fourth Year options available to them. Students must confirm their units with the Head/Director of Programme before registering them.

**Joint-Honours students and General students** are reminded that restrictions on the selection of course units apply and are available from the Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| COMP 3002 | Operating Systems | **C** |
| COMP 3006 | Program Design & Verification 1 | **C** |
| COMP 3007 | Formal Syntax | **C** |
| COMP 3011 | Object Oriented Programming | **C** |
| COMP 3013 | Software Engineering Project | **C** |
| COMP 3017 | Foundations of Computing | **C** |
| COMP 3019 | Principles of Programming Languages | **C** |
| COMP 3020 | Processor Design | **C** |

**Students choose two of the following optional units as recommended by the Head/Director of Programme:**

| | |
|---|---|
| COMP 3005 | Information Systems I |
| COMP 3008 | Computer Networks |
| COMP 3009 | Introduction to Artificial Intelligence |
| COMP 3021 | Introductory Computer Graphics |
| MATH 3207 | Graph Theory |
| STAT 3224 | Statistics and Visualization |

### Description of Computer Science Units

**Operating Systems** **COMP 3002**

Introduction to OSs, OS Structure, Hardware features and OSs. Processes: Independent and Co-operative processes, Sychronisation Mechanisms, Deadlocks and Starvation. Memory Management: Binding and Relocation, Memory Organisations (fixed and variable partitions), Paging Technique, Segmentation Technique, Virtual Memory. File Management: File System structures, Files, Directories, File System Implementation. Introduction to Security and Protection: Basic Issues, Security Problem, Authentication, Encryption, Protection Problem, Trusted Systems. Case Studies: Unix, Win NT.

**Program Design & Verification 1** **COMP 3006**
Propositional and predicate calculus; theorem proving; the correctness of programs; WP-calculus; derivation of loop programs; efficiency considerations; strengthening invariants.

**Formal Syntax** **COMP 3007**
Formal languages and their descriptions; grammars; Chomsky hierarchy; regular language; finite state automata; context free grammars; push-down automata; top-down/bottom-up parsing.

**Object Oriented Programming** **COMP 3011**
Fundamental object-oriented concepts: classes, objects, messages, encapsulation, inheritance, polymorphism, dynamic binding; elementary object-oriented design; practical programming in an object-oriented language, e.g. C++.

**Software Engineering Project** **COMP 3013**
A group project in software engineering building a complete system based on the application of analysis, design and implementation techniques.

**Foundations of Computing** **COMP 3017**
Mathematical notation and terminology; finite automata and regular languages; definitions and properties, regular expressions; universal models and computability theory; Turing machines, primitive recursive functions; complexity of algorithms: efficiency of algorithms, complexity classes, complexity analysis in practice.

**Principles of Programming Languages** **COMP 3019**
This course introduces the principles underlying programming languages, with an emphasis on how these ideas relate to practical software engineering challenges. Specific topics covered include variable scooping, static and dynamic type checking, imperative programming, functional programming, and logic programming.

**Processor Design** **COMP 3020**
*Hardware/software co-design; instruction set architecture design; assembly language; instruction set simulation; processor components; Verilog; RISC, CISC, and VLIW architectures; FPGA, ASIC.*

**Optional Units**

**Information Systems I** **COMP 3005**
Kinds of information system; DBMS: concepts; 3-level architecture; entity-relationship model; network model and CODASYL; relational model; SQL; database design; normalisation. Information retrieval: classification (heuristic – automatic classification) – graph-theoretic – cluster-based retrieval – user models.
*(Not available to students who have taken 2006.)*

**Computer Networks** **COMP 3008**

Network types, functions, topologies, transmission, switching, routing, management, reference models, architectures, protocols and standards; network user applications; flow and congestion control strategies; design and implementation considerations.

*(Prerequisite for COMP 4014.)*

**Introduction to Artificial Intelligence** **COMP 3009**

Intelligent problem solving, knowledge representation, search algorithms, learning, planning, intelligent re-use and experience-based reasoning, applications of AI. *(Prerequisite for COMP 4017, COMP 4018, COMP 4019, COMP 4030.)*

**Introductory Computer Graphics** **COMP 3021**

Physics and biology of vision; mathematical foundations of computer graphics; geometric modelling of the world; geometric transformation; perspective and orthographic projections; models of computer rendering; surface modelling; animation; lighting; colour and textures; clipping, culling and compositing; performance optimisation; modelling natural phenomena. The practical component will involve hands-on experience with a modern graphics library such as OpenGL.

*Prerequisite: MATH 2202 (linear algebra) or consent of the lecturer.*

## Computer Science (Denominated Entry)

Denominated entry students are required to take eight core units plus two additional Computer Science units. Details of these units are available from the Head/Director of Programme.

## Environmental Biology

The Third Year Environmental Biology programme comprises ten course units. Eight core units (four from Botany and/or Industrial Microbiology and/or Zoology) are combined with two optional units from the Science programme. Core units are marked with the letter **C**. Selection of core units depends on the student's Second Year subject combination. Selection of all units, both core and optional, must be agreed by the Programme Directors.

Details of the course units are available under the subject listings for Botany, Industrial Microbiology and Zoology.

### Core Units in Environmental Biology (eight in total to be chosen from two of the subjects)

**Botany core course units**[*]:

| | | |
|---|---|---|
| BOTN 3001 | Diversity and Ecology of Fungi | **C** |
| BOTN 3003 | Plant/Soil Interactions in Wetlands | **C** |
| BOTN 3004 | Plant Growth and Nutrient Assimilation | **C** |
| BOTN 3007 | Vegetation Ecology and Biogeography | **C** |

**AND/OR Industrial Microbiology[¥] core course units:**

| | | |
|---|---|---|
| INDM 3001 | Bacteriology and Mycology | **C** |
| INDM 3002 | Microbial Growth, Biochemistry and Physiology | **C** |
| INDM 3004 | Environmental Microbiology | **C** |
| INDM 3007 | Gene Expression and Regulation | **C** |

**AND/OR Zoology core course units:**

| | | |
|---|---|---|
| ZOOL 3011 | Arthropoda | **C** |
| ZOOL 3014 | Systems Ecology | **C** |
| ZOOL 3016 | Diversity of Vertebrates | **C** |
| ZOOL 3017 | Fisheries and Wildlife Management | **C** |

[*] Students taking Botany as part of their core course must attend the Burren Field Course (BOTN 4021) after the Summer Examination in their Third Year.

[¥] Students taking Botany and Industrial Microbiology as their core courses should discuss the choice of units with the Programme Director.

**Students choose two optional units as recommended by the Programme Director:**

| | | |
|---|---|---|
| STAT 3221 | Biostatistics | ** |
| BOTN 3002 | Plant Population Biology | |
| INDM 3003 | Industrial Microbiology | |
| INDM 3005 | Healthcare Microbiology | |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. | |
| ZOOL 3013 | Animal Behaviour | |
| ZOOL 3015 | Evolutionary Biology | |

## Environmental Geochemistry

Core units are marked with the letter **C.** Descriptions of the units may be obtained from the Third Year courses in Chemistry and Geology.

The Third Year Environmental Geochemistry programme comprises ten units. Eight core units (three from Chemistry and five from Geology) are combined with two optional units from the Science programme to be decided in consultation with the Programme Director.

Students please note that the optional units are for guidelines only. Should a student wish to take an alternative unit, they should contact the Head/Director of Programme directly. Please note that in certain instances prerequisites apply for certain units. Check the individual Schools for details.

**Core Units:**

| | | |
|---|---|---|
| CHEM 3101 | Transition Metal and Organometallic Chemistry | **C** |
| CHEM 3105 | Chemistry of the Main Group Elements | **C** |
| CHEM 3108 | Environmental Chemistry | **C** |
| GEOL 3002 | Phanerozoic Stratigraphy | **C** |
| GEOL 3003 | Precambrian and Geotectonics | **C** |
| GEOL 3004 | Applied Geology | **C** |
| GEOL 3005 | Geochemistry | **C** |
| GEOL 3013 | Applied Geochemistry | **C** |

**Students choose two optional units as recommended by the Head/Director of Programme:**

| | |
|---|---|
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |
| GEOL 3014 | Palaeobiology |
| GEOL 3007 | Structural, Petroleum Geology |

** All students take STAT 3221, Biostatistics

**Description of Geochemistry Unit**

**Applied Geochemistry** **GEOL 3013**

Geochemistry of groundwaters, rivers, lakes, estuaries, coasts and the marine environment. Kinetics of mineral-water interactions. Role of particulates, colloids, sorption, desorption, ligand interactions in the hydrosphere. Eh-pH diagrams. Role of organics and organometallic compounds. Bioavailability. Mechanisms and timescales of pollutant recycling and dispersal.

The Third Year course involves geological field classes.

## Experimental Physics

**Courses for General and Honours Degrees**

**Third Year Honours and Single Subject General Degree** are required to take modules EXPH 3006 to EXPH 3009 and EXPH 3011 to EXPH 3013, but can choose between either EXPH 3005 or EXPH 3010, unless advised otherwise by the Head/Director of Programme. They may also choose EXPH 3017 in place of an optional unit in consultation with the Head/Director of Programme.

### Advanced Laboratory I

Students are required to complete an appropriate number of mini practical projects. These projects are designed to provide an opportunity to explore a range of areas of physics independently in a supportive environment. In addition to laboratory projects, students will generally undertake a computational and an electronics project. Students will also be required to present a short seminar on some aspect of physics of their choice.

Students taking Experimental Physics units as additional (non-major) units will be required to complete one mini project for each Experimental Physics unit undertaken.

**Core Units:**

| | | |
|---|---|---|
| EXPH 3006 | Thermodynamics and Statistical Physics | **C** |
| EXPH 3007 | Solid State Physics | **C** |
| EXPH 3008 | Electromagnetism | **C** |
| EXPH 3009 | Optics | **C** |
| EXPH 3011 | Classical Mechanics and Special Relativity | **C** |
| EXPH 3012 | Nuclear Physics | **C** |
| EXPH 3013 | Quantum Mechanics | **C** |

**Students choose one of the following units:**

| | |
|---|---|
| EXPH 3005 | Instrument Science |
| EXPH 3010 | Electronics |

**Optional units:**

| | |
|---|---|
| EXPH 3017 | Space and Planetary Science |

**Students may choose EXPH 3017 from the above optional units plus one unit from the following:**

| | |
|---|---|
| MATH 3201 | Complex Analysis |
| MATH 3203 | Advanced Calculus |
| MATH 3204 | Groups and Vector Spaces |
| MAPH 3071 | Numerical Methods |
| MAPH 3111 | Methods B |
| MAPH 3120 | Methods C |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |

If they do no choose EXPH 3017 they may select either two units from the above list or one of the above and one of the units LANG 3002-3006. Their selection must always include one Mathematics or Mathematical Physics unit.

### Third Year Joint Honours Degree Programme

Students must take five units from Experimental Physics EXPH 3005-3013 and five units from the other subject. Students should note that admission to Joint Honours Programmes is contingent on approval from both Heads/Directors of Programmes.

| | |
|---|---|
| EXPH 3005 | Instrument Science |
| EXPH 3006 | Thermodynamics and Statistical Physics |
| EXPH 3007 | Solid State Physics |
| EXPH 3008 | Electromagnetism |
| EXPH 3009 | Optics |
| EXPH 3010 | Electronics |
| EXPH 3011 | Classical Mechanics and Special Relativity |
| EXPH 3012 | Nuclear Physics |
| EXPH 3013 | Quantum Mechanics |
| Students also choose five units from the second subject as agreed by both Schools. | |

## Description of Experimental Physics Units

### Instrument Science — EXPH 3005

Introduction to measurement systems. Instrument definition, static and dynamic characteristics. Zero, first and second order instrument systems. Deterministic and random noise. Noise reduction and signal processing techniques. Digital-to-analogue and analogue-to-digital conversion. Sensor conversion processes. Mechanical, electrical, electronic, optical and opto-electronic transducers. Thermoelectric and piezo-electric systems.

### Thermodynamics and Statistical Physics — EXPH 3006

Temperature. First law of thermodynamics. Work and energy. Second law. Carnot cycle. International temperature scale. Entropy. Maxwell relationships. Applications of

thermodynamics. Phase changes. Thermal radiation. Introduction to statistical physics. Maxwell-Boltzmann statistics and applications. Fermi-Dirac statistics. Bose-Einstein statistics. Planck's Law. B-E condensation. Properties of liquid helium.

**Solid State Physics** **EXPH 3007**

Binding forces in crystals. Lattice dynamics – vibrational modes. Acoustic and optical branches, phonons. Lattice specific heats – Einstein and Debye models. Classical free electron gas; quantum effects; Fermi energy; pressure of an electron gas; specific heat of a degenerative electron gas. Periodic lattices; Bloch functions; Kronig-Penney model – band structures. Paramagnetism.

**Electromagnetism** **EXPH 3008**

Vector and scalar fields. The vectors **E,D,B,H,M** and **P.** Maxwell's equations. Lorentz gauge. Electromagnetic waves. The scalar and vector potentials. Field-defining equations. Energy transport. Wave propagation in dielectrics and metals. Dispersion. Plasma frequency. Refractive index of plasmas and metals. Transmission lines. Resonant cavities. Waveguides.

**Optics** **EXPH 3009**

Geometrical optics – thin lenses, aperture and field stops, thick lenses, aberrations, optical instruments. Matrix optics, Fourier theory and Fraunhofer diffraction. Fresnel diffraction. Coherence. Convolution and correlation. Optical processing and imaging. Holography. Interferometers.

*Prerequisite: EXPH 2001.*

**Electronics** **EXPH 3010**

An introduction to analogue electronics with emphasis on operational amplifiers and their applications to analogue signal processing. Topics covered include negative feedback, analogue computation, linear and non-linear circuits. An introduction to digital electronics is also presented with emphasis on the TTL logic family, in particular, gates, monostables, counters and applications. The influence of noise in electronic circuits is also discussed.

**Classical Mechanics and Special Relativity** **EXPH 3011**

Classical mechanics – Variational principles and Lagrange's equations. The central force problem. Hamilton's equations. Special relativity – classical background. Michelson-Morley experiment. Einstein's postulates. Lorentz transformation equations experimental confirmation. Geometrical representation. Four vectors and relativistic invariance. Energy-momentum transformation equations. Relativistic momentum energy relationship. The transformation of force.

*Prerequisite: EXPH 2003*

**Nuclear Physics** **EXPH 3012**

Introduction and basic concepts. Natural and artificial radioactivity. Interaction of radiation with matter. Alpha decay. Beta decay and the electron neutrino. Parity and its non-conservation. Gamma decay. Internal conversion. $\Upsilon - \Upsilon$ correlation. Liquid drop model of the nucleus. Spontaneous and induced fission. Fission reactors. Neutron activation analysis. Nuclear reactions.

**Quantum Mechanics** **EXPH 3013**

Postulates of Quantum Mechanics. Operators, observables and eigenfunctions. Co-ordinate and momentum representations. Hermitian operators. Matrix methods. Uncertainty Principle. Ehrenfest's theorem. Harmonic oscillator. Ladder operators. Angular momentum. Schrödinger theory of the hydrogen atom. Degeneracy. Fine structure. Normal Zeeman effect. Pauli theory of electron spin. Stern-Gerlach experiment. Spin-orbit interaction. Total angular momentum. Clebsch-Gordan coefficients.

**Space and Planetary Science** **EXPH 3017**

Introduction to the solar system and its constituents: the Sun; the planets and their moons; comets; asteroids; meteorites and dust. The Oort cloud and the Kuiper belt. Impacts. The formation, evolution and dynamics of the solar system. The solar wind and aurorae. Coronal mass ejections. Space weather. Solar system exploration missions of NASA and ESA. Extrasolar planets. Spectroscopic and photometric planetary detection techniques. Exobiology.

**The Formation and Evolution of Stars** **MAPH 3232**

The origin of the light elements. Viral Theorem. Binary systems and classification. Stellar spectroscopy. The Hertzsprung-Russell diagram. The modelling of stellar interiors. Stellar formation, evolution and death. White Dwarfs, neutron stars and pulsars. Supernovae.

## Genetics

Students seeking admission to the Joint Honours Degree in Genetics and a Biological Subject, select one of the following biological subjects: Biochemistry, Botany, Pharmacology and Zoology. They must: -

- Have followed a Second Science programme including at least two biological subjects, one of which must be Biochemistry or Industrial Microbiology or Zoology.
- Pass the Second Science Examination, obtaining the qualifying standard for admission to the Honours course in their chosen biological subject.

## Courses for General and Honours Degrees

Students are required to take the five course units listed below. In addition to five units taken in the Biological Subject.

**Core Units:**

| | | |
|---|---|---|
| GENE 3001 | Genetics | **C** |
| GENE 3002 | Genome Structure | **C** |
| GENE 3003 | Gene Expression | **C** |
| BIOC 3004 | Gene Manipulation, Regulation and Evolution | **C** |
| BIOC 3009 | Bioinformatics and Proteomics | **C** |

### Genetics — GENE 3001

Mendelian Genetics: comprehensive treatment of basic concepts; genetic crosses; continuous variation; partial and co-dominances; gene interactions; linkage and chromosome mapping.

Molecular Genetics: DNA structure; transcription; chromatin structure. Recombinant DNA technology: restriction enzymes; DNA cloning; sequence analysis; PCR.

Applied Molecular Genetics: Map based cloning. Tools for genetic analysis; mini-satellites; RFLPs. Genetic analysis of human diseases: cystic fibrosis.

### Genome Structure — GENE 3002

Gene 3002 outlines the structure of the Eukaryotic genome with an emphasis on the dynamic nature of the evolving genome. The unit covers topics in gene splicing, C-value and multigene family paradoxes, repetitive elements, and examples of programmed genetics variation such as the mechanism underpinning antibody diversity.

### Gene Expression — GENE 3003

Regulation of gene expression: transcription, termination, anti-termination, attenuation, translational feedback control, antisense RNA. Bacteriophage lambda as a model system. Regulation of gene expression in eukaryotes: basal transcription complex; enhancers, signal chain transduction in plants. Genomic imprinting. Mechanisms of recombination: gene conversion, transposition, retroposons and retroviruses. Homologous recombination, its use in transgenesis.

### Gene Manipulation & Regulation — BIOC 3004

For details of unit see under Biochemistry.

### Bioinformatics and Proteomics — BIOC 3009

For details of unit see under Biochemistry.

# Geology

## Courses for General and Honours Degrees

**Third Year Honours and Single Subject General Degree** students in Geology take GEOL 3002 to 3014 inclusive. Core units are marked with the letter **C.**

Field work is an integral part of the Geology syllabus. See page 104 (Field Work in Geology) for details of Third Year field programmes.

Students please note that the optional units are for guidelines only. Should a student wish to take an alternative unit, they should contact the School directly. Please note that in certain instances prerequisites apply for certain units. Details are available from the Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| GEOL 3002 | Phanerozoic Stratigraphy | **C** |
| GEOL 3003 | Precambrian and Geotectonics | **C** |
| GEOL 3004 | Applied Geology | **C** |
| GEOL 3005 | Geochemistry | **C** |
| GEOL 3006 | Sedimentology and Volcanology | **C** |
| GEOL 3007 | Structural, Petroleum Geology | **C** |
| GEOL 3008 | Igneous, Metamorphic Petrology | **C** |
| GEOL 3009 | Applied Geophysics | **C** |
| GEOL 3014 | Palaeobiology | **C** |

**Students choose one of the following optional units as recommended by the Head/Director of Programme**

| | |
|---|---|
| GEOL 3010 | Seismology, Global Geophysics |
| GEOL 3013 | Applied Geochemistry |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |
| ZOOL 3014 | Systems Ecology |

### Third Year Two-Subject General Degree Programme

Third Year Two-Subject General Degree students will normally take GEOL 3001 to 3004 inclusive. Core units are marked with the letter **C.** Students will be required to take a minimum of four units shown below, plus four units (minimum) in the second subject (ten units in total). Students note that a Two-Subject General Programme may only be taken with the permission of the two subjects.

**Core Units:**

| | | |
|---|---|---|
| GEOL 3002 | Phanerozoic Stratigraphy | **C** |
| GEOL 3003 | Precambrian and Geotectonics | **C** |
| GEOL 3004 | Applied Geology | **C** |
| GEOL 3014 | Palaeobiology | **C** |

## Description of Geology Units

**Phanerozoic Stratigraphy** **GEOL 3002**

Stratigraphic principles. Study of Cambrian to Recent stratigraphy of Britain and Ireland, using the concept of orogenic cycles and plate tectonic models. Pleistocene stratigraphy and climate. Practical work includes geological survey map sheets.

*Prerequisite: Second Science Geology*

**Precambrian and Geotectonics** **GEOL 3003**

Introduction to radiogenic isotope systems and geochronology. Precambrian time subdivisions. Precambrian geological evolution of Canada, Scandinavia, Britain and Ireland. The Dalradian Supergroup. Seafloor spreading. Plate motion studies: Magnetic, seismic and geological methods. Rifts. Destructive plate margins. Accretionary prisms. Orogenic belts: Caledonian, Variscan (Hercynian), Alpine-Himalayan. Practical work on geological survey maps.

*Prerequisite: Second Science Geology*

**Applied Geology** **GEOL 3004**

Hydrogeology – aquifers and groundwater chemistry. Occurrence, mode of formation of metallic ore and industrial mineral deposits. Ore petrography and petrology. Geochemical techniques for mineral exploration. Coal Geology. Remote sensing. Engineering Geology.

*Prerequisite: Second Science Geology*

**Geochemistry** **GEOL 3005**

Radiogenic and stable isotope geochemistry. Geochronology. Analytical methods. Use of geochemical variation diagrams in crystal-liquid systems. Meteorites and the composition of the solar system; composition and chemical evolution of the Earth and Moon. Element partitioning between crystals and melts; partial melting and fractional crystallization. Diffusion. Chemical weathering, sediment geochemistry and provenance. Use of stable isotopes.

*Prerequisite: Second Science Geology*

**Sedimentology and Volcanology** **GEOL 3006**

Principals of facies and sequence analysis. Earth surface processes. Depositional models. Sedimentary structures and deposits of the main continental, paralic and marine environments. Palaeocurrents and provenance. Volcano eruption mechanisms, pryoclastic and epiclastic deposition. Stratigraphic and plate tectonic context of volcanic and volcaniclastic rocks. Volcanic hazards.

*Prerequisite: Second Science Geology*

**Structural, Petroleum Geology** **GEOL 3007**

Coaxial and non-coaxial deformation and the brittle and ductile structures produced. Volume change and slaty cleavage. Transpression and transtension. Recognition of shear sense and kinematic indicators. Multiple deformation. Shallow and deep crustal structure. Basin development and analyses. Seismic reflection profiling and seismic stratigraphy. Origin, migration and accumulation of hydrocarbons. Oil exploration.

*Prerequisite: Second Science Geology*

**Igneous, Metamorphic Petrology** **GEOL 3008**

Classification of igneous rocks. Petrogenesis of mid-ocean ridge, subduction-related, intraplate, rift-related, potassic, ultrapotassic and granitic rocks. Magmatic processes in layered basic intrusions, ophiolites and Alpine peridotites. Geothermobarometry, equilibrium thermodynamics and Schreinemakers' method. Metamorphic reactions, isograds and metamorphic zonal schemes for pelites. Scottish and Irish Dalradian. Blueschist and Granulite facies. Migmatites. Metamorphism of ultramafic rocks. PTt paths and tectonic setting of regional metamorphism.

*Prerequisite: Second Science Geology*

**Applied Geophysics** **GEOL 3009**

Gravity methods. Magnetic methods. Engineering and exploration seismology. Applied tomography. Electromagnetic exploration techniques. Electrical methods in exploration. Side scan sonar. Borehole methods. Ground penetrating radar. Survey design. Position fixing.

**Palaeobiology** **GEOL 3014**

Fossils as environmental indicators. Palaeocommunities and ecosystems. Trace fossils and ichnofabrics. Taphonomy. Exceptional faunas. Palaeoecology. Functional morphology and adaptation. Ancient reefs and bioconstructions. Evolution and the fossil record.

## Geophysical Science

The Third Year Geophysical Science programme comprises ten units. Eight core units (three from Experimental Physics and five from Geology) are combined with two optional units from the Science programme to be decided in consultation with the Programme Director.

Students please note that the optional units are for guidelines only. Should a student wish to take an alternative unit, they should contact the School directly. Please note that in certain instances prerequisites apply for certain units. Details are available from the Head of Subject.

**Core Units:**

| | | |
|---|---|---|
| EXPH 3005 | Instrument Science | **C** |
| EXPH 3008 | Electromagnetism | **C** |
| EXPH 3010 | Electronics | **C** |
| GEOL 3002 | Phanerozoic Stratigraphy | **C** |
| GEOL 3003 | Precambrian and Geotectonics | **C** |
| GEOL 3008 | Igneous, Metamorphic Petrology | **C** |
| GEOL 3009 | Applied Geophysics | **C** |

**and either**

| | |
|---|---|
| GEOL 3010 | Seismology, Global Geophysics |

**or**

| | |
|---|---|
| GEOL 4013 | Data Processing and the Crust |

**Students choose two of the following optional units as recommended by the Head/Director of Programme:**

| | |
|---|---|
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |
| GEOL 3007 | Structural, Petroleum Geology |
| GEOL 3014 | Palaeobiology |

### Description of Geophysics Units

**Seismology, Global Geophysics** **GEOL 3010**

Material flow properties, strain rate and viscosity. Time and temperature effects on rheology. Earthquake location, quantification, source mechanisms. Models for earthquake genesis. Friction. Fracturing, failure, brittle-ductile transitions. Seismic cycle, earthquake prediction. Seismotectonics. Seismic radiation and deep structure. Wave attenuation. Tomography. Long period oscillations of the Earth.

*Prerequisite: Second Science Geology and Experimental Physics*

The Third Year courses involve both geological and geophysical field classes.

# Industrial Microbiology

## Courses for General and Honours Degrees

***Prerequisite for all units: INDM 2001 to INDM 2004 inclusive.***

Students not taking Industrial Microbiology as a full subject but wishing to select optional units from the Industrial Microbiology programme must have the approval of the Head of Subject.

**Core Units:**

| | | |
|---|---|---|
| INDM 3001 | Bacteriology and Mycology | **C** |
| INDM 3002 | Microbial Growth, Biochemistry and Physiology | **C** |
| INDM 3003 | Industrial Microbiology | **C** |
| INDM 3004 | Environmental Microbiology | **C** |
| INDM 3005 | Healthcare Microbiology | **C** |
| INDM 3006 | Medical Microbiology | **C** |
| INDM 3007 | Gene Expression and Regulation | **C** |
| INDM 3008 | Applied Microbial Enzymology | **C** |
| INDM 3011 | Special Topics | **C** |
| STAT 3221 | Biostatistics | **C** |

## Description of Industrial Microbiology Units

**Bacteriology and Mycology** **INDM 3001**

Structure-function relationships within the prokaryotic cell. Methods of studying cell structure and function. The contribution of organelles to bacterial activities. Fungal nutritive modes. Fungi as agents of decay and disease in plants and animals. Bacteria and fungi as producers of secondary metabolites.

**Microbial Growth, Biochemistry and Physiology** **INDM 3002**

Biosynthesis of amino acids and nucleotides. Metabolic pathways and molecular biotechnology. Industrial production of amino acids. Principles of microbial growth and cultivation. Fermentation systems – development and application of batch, fed-batch and continuous culture techniques. Environmental factors influencing microbial growth.

**Industrial Microbiology** **INDM 3003**

Principles of biotechnological processing: Bioreactor design, process analysis and models. Case studies from the brewing and fermentation industries. Food Microbiology: Microbial sources of contamination. Food spoilage and factors influencing it. Traditional and alternative methods of preservation.

**Environmental Microbiology** **INDM 3004**

Ecology and environmental interactions of microorganisms in diverse ecosystems. An assessment of microbial activities within the soil, freshwater and marine environments.

Pollution of natural waters and the role of microorganisms in waste treatment. Microorganisms in extreme environments.

**Healthcare Microbiology** **INDM 3005**

Microbial spoilage. Prediction of product shelf-life. Antiseptics, disinfectants and preservatives. Principles and practice of sterilisation. Application of microorganisms in biotransformation/synthesis of pharmaceuticals. Quality function in the healthcare industry. Process monitoring and validation. Controlled environments, clean-air maintenance and standards. Antibiotics, activity spectra and mechanisms of anti-microbial action. Infectious drug resistance.

**Medical Microbiology** **INDM 3006**

Basic immunology and antigen/antibody reactions. Spread of infection and 'host-parasite' relationships. Bacteriology: Anaerobic infections, zoonoses, enterobacteria, bacterial chemotherapy and sterilisation. Virology: Introduction, morphology, replication and classification of DNA and RNA viruses. Enteroviruses, herpes-viruses, myxoviruses, tumour viruses, hepatitis and diagnostic virology.

**Gene Expression and Regulation** **INDM 3007**

Theory and practice of mutation. Principles and practice of gene manipulation. Industrial strain development. Gene expression in prokaryotes and eukaryotes. Overexpression of cloned genes.

**Applied Microbial Enzymology** **INDM 3008**

Enzymes as industrial catalysts. Enzyme development for large scale processes – screening, production, purification and applications. Kinetics and applied enzymology.

**Special Topics** **INDM 3011**

A wide range of topics covering the special interests of the staff in the subject area will be offered and students will be expected to undertake a literature survey on one of those topics and make written and oral presentations.

## Languages

The Applied Language Centre offers a number of courses, one of which may be selected as an optional unit by Third Science students. Students should consult with their Head/Director of Programme before signing up for a language course.

| | |
|---|---|
| LANG 3002 | Beginners Japanese for Science |
| LANG 3003 | Advanced French for Science (Post- Leaving Certificate) |
| LANG 3004 | Advanced German for Science (Post-Leaving Certificate) |
| LANG 3005 | Beginners Spanish for Science |
| LANG 3006 | Beginners Chinese for Science |

For Beginners courses, no previous knowledge of the language is needed. The following topics are covered: oral communication in everyday situations; introduction to scientific reading texts; basic grammatical structures; functional writing.

For Post-Leaving Certificate courses, students should note that Leaving Certificate or the equivalent standard is required. Courses cover the following topics: communicating in face-to-face professional situations; making oral presentations; skills in listening comprehension; functional writing skills, e.g. report-writing, correspondence, etc.

## Mathematical Physics

**Courses for General and Honours Degrees**

### Third Year Two-Subject General Degree Programme

A Single Subject General Degree Programme is not offered in Mathematical Physics. Instead, students take the Two-Subject General Degree Programme.

Students take a maximum of ten units. Core units are marked with the letter **C**. Students must take a minimum of four units: MAPH 3030, MAPH 3031, MAPH 3051, and either MAPH 3041 or MAPH 3071, along with the second subject, chosen in agreement with the Head/Director of Programme of each core area.

**Core Units:**

| | | |
|---|---|---|
| MAPH 3030 | Electrostatics/Quantum Mechanics | **C** |
| MAPH 3031 | Analytical and Quantum Mechanics | **C** |
| MAPH 3051 | Mechanics and Special Relativity | **C** |

**And one of the following units:**

| | |
|---|---|
| MAPH 3041 | Methods 3 |
| MAPH 3071 | Numerical Methods |
| Students also choose a second subject in agreement with the Head/Director of Programme of each core area. | |

### Third Year Single Honours Degree Programme

Core units are marked with the letter **C.** Students must include the eight core units as stated and two optional units, as recommended by the Head/Director of Programme. Details of the optional units may be obtained from the two core areas in this booklet or the Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| MAPH 3111 | Methods B | **C** |
| MAPH 3120 | Methods C | **C** |
| MAPH 3130 | Thermal and Statistical Physics | **C** |
| MAPH 3141 | Potential Theory | **C** |
| MAPH 3151 | Electromagnetic Theory | **C** |
| MAPH 3161 | Quantum Mechanics | **C** |
| MAPH 3171 | Fluid Mechanics | **C** |
| MAPH 3180 | Dynamical Systems and Chaos | **C** |

| Plus two optional units in agreement with the Head/Director of Programme |
|---|

**Third Year Joint Honours Degree Programme**

Students take ten units, five from Mathematical Physics as stated and five from another subject in agreement with the two Heads/Directors of Programmes. Core units are marked with the letter **C.**

**Core Units:**

| | | |
|---|---|---|
| MAPH 3111 | Methods B | **C** |
| MAPH 3120 | Methods C | **C** |
| MAPH 3130 | Thermal and Statistical Physics | **C** |
| MAPH 3161 | Quantum Mechanics | **C** |
| MAPH 3171 | Fluid Mechanics | **C** |

Students should consult the School about prerequisites. Units MAPH 3081, MAPH 3091, MAPH 3211, MAPH 3220, and MAPH 3231 may not be offered every year. In certain circumstances, and only with the permission of the Head/Director of Programme, students may substitute MAPH 3232 for one of the listed core units.

## Description of Mathematical Physics Units

**Electrostatics/Quantum Mechanics** **MAPH 3030**

Electrostatics: Electrostatic potential; Gauss's law; Poisson's equation; dielectrics; electrostatic energy.

Quantum Mechanics: Postulates of quantum mechanics, uncertainty principle, one-dimensional systems including the harmonic oscillator, angular momentum, hydrogen atom, time evolution.

**Analytical and Quantum Mechanics** **MAPH 3031**

Analytical Mechanics: Lagrange's equation, variational principles. Small oscillations, normal modes. Hamilton's equations, canonical transformations, Poisson brackets.

Quantum Mechanics: Introduction, Postulates of Quantum Mechanics, One-dimensional examples: Potential well and harmonic oscillator, the Heisenberg uncertainty principle, Quantum tunnelling.

**Methods 3** **MAPH 3041**

Partial Differential Equations of Physics: First order ordinary differential equations. Systems of first order linear and non-linear ordinary differential equations; critical points and stability. First order linear and non-linear partial differential equations and the method of characteristics. Classification of second order linear partial differential equations. Integral transforms.

**Mechanics and Special Relativity** **MAPH 3051**

Mechanics: Dynamics of rigid bodies, rotating earth, spinning top, moments of inertia, principal axes, Euler's equations of motion.

Special Relativity: Inertial frames, Lorentz transformations, space-time, tensors, relativistic mechanics, energy-momentum conservation.

**Numerical Methods** **MAPH 3071**

Solution of equations by iteration. Numerical integration and differentiation. Numerical methods for differential equations. Systems of linear equations. Gauss elimination.

**Computational Physics** **MAPH 3081**

Ordinary differential equations; initial value (satellite motion and chaotic systems) and boundary value problems (energy eigenvalues of Schrödinger's equation). Partial differential equations; finite differences and finite elements (wave motion, heat transfer equation, Schrödinger's equation and Poisson's equation). Monte Carlo methods; kinetic theory of gases and the Ising model for ferromagnetism.

**Mathematical Modelling** **MAPH 3091**

Methods of Mathematical Modelling: Non-dimensionalisation, asymptotics, perturbation methods.

Mathematical Models: Diffusion models, viscous fluid flow, solid mechanics, electromagnetic wave propagation.

**Methods B** **MAPH 3111**

Complex Variables: Cauchy-Riemann equations, singular points. Complex integration (Cauchy's theorem, line integrals). Taylor and Laurent series. The Residue Theorem.

Euclidean Spaces: Convergence, Bessel's inequality, Parseval's equality. Fourier series (Piecewise continuous functions, Riemann-Lebesgue lemma, Weierstrass approximation theorem, Pointwise convergence). Orthogonal series of polynomials (Legendre polynomials, Hermite polynomials, Laguerre polynomials, Bessel functions).

**Methods C** **MAPH 3120**

First order partial differential equations. Second order linear partial differential equations – classification, uniqueness, stability. The wave equation, diffusion equation and Laplace's equation. Separation of variables, Laplace and Fourier transforms. Green's functions. Perturbation methods.

**Thermal & Statistical Physics** **MAPH 3130**

Thermodynamics: Laws of thermodynamics, temperature, entropy, Clausius's theorem, Maxwell's relations.

Kinetic Theory: Maxwell's distribution, the Boltzmann equation, Maxwell-Boltzmann distribution.

Introduction to Statistical Mechanics: The microcanonical, canonical and grandcanonical ensembles, the classical ideal gas, quantum statistical mechanics, the ideal Fermi and Bose gases, the imperfect Fermi gas.

**Potential Theory** * **MAPH 3141**

Electrostatics: electrostatic potential; Gauss's law; Poisson's equation; dielectrics; electrostatic energy. Magnetic fields due to steady currents: vector potential; Ampère's circuital law; magnetic materials.

**Electromagnetic Theory** * **MAPH 3151**

Maxwell's equations. Energy and momentum: Poynting vector. Plane waves in non-conducting and conducting media. Wave guides. Radiation from bounded sources. Liénard-Wiechert potentials. Relativistic formulation of electro-magnetic theory.

**Quantum Mechanics** **MAPH 3161**

Hilbert spaces, Hermitian and unitary operators, observables, spectral measures. Postulates of quantum mechanics, uncertainty principle, harmonic oscillator, creation and annihilation operators, angular momentum, hydrogen atom. One-dimensional potential wells, potential barriers, tunnelling. Elements of time-independent perturbation theory, WKB approximation. Time evolution in Schrödinger picture and Heisenberg picture.

**Fluid Mechanics** **MAPH 3171**

Representation of fluid flow, elementary physical considerations, Stokes' analysis, velocity potential for irrotational flows, stream functions for incompressible flows, Navier Stokes' equations, inviscid flow equations, motion of a sphere through an incompressible fluid, 2D incompressible flows, conformal transformations, sound waves, water waves.

**Dynamical Systems and Chaos** **MAPH 3180**

Phase portraits, flows and evolution

*Linear systems*: Classification of linear systems, phase portraits of linear systems.

*Non-linear systems in the plane*: Local and global behaviour, fixed points, linearization, stability of fixed points, limit points and limit cycles, Poincaré-Bendixson theory.

*Non-linear systems in higher dimensions*: Hyperbolic and non-hyperbolic fixed points, closed orbits, attracting sets and attractors.

*Chaotic orbits*.

**General Relativity & Cosmology** **MAPH 3211**

This course is an introduction to General Relativity and Cosmology:

Tensor calculus. Einstein's field equations. Static and stationary black holes. Energy extraction from rotating black holes. Cosmological models.

**Electromagnetic Theory (Minor)** **MAPH 3220**

Electrostatics. Magnetostatics. Maxwell's equations. Plane electromagnetic waves. Scalar and vector potentials, radiation. Relativistic formulation of electromagnetic theory.

* Units MAPH 3141 and MAPH 3151 must be taken together.

**Gauge Field Theory** **MAPH 3231**

This course is an introduction to Gauge Field Theory:

Introduction to Lie groups and Lie algebras. Yang-Mills field equations. Magnetic monopole and instanton solution. Gauge theory of the standard model of Electro-Weak interactions.

**The Formation and Evolution of Stars** **MAPH 3232**

The origin of the light elements. Virial Theorem. Binary systems and classification. Stellar spectroscopy. The Hertzsprung-Russell diagram. The modelling of stellar interiors. Stellar formation, evolution and death. White Dwarfs, neutron stars and pulsars. Supernovae.

## Mathematical Science

Students take ten units with at least two units from each subject. The combination of courses must be approved by the Programme Director. Details on each unit may be found under the relevant subjects.

**Mathematics**

| | |
|---|---|
| MATH 3102 | Field Theory |
| MATH 3104 | Functions of One Complex Variable |
| MATH 3105 | Logic and Discrete Mathematics |
| MATH 3106 | Algorithms |
| MATH 3107 | History of Mathematics |
| MATH 3109 | Advanced Linear Algebra |
| MATH 3110 | Metric Spaces |

**Mathematical Physics**

| | |
|---|---|
| MAPH 3120 | Methods C |
| MAPH 3130 | Thermal and Statistical Physics |
| MAPH 3141 | Potential Theory |
| MAPH 3151 | Electromagnetic Theory |
| MAPH 3161 | Quantum Mechanics |
| MAPH 3171 | Fluid Mechanics |
| MAPH 3180 | Dynamical Systems and Chaos |

**Statistics**

| | |
|---|---|
| STAT 3208 | Statistical Methods I |
| STAT 3209 | Statistical Methods II |
| STAT 3210 | Data Analysis and Statistical Software |
| STAT 3216 | Actuarial Statistics I |
| STAT 3217 | Actuarial Statistics II |
| STAT 3222 | Stochastic Processes I |

# Mathematics

**Courses for General and Honours Degrees**

### Third Year Two-Subject General Degree

A Single Subject General Degree Programme is not offered in Mathematics. Students take a Two-Subject General Degree following agreement with the School.

| | |
|---|---|
| MATH 3201 | Complex Analysis |
| MATH 3203 | Advanced Calculus |
| MATH 3204 | Groups and Vector Spaces |
| MATH 3205 | Combinatorial Mathematics |
| MATH 3207 | Graph Theory |
| MATH 3208 | Mathematical Logic |

### Third Year Single Honours

Students take a total of ten units, six core units, two additional Mathematics units and two optional units as recommended by the Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| MATH 3102 | Field Theory | **C** |
| MATH 3104 | Functions of One Complex Variable | **C** |
| MATH 3105 | Logic and Discrete Mathematics | **C** |
| MATH 3106 | Algorithms | **C** |
| MATH 3109 | Advanced Linear Algebra | **C** |
| MATH 3110 | Metric Spaces | **C** |

**Students choose two additional units from:**

| | |
|---|---|
| MATH 3107 | History of Mathematics |
| MATH 3203 | Advanced Calculus |
| MATH 3205 | Combinatorial Mathematics |
| MATH 3207 | Graph Theory |

**Students choose two optional units as recommended by the Head/Director of Programme:**

| | |
|---|---|
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |
| STAT 3205 | Statistical Theory I |
| STAT 3206 | Statistical Theory II |
| STAT 3207 | Statistical Theory III |
| STAT 3208 | Statistical Methodology I |
| STAT 3209 | Statistical Methodology II |
| MAPH 3041 | Methods 3 |
| MAPH 3071 | Numerical Methods |
| MAPH 3091 | Mathematical Modelling |
| MAPH 3111 | Methods B |
| MAPH 3120 | Methods C |
| COMP 3006 | Program Design & Verification |
| COMP 3007 | Formal Syntax |
| MATH 3107 | History of Mathematics |

### Third Year Joint Honours

Students take the following core courses. Students note that joint honours programmes must only be taken with the permission of both Heads/Directors of Programmes.

| | | |
|---|---|---|
| MATH 3102 | Field Theory | **C** |
| MATH 3104 | Functions of One Complex Variable | **C** |
| MATH 3105 | Logic and Discrete Mathematics | **C** |
| MATH 3109 | Advanced Linear Algebra | **C** |
| MATH 3110 | Metric Spaces | **C** |

## Description of Mathematics Units

### Complex Analysis — MATH 3201

Analytic functions. Cauchy's theorem and Cauchy's integral formula. Integrals and residues.

### Advanced Calculus — MATH 3203

Vector fields. Green's theorem. Stokes's theorem and the divergence theorem. Fourier and Laplace transforms with applications to differential equations.

### Groups and Vector Spaces — MATH 3204

Permutation groups, matrix groups and symmetry groups. General properties of groups. Representations of groups by matrices.

**Combinatorial Mathematics** **MATH 3205**
Congruences and finite fields. Error-detecting and error-correcting codes. Hamming codes, Huffman codes, RSA codes. Information and entropy. Shannon's first theorem.

**Graph Theory** **MATH 3207**
Trees. Paths and circuits in graphs. Planar and dual graphs. Graph-theoretic algorithms.

**Mathematical Logic** **MATH 3208**
Formal systems and rules of deduction. Consistency and completeness. First order languages. Godel-Henkin completeness theorem. Resolution in the propositional calculus.

**Special Topics** **MATH 3209**
Courses on special topics may be offered, depending on demand. Students may also be given permission to take part of an Honours course as a Special Topic.

**Honours Courses**

**Field Theory** **MATH 3102**
A review of ring theory. Construction of fields. Roots of polynomials. Finite fields. Galois theory.

**Functions of one complex variable** **MATH 3104**
Cauchy-Riemann equations, Cauchy's integral theorems, Taylor and Laurent expansions, identity theorem for analytic functions, residues, applications to evaluation of integrals and summation of series, maximum-modulus principle, Schwarz's lemma, principle of the argument.

**Logic and Discrete Mathematics** **MATH 3105**
Binary logic, predicates and quantifiers, axiomatic systems, consistency and completeness, axiomatic set theory, cardinality, axiom of choice.

**Algorithms** **MATH 3106**
Graph-theoretic algorithms. Greedy algorithms. Divide and conquer methods. Number-theoretic algorithms. Matrix problems and linear systems. Efficiency and complexity.

**History of Mathematics** **MATH 3107**
Mathematics of ancient civilizations. Number systems. Euclid and Archimedes. Development of algebra. Discovery of calculus. Geometric construction problems. Greek astronomy.

**Special Topics** **MATH 3108**

**Advanced Linear Algebra** **MATH 3109**
Endomorphism algebras, matrix algebras, characteristic and minimal polynomials, direct sums, canonical forms of matrices.

**Metric Spaces** **MATH 3110**
Euclidean spaces, metrics, normed linear spaces, convergence, continuity and uniform continuity, compactness, completeness, Banach fixed point theorem, connectedness, examples.

## Occupational Safety and Health
**(SCBDF0013)**

Students who pass Second Science in any combination of subjects, having taken Combination (a) in First Science, may apply for admission to this Degree course. These courses are only available to students taking the BSc in Occupational Safety and Health. Students take all ten courses.

Admission is granted by the Academic Director(s) and is subject to space and number restrictions.

### Description of Occupational Safety and Health Units

**Safety and Health Legislation** **SHWW 3001**
This unit provides an opportunity for understanding the important developments in legislation relating to safety and health in the workplace at both Irish and European Union levels.

**Occupational Hygiene** **SHWW 3004**
This unit is concerned with the recognition, evaluation and control of physical (e.g. noise) and chemical (e.g. gases) agents in the workplace. Basic monitoring equipment is demonstrated practically.

**Chemical Safety and Toxicology** **SHWW 3005**
Chemical actions and interactions in the human body and the toxic effects of major classes of toxicants are examined. The principles of chemical hazards and risk assessment are addressed and appropriate control and preventative strategies for toxic chemicals.

**Industrial Placement** **SHWW 3009**

**Projects** **SHWW 3010**
Teaching and assessment for the project unit formally introduces students to generic and transferable skills: information search and retrieval, professional and academic report writing; presentation skills; study skills and examination techniques.

**Health and Safety Management** **SHWW 3022**

This unit introduces students to the systematic management of occupational health and safety, including the development and implementation of effective systems to reduce the risk of injury and loss.

**Occupational Health** **SHWW 3023**

This unit addresses the effects of work on health and enables students to identify risks to health in the workplace, and to advise on methods to investigate the incidence and reduce the risk of ill health. Occupational disease prevention, surveillance and management are addressed.

**Human and Organisational Behaviour at Work** **SHWW 3026**

This unit examines human and organisational behaviour in relation to safety and health at work, and applies this knowledge to the improvement of the working environment and the promotion of safe work practices.

**Safety Technology** **SHWW 3027**

This unit examines aspects of safety technology to ensure the provision of a safe place of work and the development of safe systems of work, including developing and implementing emergency response systems in the workplace.

**Statistics in Health and Safety** **SHWW 3028**

An overview of the epidemiological approach to the monitoring of health and safety in the workplace is given. Data collection methods, the choice of appropriate study design, the interpretation and use of statistics and the role of computers in the research and information management process are examined.

# Pharmacology

## Courses for General and Honours Degrees

Third Year Honours and Single Subject General Degree programmes share the same core and optional units. Core units are marked with the letter C. Students must include the eight core units as stated and two of the optional units, as recommended by the Head/Director of Programme. Details of the optional units may be obtained from the relevant Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| PHAR 3001 | Chemotherapeutic Agents | **C** |
| PHAR 3002 | Neuropharmacology II | **C** |
| PHAR 3003 | Endocrine and Reproductive Pharmacology. Autocoids | **C** |
| PHAR 3004 | Toxicology | **C** |
| PHAR 3005 | Topics on Novel Aspects of Neuropharmacology | **C** |
| PHAR 3006 | Topics on Novel Aspects II | **C** |
| PHAR 3008 | Molecular Biological Analysis of Therapeutic Targets | **C** |
| STAT 3221 | Biostatics | **C** |
| Students choose two optional units as recommended by the Head/Director of Programme. | | |

**Third Year Two-Subject General Degree** students choose ten units in total. Core units are marked with the letter **C.** Students choose the four core units as shown and the remaining units as recommended by the Head/Director of Programme.

| | | |
|---|---|---|
| PHAR 3001 | Chemotherapeutic Agents | **C** |
| PHAR 3002 | Neuropharmacology II | **C** |
| PHAR 3003 | Endocrine and Reproductive Pharmacology. Autocoids | **C** |
| PHAR 3004 | Toxicology | **C** |

**Third Year Joint Honours Degree** students pick five units of Pharmacology from the Single Honours List shown above and five units from a second subject. Students note that Joint Honours Degree Programmes may only be chosen with the agreement of both Heads/Directors of Programmes.

## Description of Pharmacology Units

**Chemotherapeutic Agents** **PHAR 3001**

Introduction to microbial cell biology. Mechanism of action of antibacterial drugs. Antimicrobial therapy. Cytotoxic drugs and cancer treatments.

**Neuropharmacology II** **PHAR 3002**

Advanced pharmacology including structure activity relationships of drugs affecting peripheral and central nervous systems. Behavioural and psychopharmacology.

**Endocrine and Reproductive Pharmacology. Autocoids** **PHAR 3003**
Pharmacology of the endocrine and reproductive systems. Audocoids, local hormones, biogenic amines, prostaglandins, kinins, substance P.

**Toxicology** **PHAR 3004**
General principles, statistical evaluation, toxicity testing, routes of entry, metabolism, excretion, pollutants, pesticides, heavy metals, food additives. Mutagenesis, teratogenesis, carcinogenesis.

**Topics on Novel Aspects of Neuropharmacology** **PHAR 3005**
Topics covered with associated tutorials, practicals and reference lists include: neuronal development; ocular neuropharmacology; advanced CNS pharmacology.

**Topics on Novel Aspects II** **PHAR 3006**
Topics covered with associated tutorials and reference lists on novel aspects include: intracellular signalling (heterotrimeric G-proteins, tyrosine kinases and estrogen receptor action) and peptide Pharmacology.

**Molecular Biological Analysis of Therapeutic Targets** **PHAR 3008**
General structure and function of a group of membrane receptors and kinases; 3-D structural analysis of these proteins; primary structure of receptor proteins – functional and structural motifs; receptor encoding genes, structure and expression; cloning of receptor genes/gene families and bioinformatic and functional characterisation of the cloned genes; recombinant receptors as drug discovery tools; receptor and kinase gene polymorphisms and their analysis; natural receptor mutations and associated diseases; strategies for mutant receptor replacement by gene therapy; pharmacogenomics (selected topics).

# Physiology

## Courses for General and Honours Degrees

Third Year Honours and Single Subject General Degree share the same core units. Core units are marked with the letter C. Students must include the eight core units as stated and two of the optional units, as recommended by the Head/Director of Programme. Details of the optional units may be obtained from the relevant Heads/Directors of Programmes.

**Core Units:**

| | | |
|---|---|---|
| PHYS 3002 | Regulatory Mechanisms | **C** |
| PHYS 3004 | Digestion, Absorption, Excretion | **C** |
| PHYS 3005 | Neurophysiology I | **C** |
| PHYS 3007 | Neurophysiology II | **C** |
| PHYS 3009 | Physiological Measurement | **C** |
| PHYS 3011 | Circulation | **C** |
| PHYS 3012 | Respiratory Physiology | **C** |
| STAT 3221 | Biostatistics | **C** |
| Students choose two optional units as recommended by the Head/Director of Programme | | |

## Description of Physiology Units

**Regulatory Mechanisms** **PHYS 3002**

Ion channels and membrane potential, mechanisms of action potential generation, receptors, second messengers and signal transduction, regulation of excitation-contraction coupling (skeletal, cardiac and smooth), mechanisms of synaptic transmission, gap junctions, transmembrane/cellular transport of solutes and water, secretion, homeostasis, control systems, feedback and feed- forward control.

**Digestion, Absorption, Excretion** **PHYS 3004**

Alimentary canal; control of motility. Salivary, gastric, intestinal, pancreatic and biliary secretions. Digestion and absorption. Dietary factors, dietary disorders. Metabolic rate, energy balance, body temperature. Hormonal regulation of metabolism: insulin, glucagon, thyroid hormones, glucocorticoids. Control of growth. Renal circulation, glomerular filtration, tubular functions. Renal regulation of water and electrolyte balance.

**Neurophysiology I** **PHYS 3005**

Neuroanatomy of somatosensory pathways, excitation/inhibition in the central nervous system, signalling in nerve trunks, single ion channel physiology, visual system, auditory and vestibular function, olfaction, gustation.

**Neurophysiology II** **PHYS 3007**

Cortical control of movement, corticospinal tracts and extrapyramidal system, brainstem, basal ganglia, cerebellum, control of posture, learning and memory, sleep, cellular mechanism and neurotransmitters, synaptic plasticity.

**Physiological Measurement** **PHYS 3009**

This unit will discuss methodologies used in physiological measurement reflecting the expertise of individual staff members.

**Circulation** **PHYS 3011**

Cardiac electrophysiology. Regulation of myocardial contractile function. Arterial circulation; short- and long-term control of pressure. Microcirculation; capillary exchange and regulation of tissue blood flow. Venous circulation. Mechanoreceptors. Autonomic control of the circulation. Cardiovascular responses to hypovolaemia and exercise.

**Respiratory Physiology** **PHYS 3012**

Structure and function of the respiratory system. Respiratory mechanics; resistance and compliance. Blood gas transport. Pulmonary circulation and gas exchange. Control of breathing; sensory receptors and efferent control mechanisms. Respiratory responses to exercise, hypoxia and altitude.

## Plant Genetic Engineering

### Third Year General Topical Degree Programme

Students choose ten units in total. Core units are marked with the letter C. Students must include the seven core units as stated and three of the optional units, as recommended by the Head/Director of Programme. Details of the units may be obtained from the relevant Heads/Directors of Programmes.

**Core Units:**

| | | |
|---|---|---|
| BOTN 3006 | Seed Plant Reproduction | **C** |
| BOTN 3007 | Vegetation Ecology and Biogeography | **C** |
| BOTN 3008 | Plant Biotechnology | **C** |
| BOTN 3010 | Plant Development and Metabolism | **C** |
| GENE 3001 | Genetics | **C** |
| GENE 3002 | Genome Structure | **C** |
| GENE 3003 | Gene Expression | **C** |

**Students choose three optional units as recommended by the Programme Director:**

| | |
|---|---|
| BOTN 3001 | Diversity and Ecology of Fungi |
| BOTN 3002 | Plant Population Biology |
| BOTN 3003 | Plant/Soil Interactions in Wetlands |
| BOTN 3004 | Growth & Nutrient Assimilation |
| LANG 3002-3006 | Students may choose one language as an optional unit if they so wish. They should refer to page 62 for details. |
| STAT 3221 | Biostatistics |

## Statistics

### Courses for General and Honours Degrees

Third Year Honours and Single Subject General Degree share the same core units. Core units are marked with the letter C. Students must include the eight core units as stated and two of the optional units, as recommended by the Head/Director of Programme. Details of the optional units may be obtained from the relevant Heads/Directors of Programmes.

Students are free to select any optional units allowed by the timetable and subject to the student satisfying the prerequisites and with the recommendation of the Head/Director of Programme.

**Core Units:**

| | | |
|---|---|---|
| STAT 3205 | Statistical Theory I: Probability | **C** |
| STAT 3206 | Statistical Theory II: Statistical Inference | **C** |
| STAT 3207 | Statistical Theory III: Bayesian Statistics and Stochastic Processes | **C** |
| STAT 3208 | Statistical Methods I | **C** |
| STAT 3209 | Statistical Methods II | **C** |
| STAT 3210 | Data Analysis and Statistical Software | **C** |
| STAT 3218 | Survey Sampling | **C** |
| STAT 3224 | Statistics and Visualisation | **C** |

**If not already taken, students also choose the following units. Otherwise students choose two optional units as recommended by the School of Mathematical Sciences:**

| | |
|---|---|
| MATH 2205 | Calculus I |
| MATH 2202 | Linear Algebra |

### Third Year Two-Subject General

Students choose ten units with a minimum of four core units in Statistics and the other units chosen in agreement with the two Heads/Directors of Programmes.

| | | |
|---|---|---|
| STAT 3208 | Statistical Methods I | **C** |
| STAT 3209 | Statistical Methods II | **C** |
| STAT 3210 | Data Analysis and Statistical Software | **C** |
| STAT 3218 | Survey Sampling | **C** |

### Third Year Joint Honours

Students choose ten units with five core units in Statistics and the other units chosen in agreement with the two Heads/Directors of Programmes.

| | | |
|---|---|---|
| STAT 3205 | Statistical Theory I: Probability | **C** |
| STAT 3206 | Statistical Theory II: Statistical Inference | **C** |
| STAT 3207 | Statistical Theory III: Bayesian Statistics and Stochastic Processes | **C** |
| STAT 3208 | Statistical Methods I | **C** |
| STAT 3209 | Statistical Methods II | **C** |
| STAT 3210 | Data Analysis and Statistical Software | **C** |

## Descriptions of Statistics Units

**Statistical Theory I: Probability** **STAT 3205**

Probability Theory. Combinatorics. Random Variables: univariate, bivariate and multivariate. Moment generating functions. Functions of a random variable. Standard Probability Laws.

**Statistical Theory II: Statistical Inference** **STAT 3206**

(a) Estimation Theory: Chebyshev Inequality. Law of large numbers. Central Limit theorem. Methods of moments and maximum likelihood. Point estimation and interval estimation.

(b) Hypothesis testing: Neyman Pearson Lemma. Likelihood ratio tests.

**Statistical Theory III: Bayesian Statistics and Stochastic Processes** **STAT 3207**

Bayesian statistical inference. Stochastic processes. Poisson processes. Birth and death processes. Branching processes.

**Statistical Methods I** **STAT 3208**

Simple linear regression. Hypothesis testing and inferences concerning the regression equation. Polynomial and multiple regression. Regression diagnostics and transformations. Selecting the best regression model.

**Statistical Methods II** **STAT 3209**

One- and two-way analysis of variance. Fixed random and mixed effect models. Contrasts. Interaction. Multiple comparison procedures. Introduction to experimental design. Nonparametric statistics. Introduction to generalized linear models.

**Data Analysis and Statistical Software** **STAT 3210**

Data screening and cleaning. The SAS software package for data analysis.

**Actuarial Statistics I** **STAT 3216**

Decision theory. Loss distributions. Reinsurance. Risk models. Run off triangles and experience rating systems.

**Actuarial Statistics II** **STAT 3217**

Ruin theory. Bayesian statistics. Credibility theory. Introduction to generalised linear models.

**Survey Sampling** **STAT 3218**

Elements of the sampling problem. Simple random sampling. Stratified random sampling. Radio estimation. Cluster sampling. Systematic sampling.

*Prerequisite: MATH 2104 or Second Science Statistics.*

**Biostatistics** **STAT 3221**

Data reduction and representation. Probability distributions. Sampling. Confidence intervals. Hypothesis testing. Independent and paired samples. Sample size calculations. Design of experiments. Correlation. Linear regression.

**Official Statistics** **STAT 3223**

Collection of official statistics including macro-economics, business, demographic and social statistics. Accessing official statistics and their applications. Estimation, imputation and seasonal adjustment.

**Statistics and Visualization** **STAT 3224**

Descriptive statistical and graphical methods for displaying data. From data to information. Visualization and presentation of data. Aspects of multivariate analysis. Simulation. S-plus software.

**Models - Stochastic Models** **STAT 3253**

An introduction to the classification and simulation of stochastic processes. Discrete and continuous time models. Stochastic calculus.

## Theoretical Physics
**(SCBDF0012)**

Students must take the Core Courses and one of the Optional Courses listed below.

Details of the core course units are presented under the subject listings for Experimental Physics, and Mathematical Physics. Students will be required to complete Experimental Physics laboratory work commensurate with the EXPH units undertaken.

**Core Units:**

| | | |
|---|---|---|
| MAPH 3111 | Methods B | **C** |
| MAPH 3120 | Methods C | **C** |
| MAPH 3141 | Potential Theory | **C** |
| MAPH 3151 | Electromagnetic Theory | **C** |
| MAPH 3161 | Quantum Mechanics | **C** |
| MAPH 3171 | Fluid Mechanics | **C** |
| EXPH 3006 | Thermodynamics and Statistical Physics | **C** |
| EXPH 3007 | Solid State Physics | **C** |
| EXPH 3013 | Quantum Mechanics | **C** |

**Students choose one optional unit as recommended by the Head/Director of Programme:**

| | |
|---|---|
| MAPH 3180 | Dynamic Systems and Chaos |
| MAPH 4120 | Differential Geometry |
| MAPH 4130 | Mathematical Foundations of Quantum Mechanics |
| EXPH 4002 | Quantum Mechanics and Nuclear Physics |
| EXPH 4004 | Atomic and Molecular Physics |
| EXPH 4005 | High Energy Particle Physics |
| EXPH 4009 | Perspectives in Modern Astrophysics |
| EXPH 4010 | Atomic Structures and Spectra |
| EXPH 4013 | Condensed Matter Physics |

## Zoology

### Courses for General and Honours Degrees

**Third Year Honours and Single Subject General Degree** share the same core and optional units. Core units are marked with the letter **C.** Students must include the nine core units as stated and one of the optional units, as recommended by the Head/Director of Programme. Details of the optional units may be obtained from the relevant Heads/Directors of Programmes.

**Core Units:**

| | | |
|---|---|---|
| ZOOL 3009 | Functional Morphology | **C** |
| ZOOL 3010 | Animal Development | **C** |
| ZOOL 3011 | Arthropoda | **C** |
| ZOOL 3012 | Immunology | **C** |
| ZOOL 3013 | Animal Behaviours | **C** |
| ZOOL 3014 | Systems Ecology | **C** |
| ZOOL 3015 | Evolutionary Biology | **C** |
| ZOOL 3016 | Diversity of Vertebrates | **C** |
| ZOOL 3017 | Wildlife and Fisheries Management | **C** |

**Students choose one of the following optional units as recommended by the Head/Director of Programme:**

| | |
|---|---|
| GENE 3001 | Genetics |
| STAT 3221 | Biostatistics |
| GEOL 3001 | Palaeobiology |

### Third Year Joint Honours and Two-Subject General

Students choose five units from the following list (four core and one optional) and five units from the second subject in agreement with the two Heads/Directors of Programmes.

Students note that in order to take a Joint Honours or Two-Subject General Degree programme, permission is required from both Heads/Directors of Programmes.

| | |
|---|---|
| ZOOL 3009 | Functional Morphology |
| ZOOL 3010 | Animal Development |
| ZOOL 3011 | Arthropoda |
| ZOOL 3012 | Immunology |
| ZOOL 3013 | Animal Behaviour |
| ZOOL 3014 | Systems Ecology |
| ZOOL 3015 | Evolutionary Biology |
| ZOOL 3016 | Diversity of Vertebrates |
| ZOOL 3017 | Wildlife and Fisheries Management |

**Zoology and Genetics Joint Honours Degree Programme**

For a Joint Honours Degree Programme with Genetics, students must choose the five units of Zoology as shown above along with the following units:

| | | |
|---|---|---|
| GENE 3001 | Genetics | **C** |
| GENE 3002 | Eukaryotic Genome, Structure and Function | **C** |
| GENE 3003 | Gene Expression and Recombination | **C** |
| BIOC 3004 | Gene Manipulation and Regulation | **C** |
| ZOOL 3015 | Evolutionary Biology | **C** |

## Descriptions of Zoology Units

**Functional Morphology** **ZOOL 3009**

Anatomy/biochemistry of muscle, bone-muscle systems, supporting tissues, aquatic and terrestrial locomotion, flight, brain and sensory systems, temperature and energy metabolism, thermal strategies of animals.

**Animal Development** **ZOOL 3010**

Pattern formation, cell signalling, sex determination, differentiation, morphogenesis, evolution and development. Morphological and genetic basis of development, in model organisms such as *C. elegans*, *Drosophila*, sea urchin, zebrafish and mouse.

**Arthropoda** **ZOOL 3011**

Diversity, classification, biology, functional morphology, life cycles and strategies for survival of arthropods and related taxa; cladistics and phylogenetic relationships; impacts of pest, parasitic and beneficial species.

**Immunology** **ZOOL 3012**

Antigens, antibody structure and function, B cells, Tcells, MHC, diversity, cytokines, complement, inflammation, immunity to viruses, bacteria and parasitic infections, polyclonal, monoclonal and phage display antibodies.

**Animal Behaviour** **ZOOL 3013**

Sensory inputs. Chemical cues and escalating responses, stereotyped and modifiable. Integration of information. Evolution of behaviour. Social systems. Measuring behaviour. Genes and environment. Learning. Dominance. Aggression. Cooperation. Mating systems.

**Systems Ecology** **ZOOL 3014**

Global change, greenhouse effect, carbon cycle, nitrogen cycle, acid precipitation, stream and lake ecology/succession, stream habitats, indicator species, water quality, marine ecology, deep-sea and polar systems, larval ecology, benthic ecology.

**Evolutionary Biology** **ZOOL 3015**

Quantitative genetics; Gene flow in populations; Genetic drift; Heterozygosity; Heredity; Selection Models, Fitness/Relative Fitness; Molecular Evolution; Evolutionary Ecology; Species Concept; Speciation.

**Diversity of Vertebrates** **ZOOL 3016**

Study of phylogeny/diversity, pre-vertebrate chordates, vertebrate skeletons, transition from water to land, phylogeny, diversity, radiation and biogeography of fishes, amphibians, reptiles, birds and mammals.

**Wildlife and Fisheries Management** **ZOOL 3017**

The necessity of management, estimating population size, using models (types and estimation of parameters), habitat analysis and GIS, species re-introductions, the use of Protected Areas, case studies.

# Fourth Science

**BSc (Honours) One-Subject: SCBDF0005**

**BSc Joint Honours: SCBDF0006**

**BSc Topical (Honours): SCBDF0008**

**BSc Theoretical Physics: SCBDF0012**

**BSc Mathematical Science: SCBDF0014**

**BSc Computer Science: SCBDF0015**

# Regulations for Fourth Year Honours Science Students

## 1. Selection of Courses

All Fourth Year Honours Science students select courses of study as indicated by the relevant Head/Director of Programme.

## 2. Examinations

Having passed the Third Year Honours Examinations, students must attend, for one academic year, courses in the major subject, and must present at the end of that academic year for the Final Examination for the Degree of BSc (Honours). The distribution of marks for the Final Examination will be provided to students by the Schools concerned.

Candidates may present only once for the BSc (Honours) Degree Examination or the BSc Honours Topical Degree Examination. Exemption from this regulation may be granted for grave reasons by the Academic Council on the recommendation of the College concerned.

### Beneficial Aggregation of Marks

The grade of all Honours Degrees in Science will be determined by beneficial aggregation of marks where aggregation operates to the benefit of the student, as follows:

*Either:*
Aggregation of 25% of the Third Science Examination results with 75% of the Final Year Examination result

*Or:*
100% of the Final Year Examination result.

Beneficial Aggregation of marks will also be applied to the grade of all Joint Honours and Honours Topical Degree programmes.

The BSc (Honours) Degree may be awarded as follows:

| | |
|---|---|
| First Class Honours | 70% |
| Second Class Honours (Grade I) | 60% |
| Second Class Honours (Grade II) | 50% |
| Third Class Honours | 45% |

Candidates who have completed the Fourth Year Honours course and who do not reach the Pass Standard (40%) shall be awarded a BSc (General) Degree.

# Syllabus of Courses for Fourth Year Science

## Applied and Computational Mathematics – IDSC 4005

Ten units to be taken, selected from the following, subject to the approval of the Programme Director:

| | | |
|---|---|---|
| MATH 3203 | Advanced Calculus | (1 unit) |
| MATH 4108 | Financial Mathematics | (1 unit) |
| MATH 3205 | Combinatorial Mathematics | (1½ units) |
| MATH 3106 | Algorithms | (1½ units) |
| MAPH 3171 | Fluid Mechanics | (1 unit) |
| MAPH 3091 | Mathematical Modelling | (1 unit) |
| MAPH 3120 | Methods C | (1 unit) |
| MAPH 4194 | Viscous Flow | (1 unit) |
| STAT 3208 | Statistical Methods I | (1 unit) |
| STAT 3209 | Statistical Methods II | (1 unit) |
| STAT 3210 | Data Analysis and Statistical Software | (1 unit) |
| STAT 4213 | Applied Statistics II | (1 unit) |

## Astrophysics

For admission to fourth year, students must pass the third year examination at the first attempt, and obtain honours standards in at least six units. Students who fail to reach this standard but pass the examination will be awarded the (three year) BSc General Topical Degree.

Laboratory: Students will take suitable experiments from the fourth year EXPH laboratory commensurate with the number of EXPH units taken.

**Courses in Astrophysics:**

| | |
|---|---|
| EXPH 4018 | Black Holes, Galaxies and Observational Cosmology |
| MAPH 4212 | Theoretical Astrophysics |

**Courses in Physics:**

| | |
|---|---|
| EXPH 4001 | Quantum Mechanics |
| EXPH 4005 | High Energy Particle Physics |

**Optional Units:**

| | |
|---|---|
| EXPH 4002 | Quantum and Nuclear Physics |
| EXPH 4003 | Applied Electromagnetism and Plasma Physics |
| EXPH 4004 | Atomic and Molecular Physics |
| EXPH 4007 | Applied Optics |
| EXPH 4010 | Atomic Structure and Spectra (requires EXPH 4004) |
| MAPH 4110 | Nonlinear waves and solitons |
| MAPH 4120 | Differential Geometry |
| MAPH 4161 | Computational Physics |

MAPH 4171 General Relativity (requires MAPH 3151 in third year and MAPH 4120)

Laboratory: There will be a teamwork project in first term based on the data taken on the field trip in third year. The students will take two suitable experiments from the fourth year EXPH lab during first term. There will be a one semester project carried out in an astrophysics/particle physics group during the second term.

## Biochemistry – BIOC 4000/4200

**Biochemical Immunology** **BIOC 4001**

Structure and function of ion-channels. Aetiology of Type-I & Type-II diabetes. Antigen presentation and activation of the adaptive immune system. Mechanisms of T-lymphocyte activation, deletion and anergy. Receptor and non-receptor Tyrosine kinases and signal transduction in cells of the immune system. Cytokine networks.

**Redox Enzymes** **BIOC 4002**

The properties of redox centres found in enzymes are surveyed, with an emphasis on recent work. The redox properties of flavoproteins are studied in detail, using the electron carrier flavodoxin to illustrate how these properties are modulated by interactions with protein.

**Neurochemistry I** **BIOC 4003**

Topics include release, transport, synthesis and metabolism of amino acid neurotransmitters. Structure, function and diversity of amino acid receptors in the CNS. Mechanisms of excitotoxicity and neurodegenerative disease.

**Complex Modes of Gene Regulation** **BIOC 4007**

Investigation of aspects of regulation of gene expression: DNA topology and nucleosome structure; interaction of transcription factors with chromatin; identification of nuclear localisation signals; regulated nuclear localisation of transcription factors; nuclear gradients in Drosophila development; comparison of immune response pathways in Drosophila and mammals; effect of phosphorylation on nuclear transport.

**Biological NMR** **BIOC 4008**

Basic NMR theory, relaxation mechanisms in small and large molecules, optimising signal-to-noise, 1D-pulse sequences used in biological NMR, $^{13}$C-NMR of biological molecules, protein structure determination.

**Cell Signalling** **BIOC 4009**

This course details the signal transduction cascades of G-protein coupled receptors and heterotrimeric G proteins; growth factor receptor tyrosine kinases; monomeric G proteins; mitogen activated protein kinase (MAPK) and stress activated protein kinases (SAPKs). Attention is paid to structure/function aspects of signalling components and to integration of the various cascades.

**Proteases and Inhibitors** **BIOC 4010**

Introduction to classes and mechanisms of proteases and protease inhibitors. Extracellular and intracellular proteolytic events including plasma cascades, proteasome protein degradation and antigen processing. Mechanisms of programmed cell death (apoptosis).

**Cancer Studies** **PHAR 4003**

Details of this course are available from the School of Biomolecular and Biomedical Science.

**Protein Engineering** **BIOC 4012**

Academic and practical reasons for engineering proteins. Alternatives. Prerequisites: High-resolution structure, homology, conserved residues? Tyrosyl tRNA synthetase: H-bonds. Subtilisin: thermostability. Homology-based engineering: coenzyme specificity in disulphide reductases. Substrate specificity in $\alpha$-hydroxyacid dehydrogenases. Engineering without 3-D structure: E2 lipoyl domains. Criteria of success. Limitations. Hybrid approaches; SDM/random. Amino acid dehydrogenases.

**Neurochemistry II** **BIOC 4015**

The course will cover the biogenic amine neutrotransmitters serotonin, dopamine and noradrenaline; the functions of biogenic amines in the brain; structure, function and regulation of monoamine receptors and transporters; molecular basis of neurological disorders, such as depression, Parkinson's disease and drug addiction; molecular mechanisms of antidepressants and drugs of abuse.

**Structural Bioinformatics** **BIOC 4016**

Structural Bioinformatics is one of the most vibrant and active research areas in modern biology. The methods covered in this course are: Protein structure prediction, homology modelling, protein electrostatics calculations, pKa calculations, molecular dynamics (MD) simulations, molecular force fields, drug/protein-protein docking and prediction of protein folding pathways.

**Problem Paper** **BIOC 4017**

Only available to fulltime Fourth Year Honours Biochemistry students.

**Statistics – Laboratory Assays** **STAT 4230**

## Botany – BOTN 4000/4200

The following courses are offered in a range of topics, reflecting the specialist interests of the School's staff. Students must select their courses in consultation with the Head/Director of Programme.

**Peatland Ecology and Conservation** **BOTN 4001**
Characteristics of peatland habitats. Ecology of peatland plants. European and world distribution of peatlands. Peatland classification systems. Variation in European peatlands. Peatland vegetation types. Irish peatlands – distribution, ecology, vegetation, habitat destruction, restoration and conservation.

**Ecotoxicology** **BOTN 4002**
Pollutants in ecosystems. The behaviour of pollutants in, and their effects on, ecosystems; predictions of effects of pollutants in ecosystems, and biomonitoring of pollutants in the environment.

**Evolution in Plant Populations** **BOTN 4003**
Natural selection in plant populations. The existence of infraspecific genetic variation: ecotypes, clines. Gene flow in populations; neighbourhood size. Spatial and temporal scales of population differentiation. Life-cycle components of selection.

*Prerequisites: BOTN 3002 and BOTN 3006.*

**Mycorrhizal Symbiosis** **BOTN 4004**
Structure and function of the main mycorrhizal types. Mycorrhizal populations in forest, heathland and grassland ecosystems. The role of mycorrhizal associations in improving the nitrogen and phosphorus nutrition of trees, crops and heathland plants.

**Plant – Pathogen Interactions** **BOTN 4008**
Disease and disease resistance in plants; the ways in which pathogens gain entry and colonise host tissues; toxins, cell-wall-degrading enzymes, growth de-regulators; the constitutive and induced defensive responses of plants; mechanical and biochemical resistance, including hypersensitive response, phytoalexins and PR proteins.

**In Vitro Techniques** **BOTN 4009**
Regulatory aspects of growth and metabolism of plant cells in culture. Growth and production kinetics of cultured plant cells; screening for chemical variants; cloning, clonal analysis and stability of isolates; possible origins of cellular heterogeneity; selection by amino acid analogue resistance.

**Critiques of Scientific Papers** **BOTN 4011**
Essential skills in the analysis and writing of scientific papers: titles, abstracts, presentation of materials and methods, data presentation and analysis, validity of conclusions. This tutorial course is designed to provide critical reading and writing skills.

**Ecological Significance of Different Photosynthetic Pathways** **BOTN 4012**
Fundamental characteristics of carbon assimilation in terrestrial C3, C4, C3-C4 and CAM plants. Photosynthetic mechanisms in aquatic plants. Plant distribution and photosynthetic pathway. Examination of the effects of irradiance, temperature, $CO_2$, water and nutrients on carbon assimilation. Predicting the response of plants and vegetation to global changes in climate.

**Science and Society** **BOTN 4013**
Social creation of scientific knowledge: theories of Merton, Kuhn, Feyerabend. Role of science in society: reliability, use and abuse of scientific knowledge; should science be planned to meet social needs?; the public understanding of science. Limits of science: does science have conceptual or ethical limits? Emergence of anti-science culture.

**Developmental Plant Genetics** **BOTN 4014**
Developmental and environmental control of plant gene expression and pattern formation. Embryogenesis, root, shoot and leaf development, formation of reproductive structures. Formation of the photosynthetic apparatus.

**GMOs in the Environment** **BOTN 4018**
The release of GMOs and their consequences. Regulatory procedures.

**Programmed Cell Death in Higher Plants** **BOTN 4020**
Introduction to programmed cell death and examination of its role in a number of different organisms; molecular and biochemical mechanisms that control the cell death process in different organisms including plants; the role of cell death in plant development and disease resistance.

**Burren Field Course** **BOTN 4021**
This five-day residential field course takes place after the Third Science Summer Examinations each year. It is compulsory for students pursuing (a) a single honours degree in Botany or (b) taking Botany as a core element in the Environmental Biology programme. The course is also available to other students who have completed BOTN 3007: *Vegetation Ecology and Biogeography*. The course covers field methods in vegetation ecology, including species identification, habitat description, vegetation description and vegetation classification. A variety of habitat types are examined, including coastal systems (cliff tops, rocky shores, salt marshes, shingle beaches, sand beaches and sand-dune systems); lake and lake shore systems (acid lakes and Burren turloughs); limestone pavement systems; mountain vegetation (arctic alpine species, species changes with increasing altitude); peatlands (raised bogs, blanket bogs and fens); river and wetland systems; and woodland systems (Corylo-Fraxinetum woodlands, Blechno-Quercetum woodlands, hazel scrub, yew/juniper scrub, pine woodland). Discussion of conservation of habitats and rare plant species take place during field excursions. Evening sessions involve confirmation of field identifications, analysis of species distributions and habitat report writing.

**Cell Signalling in Plants** **BOTN 4022**
Plant growth and development are controlled by interactions between the plant, environmental conditions and intrinsic developmental programs directed by plant hormones. This series of lectures will give an insight into current advances in signal transduction processes in plants and appropriate examples from animals, yeast and bacteria will be used to illustrate both conservation and divergence of signalling mechanisms between different organisms.

**Research Project**
Each student will carry out a research project, to be presented as a thesis and seminar for part of the Degree Examination assessment.

## Cell and Molecular Biology – CELB 4000

Each student must attend ten of the following courses, undertake a Research Project and complete an essay. The Project is to be presented as a seminar and submitted as a thesis. Selection of courses and project are subject to the approval of the Programme Director.

**Immunobiology** **CELB 4002**
Basic concepts in immunobiology. Antigen recognition by B and T cells. T cell development and T cell mediated immunity. Host defence mechanisms. Control and manipulation of the immune response.

**Neurobiology** **CELB 4003**
Molecular mechanisms underlying memory and learning. Neurodegenerative states: Alzheimer's disease. Psychotic states: schizophrenia and depression. Molecular mechanisms involved in processing and storing information derived from the internal condition and the external environment. *See also PHAR 4002.*

**Human Genetic Diseases** **GENE 4002**
For details of unit see under Genetics.

**Complex Modes of Gene Regulation** **BIOC 4007**
For details of this unit see under Biochemistry.

**Developmental Plant Genetics** **BOTN 4014**
For details of this unit see under Botany.

**Critiques of Scientific Papers** **BOTN 4011**
For details of this unit see under Botany.

**GMOs in the Environment** **BOTN 4018**
For details of this unit see under Botany.

**Programmed Cell Death in Higher Plants** **BOTN 4020**
For details of this unit see under Botany.

**Plant Cell Signalling** **BOTN 4022**
For details of this unit see under Botany.

**Developmental Biology** **PHARM 4014**
For details of this unit see under Pharmacology.

**Prion Diseases** **ZOOL 4014**
For details of this unit see under Zoology.

**Genomic Imprinting, Chromatin and Epigenetics** **ZOOL 4018**
For details of this unit see under Zoology.

**Molecular Phylogenetics – Powers and Pitfalls** **ZOOL 4024**
For details of this unit see under Zoology.

## Chemistry – CHEM 4000/4200

**Core Courses**

### Organic Chemistry
Structure and reactivity, pericyclic reactions, reaction co-ordinate diagrams; rearrangements; acid-base and enzymatic catalysis; asymmetric synthesis; biosynthesis; catalysis in chemistry and biology; retrosynthetic analysis.

### Inorganic Chemistry
Organometallic and related chemistry; structural methods in inorganic chemistry; bonding and electronic spectroscopy of coordination compounds; inorganic solid-solution chemistry; boranes, carboranes and their complexes; transition metal-catalyzed polymerizations.

### Physical Chemistry
Reaction dynamics, electrochemistry, nanochemistry, spectroscopy, thermodynamics, phase behaviour of solutions, statistical mechanics, colloids, biopolymers.

### Optional Courses
In addition to the core courses students will choose from a selection of optional courses, examples of which are given below.

Bioelectrochemistry/Neurochemistry; solution chemistry; supramolecular chemistry; atmospheric chemistry; nucleic acids and their functioning in biological systems; biomaterials; organo-main-group chemistry; organometallics veagents in organic synthesis; reactive intermediates; transition metal complexes in catalysis; synthesis and properties of polymer materials; solution-phase NMR techniques applied to structural determination; computational chemistry; biomacromolecular chemistry; bioinorganic chemistry; bioorganic and medicinal chemistry; heterocyclic and combinatorial chemistry; environmental applications of heterogeneous catalysis; solvent effects and chemistry in water; statistical mechanics of phase transitions and kinetics.

**Experimental Research Projects**
Projects are carried out in the research laboratories under the direction of members of staff.

## Computer Science – COMP 4000

Students will be required to take a total of eight units. Not all of the following units will be offered in a given year and certain restrictions may also apply. Students who have not taken the stated prerequisite courses should contact the lecturer of the course before selecting courses.

Students are also required to undertake a significant project, details of which will be provided by the School of Computer Science and Informatics.

**Computability** **COMP 4001**
Effective procedures; the spectrum of computability, from simple problems to undecidable ones; what is and is not computable; models of computability; turing machines, partial recursive functions; Markov algorithms; what is and is not tractable; complexity classes, P, NP, co-NP and NPC; coping with NCP problems; problem restriction, approximation algorithms.

**Advanced Information Systems** **COMP 4002**
Databases: recovery; concurrency; security; integrity; distributed databases; extended relational data model; object oriented data model. *Prerequisite: COMP 3005/COMP 2006*

**Introduction to Digital Image Processing and Linear System Theory COMP 4005**
Digital Image Processing System; Human Vision System; Image Representation; Histogram and algebraic operations; Linear system theory; Convolution; Image transforms (DFT, wavelets…); Filter Design; Colour Image Processing; Segmentation; Applications: – Loss less Compression; – Still image compression standards; – Digital image watermarking; – Video Coding and Compression Standards.

**Programme Design and Verification II** **COMP 4006**
Calculating programs; advanced derivational techniques; refinement calculus; reifying abstract data types; the use of simple algebras in program construction.

**Systems & Specification** **COMP 4007**
The nature of systems and basic concepts of systems theory; types of systems and their characteristic properties; formal description of systems; needs and uses; principles and practice of system specification; examples and case studies.

**Object-Oriented Design** **COMP 4008**
Object-oriented methods in the software development cycle; practical design techniques using e.g. Unified Modelling Language technique; alternative approaches to object-oriented design; frameworks and design patterns.

**Design Patterns** **COMP 4009**

Introduction to Patterns. Use of patterns in the design process. Documentation of new patterns. Creational patterns. Structural patterns. Behavioural patterns. Introduction to Frameworks. Data-driven and architecture-driven approaches. Synergy between patterns and frameworks. Case studies.

**Concurrent Programming** **COMP 4010**

Nature of concurrent programming shared memory; message passing; interference; synchronisation; mutual exclusion; semaphores; deadlock; fairness; high level constructs for concurrency; communicating sequential processes; applications to operating systems; formal verification.

**Formal Specifications** **COMP 4011**

Need for formal specifications; specification methods e.g. VDM, algebraic specifications; techniques for specifying complex systems; developing systems for specifications; case studies.

**Advanced Operating Systems** **COMP 4012**

Language mechanisms for concurrency. Security and Protection – formal models (access matrix, BLP, lattice, take grant models). Scheduling Algorithms. Distributed Operating Systems –design and implementation, Synchronisation in Distributed OS, Distributed Process Scheduling, Distributed Concurrency control (deadlock and recovery), Distributed File Systems, Distributed Shared Memory, Distributed Computer Security. Case Studies: CHORUS, MACH, AMOEBA.

**Language Engineering** **COMP 4013**

Fundamentals of natural language processing; formal models and corpus-based methods in speech and language; resources, standards and evaluation methodology; applications of human language technology.

**Distributed Systems** **COMP 4014**

Distributed systems processing and interconnection architectural/ reference models and concepts; open and closed systems; distributed operating system kernels, decomposition and consequences of distribution; security and management of distributed systems; transparency, remote operations, coordination replication, shared transactions, concurrency control, recovery and fault tolerance.

*Prerequisite: COMP 3008*

**Exploring Computer Science** **COMP 4015**

Special topics related to current research and state of art applications not covered in other units.

**Foundations of Artificial Intelligence** **COMP 4017**

The importance of representation, First Order Logic, Predicate Calculus, Normalised FOPL forms, Skolemisation, Conversion to Clausal Form, Resolution, Logic Programming, Prolog, Extra Logical features of Prolog, Semantic Networks, Frames, The Frame Problem.

*Prerequisite: COMP 3009*

**Connectionist Computing** **COMP 4018**

What is connectionism? Basics neurobiology; neurons, synapses. Simple models of neurons. Hebbian learning. Rosenblatt's perceptron. Minski and Papert's criticism of connectionism. Linear associators. Hopfield networks. Boltzmann machines. Learning tasks. Supervised learning: PAC learning, shattering, VC dimension. Multi-layer perceptrons (MLP): gradient descent, backpropagation; expressive power of MLP; sample applications of MLP; the invariance problem; countering overfitting; other learning techniques. Reinforcement learning: TD learning and backgammon. Unsupervised learning: self-supervised backpropagation, principal component analysis and clustering. Plausibility, probability and Bayes' theorem: ML and MAP. ML for MLP. Bayesian networks: inserting and updating evidence; junction tree algorithm. Learning in Bayesian networks. Bayesian network/Neural network hybrids. Recurrent and recursive neural networks. Neural networks for Directed Acyclic Graphs.

*Prerequisite: COMP 3009*

**Multi-Agent Systems (MAS)** **COMP 4019**

Definition of Distributed Artificial Intelligence (DAI). Motivations for MAS, Strong versus weak notions of agency. Intentional agent systems. Agent communication. Speech act theory. Collaboration, planning, belief desire intention (BDI) architectures. Agent oriented design, agent oriented programming and languages (Agent0, Agentalk), Multi-agent systems prototyping environment, industrial and commercial applications.

*Prerequisite: COMP 3009*

**Parallel Algorithms: Design & Analysis** **COMP 4021**

Performance and Scalability of Parallel Systems, Metrics, Sources of Parallel Overhead; Arrays and Trees – Elementary Sorting and Counting, Matrix Algorithms, Graph Algorithms; Meshes and Trees – 2-Dimensional Mesh of Trees, Elementary O(log N)-Step Algorithms, Higher-Dimensional Meshes of Trees; Hyper-cubes and Related Networks – Hypercube, Butterfly Cube-Connected-Cycles and Benes Network, Shuffle-Exchange, Packet Routing Algorithms, Sorting, FFT, Other Hypercube Networks; Parallel Systolic Algorithms – Mapping 1-D and 2-D Systolic Arrays onto Parallel Computers.

*Prerequisite: COMP 3020*

**Advanced Computer Architecture** **COMP 4023**

Principles; instruction-level parallelism; software approaches for ILP; memory hierarchy design; multiprocessors; storage systems; case studies of microprocessor systems.

**Parallel Programming Systems** **COMP 4024**

Vector and superscalar processors: architecture and programming model, optimising compilers (dependency analysis and code generation), array libraries (BLAS) parallel

languages (Fortran 90, C++). Shared-memory multi-processors: architecture and programming models, optimising compilers, thread libraries (Pthreads), parallel languages (Fortran 95, OpenMP). Distributed-memory multi-processors: architecture and programming model, performance models, message-passing libraries (MPI), parallel languages (HPF). Heterogeneous networks of computers: architecture and programming models, programming challenges, performance models, parallel programming languages (mpC), message-passing libraries (FT-MPI, HMPI).

**Spatial Information Systems** **COMP 4025**

Databases issues in information systems storing and handling spatial data: representation and manipulation of spatial data; models; relations; indexing methods for spatial data; geometric problems and algorithms; query processing in spatial databases; geographic applications; emerging research directions.

*Prerequisite: COMP 3005/ COMP 2006*

**Knowledge Based Computation** **COMP 4026**

Knowledge-based methods for artificial intelligence systems. Knowledge representation, organization, application and maintenance. Principles of memory organization, indexing and retrieval. Memory-based, analogical and case-based reasoning. Applications to understanding, explanation, planning, and advisory systems.

*Prerequisite: COMP 3009*

**Machine Learning** **COMP 4030**

This unit introduces students to the fundamental concepts of machine learning, and introduces students to the practical skills needed to develop learning systems. Specific topics include a variety of supervised learning techniques (decision-tree learning, the naïve Bayes classifier, nearest neighbour algorithms), semi-supervised approaches (EM, co-training), unsupervised techniques (association rule mining, clustering), and theoretical analysis of learning algorithms (the PAC model).

*Prerequisite: COMP 3009*

**Advanced Computer Graphics** **COMP 4031**

Advanced topics in computer graphics, which may include: GPU programming; shader languages; modelling natural phenomena; inverse kinematics; collision detection; frame-rate optimisation; real-time rendering for games; scientific, medical and information visualization; geometric optimisation; level-of-detail rendering; bi-directional reflectance distribution functions (BRDFs); environment mapping; bump mapping; subdivision surfaces; higher-order surface modelling. Exact topics will vary from year to year at the discretion of the lecturer, and of course may be taught in the form of seminars, in which case students will be expected o research and present recent papers on graphics techniques. The practical component of this course will involve a significant amount of programming, which will normally require a good working knowledge of C and OpenGL.

(Prerequisite: COMP 3021.)

**Artificial Intelligence for Games and Puzzles** **COMP 4032**
This unit will cover a number of "mind games", some of which involve an element of chance (such as poker, backgammon) and some do not (such as chess, go), which computers can play as opponents to human users. It will also to a lesser extent cover some puzzles that either computers or humans might try to solve (such as solitaire, eternity). The course is about the Artificial Intelligence aspects of game play and puzzle solving; it is not concerned at all with the kinds of games where fast or accurate user reactions are judged highly important. The main issues to be addressed include: techniques for representing positions in games and puzzles; techniques for reasoning about the effects of moves and hence choosing between them (alpha-beta and other game-tree search techniques); enhancements to such techniques (transposition tables, various heuristics); handling uncertainty in games with a chance element; machine-learning methods for improving the skill level of computer players.

## Computer Science (Denominated Entry) – COMP 4000 (SCBDF0015)

Students follow Fourth Year courses as directed by the School of Computer Science and Informatics.

## Environmental Biology – IDSC 4001

The Fourth Year Programme comprises nine lecture courses.

**Compulsory Courses**

**Environmental Regulation: Policy and Practice** **ENVB 4001**
Environmental regulation in Ireland and the EU: policy, administrative and legislative framework with regard to species/habitat conservation, pollution, and resource management in terrestrial, freshwater and marine environments.

**Environmental Impact Assessment** **ENVB 4002**
Development, philosophy and structure of the EIA framework in Ireland and other countries. Practicalities of EIA, including a mock scoping exercise and lectures from environmental consultants. Biological sampling and coastal examples will be emphasised.

**Critiques of Scientific Papers** **BOTN 4011**
For details of this unit see under Botany

## Optional courses

Students select six optional courses, with three from each of the two main subject areas contributing to their Degree programme (i.e. Botany, Industrial Microbiology, Zoology). Course selection will depend on the student's subject background and must be agreed by the relevant Heads of Schools. Please note course descriptions may be found under the relevant subject.

### Courses in Botany:

| | |
|---|---|
| BOTN 4001 | Peatland Ecology and Conservation |
| BOTN 4002 | Ecotoxicology |
| BOTN 4003 | Evolution in Plant Populations |
| BOTN 4004 | Mycorrhizal Symbiosis |
| BOTN 4012 | Ecological Significance of Different Photosynthetic Pathways |

### Courses in Industrial Microbiology:

| | |
|---|---|
| INDM 4003 | Microbial Genetics of Pathogenic Microorganisms |
| INDM 4006 | Advances in Environmental Microbiology |
| INDM 4013 | Current Topics in Fungi |
| INDM 4014 | Bacterial Genetics and Synthetic Biology |
| INDM 4017 | Food Microbiology |
| INDM 4019 | Microbial Biofilms |
| INDM 4020 | Microbial Natural Product Biosynthesis |

### Courses in Zoology:

| | |
|---|---|
| ZOOL 4001 | Biodiversity |
| ZOOL 4005 | Ecology of Tropical Rainforests |
| ZOOL 4016 | Marine Community Ecology |
| ZOOL 4019 | Bioassessment of Freshwaters |
| ZOOL 4020 | Human Evolution |
| ZOOL 4022 | Insect-Plant Interactions |
| ZOOL 4023 | Biodiversity Collections Research |

### Research Project

A project in an environmental topic is carried out in Botany, Industrial Microbiology or Zoology. Project selection may be restricted by the availability of space in laboratories. The project is a significant component of the final year course and is presented in thesis form as part of the Final Degree Examination assessment.

### Written Assignments

A library-based written assignment on an environmental topic forms part of the Final Degree Examination assessment.

## Environmental Geochemistry – IDSC 4003

**Core Units**

Students take the following eight units in Fourth Year.

### Chemistry

Students choose four core Chemistry units, CHEM 3104 Structure Determination by Spectroscopic Methods and either CHEM 3114 Electrochemistry, Colloid and Surface Chemistry or CHEM 3115 Thermodynamics and Reaction Kinetics, and two other units chosen from the Fourth Year Honours optional courses, to be decided in agreement with the Programme Director. Description of the Chemistry units may be obtained from the Third and Fourth Year courses in Chemistry.

**Sedimentology and Volcanology** **GEOL 3006**

For details of this unit see under Geology

**Igneous, Metamorphic Petrology** **GEOL 3008**

For details of this unit see under Geology

**Isotope Geochemistry I** **GEOL 4011**

Radiogenic isotopes as geochronometers and tracers. Quaternary geology and short-lived nuclides. Actinide geochemistry. $^{230}Th/^{234}U$, $^{234}U/^{238}U$, $^{231}Pa/^{235}U$ and $^{210}Pb$ dating methods. U-series mobilisation and surface hydrology. Groundwater dating and tracing. Applications to radioactive waste disposal studies. Pb isotopes as environmental tracers. Cosmogenic isotopes. Radiocarbon dating.

**Isotope Geochemistry II** **GEOL 4012**

The carbon cycle. Organic compounds in mineral inclusions, humic acids, lipids, kerogen. The organic geochemistry of peat, coal, crude petroleum and recent sediments. Extraction techniques and analytical methods. Compound specific stable isotope analysis. Stable isotope fractionation processes and temperature effects.

All Fourth Year students are required to complete a field, laboratory or combined field laboratory project(s) during the course of the year. In the case of field projects, the data are collected in the Summer before the start of the Fourth Year. This will be presented in thesis form as part of the Final Degree Examination assessment. The Fourth Year course involves geological field classes.

## Experimental Physics – EXPH 4000/4200

Students taking an Honours Degree in Experimental Physics will be required to take units EXPH 4001 to EXPH 4006 inclusive plus any two of units EXPH 4007 to EXPH 4014. It should be noted that not all of the optional units will necessarily be offered each year.

**Advanced Laboratory II**
Students are required to complete an appropriate number of mini practical projects. These projects are designed to provide an opportunity to explore a range of areas of physics independently in a supportive environment. In addition to laboratory projects, students will generally undertake a computational and a collaborative electronics project. Students will also be required to present two short seminars on some aspect of physics.

**Quantum Mechanics** **EXPH 4001**
Dirac general transformation theory. Schrödinger and Heisenberg representations as special cases. Time development of quantum systems. Definition of Hamiltonian in quantum theory. Symmetry in quantum theory. Conservation laws. Introduction to relativistic quantum mechanics. Dirac equation and its solution for free electron. "Quantum reality". Einstein Podolski Rosen paradox. Bell inequality. Aspect experiments.

**Quantum and Nuclear Physics** **EXPH 4002**
Quantum theory for Bosons and Fermions. Theory of the deuteron. Scattering theory; including partial wave analysis, scattering length and effective range concepts, proton-neutron scattering, the Born approximation and resonant scattering. Nuclear fusion including solar fusion and the solar neutrino flux. Single-particle shell model of the nucleus. Neutron physics including neutron detectors.

**Applied Electromagnetism and Plasma Physics** **EXPH 4003**
Fields due to an oscillating dipole. Rate of radiation from an oscillating charge. Scattering including Thompson scattering and Rayleigh scattering. Fields due to a moving charge. The invariance of Maxwell's equations. The current-potential four vectors. Fundamental atomic processes. Diffusion, electrical conduction and mobility. Einstein's equation. Debye length. Highly conducting plasmas. Waves in plasmas. Plasma diagnostics.

**Atomic and Molecular Physics** **EXPH 4004**
Hydrogen atom in a magnetic field. Approximation methods: Non-degenerate and degenerate perturbation theory, variation principle. Stark effect. Helium atom: spin and exchange in two-electron systems, energy level structure and spectrum. Many-electron atoms. Central field theory. Coupling schemes. Autoionisation. Time-dependent perturbation theory. Transition probabilities. The covalent bond. Properties of simple diatomic molecules.

**High Energy Particle Physics** **EXPH 4005**

Fundamental particles and interactions. Quantum numbers and conservation laws. Resonant states and quark model of hadrons. The Standard Model of particle physics: Quarks and leptons. Gauge and Higgs bosons. Feynman diagrams. Strong interactions. Electroweak unification. C, P and CP violation. Mixing and oscillation. Modern experiments at colliders. Physics of charm, beauty and top-quarks. Searches for the Higgs boson and new phenomena. Neutrino physics.

**Solid State Physics and Lasers** **EXPH 4006**

Reciprocal space. Crystalline structure. Brillouin zones. Landau levels. Measurement of the Fermi surface. Location of the Fermi level in intrinsic and extrinsic semiconductors. Low dimensional systems. Quantum Hall effect. Einstein's theory of radiation. Resonant cavities and modes. Threshold value of population inversion. Optical pumping. Types of laser. Laser output. Semiconductor lasers.

**Applied Optics** **EXPH 4007**

Polarisation and birefringence. Acousto-optic, electro-optic and magneto-optic effects. Modulators, deflectors and displays. Liquid crystals. Non-linear optics. Harmonic generation. Parametric oscillation. Phase conjugation. Memory devices. Detectors: PMT, photoconductive and junction, CCD. Planar dielectric waveguides. Optical fibres: step and graded-index, attenuation and dispersion. Optical communications. Fibre optic sensors.

**Topics in Environmental Physics** **EXPH 4008**

Radiation dosimetry. The natural radiation environment, radon and cosmic radiation doses. Properties of aerosols. Lung dosimetry of alpha emitters. Radioecology and radioecological modelling. Radioanalytical techniques, including low-level measurement techniques. Radioisotope dating. Remote sensing of environmental and surface features; including a review of remote sensing technology, and its application to water quality and land productivity estimation.

**Perspectives in Modern Astrophysics** **EXPH 4009**

The Sun, stellar evolution, gravitational potential energy, temperature pressure, luminosity and fusion reactions galaxy formation, dark matter and large scale structure of the galaxy. Neutrino flux. Supernovae, pulsars, primordial black holes, supermassive black hoses and active galactic nuclei. High energy processes and radiation mechanisms.

**Atomic Structure and Spectra** **EXPH 4010**

Single particle and many body models. Hartree and Hartree-Fock methods. Slater F and G integrals. Energy level structure in complex systems. Configuration interaction. Series perturbations. Selection rules and quantum mechanical treatment of transition probabilities. Autoionization, inner shell photoionization and non-radiative decay. Unresolved arrays and statistical methods. Modern developments in atomic physics.

**Low Temperature and Condensed Matter Physics** **EXPH 4013**

Type-I and type-II superconductors. Meissner effect. Thermodynamics and electrodynamics of superconductor equations. London penetration depth. Coherence length. Phenomenological theories. BCS theory. Energy gap. Josephson effects. SQUIDs and SLUGs. High-$T_c$ superconductors. Superfluidity in liquid helium. First and second sound. Rotons. Vortex states. Laser cooling and trapping. Bose-Einstein condensates Co-operative magnetic phenomena.

**Medical Physics** **EXPH 4014**

Photon interactions in matter. X-ray spectra and filtration. Charged particle interactions. Production of medical radiation beams. Charged particle equilibrium. Kerma and dose. Bragg and Gray cavity theory. Absolute dosimetry. Detection of ionising radiation. Radiation Protection. Medical uses of ionising radiation, external teletherapy, bracytherapy. Nuclear Medicine and diagnostic imaging.

**Black Holes, Galaxies and Observational Cosmology** **EXPH 4018**

Gravitational collapse and observational evidence for solar mass size black holes. Primordial black holes. Accretion powered systems. Galaxies and their classification. Quasars, active galactic nuclei, blazers and supermassive black holes. Galaxy forming and clustering. Gamma ray bursts. Observational cosmology. The expanding universe and supernovae observations. Dark matter.

## Genetics – GENE 4000

**Human Genetic Diseases** **GENE 4002**

This course offers students an overview of genetic disorders and the application of molecular techniques to identify disease causing genes. Topics covered include: the inheritance pattern, molecular basis and clinical consequences of inherited genetic defects: the relevance of chromosomal abnormalities and gene-environment interaction to human disease and the techniques used in identifying disease causing genes.

**Developmental Biology** **PHAR 4014**

Details available from the School of Biomolecular and Biomedical Science.

**Structural Bioinformatics** **BIOC 4016**

Structural Bioinformatics is one of the most vibrant and active research areas in modern biology. The methods covered in this course are: Protein structure prediction, homology modelling, protein electrostatics calculations, pKa calculations, molecular dynamics (MD) simulations, molecular force fields, drug/protein-protein docking and prediction of protein folding pathways.

## Geology – GEOL 4000

The Fourth Year course builds on the background of the main branches of Geology with additional material on petroleum and ore geology, geotectonics, micropalaeontology, invertebrate palaeontology and isotope geology. Students carry out an independent mapping project in the Summer before the Fourth Year to be presented as a thesis and a seminar. In addition students attend regular research seminars.

**Palaeontology** **GEOL 4001**

Fossil taxonomy and micropalaeontology; study of foraminifera, conodonts and calcareous algae; faunal provinces; evolution of reefs and their biota; Precambrian fossils and evolution of the biosphere. Major events in the history of life; origin and early evolution of life; Precambrian palaeobiology; Cambrian Radiation Event; mass extinctions in the fossil record; human evolution.

**Stratigraphy** **GEOL 4002**

Upper Palaeozoic Stratigraphy and Sedimentology of NW Europe. North Sea Basin case study: structural control and evolution of sedimentation and hydrocarbon prospectivity in rocks of Devonian to Palaeogene age. Lower Palaeozoic stratigraphy, sedimentology and volcanology of the British Isles and its relationship to tectonics.

**Sedimentology** **GEOL 4003**

Sediment yield and erosion rates. Sea level change. Principles and applications of sequence stratigraphy in alluvial, paralic, carbonate and deep-water settings. Carbonate petrography. Compaction and diagenetic modelling. Reservoir architecture. Subsidence and basin analysis. Extensional, foreland and strike-slip basin fills.

**Metamorphic petrology and Precambrian geology** **GEOL 4004**

Crustal evolution and tectonics of Laurentia-Baltica from Archaean to Neoproterozoic; tectonics and metamorphism of the Dalradian; geochronology of metamorphic processes; thermobarometry and relative thermobarometry; mixed fluid equilibria; eclogites; granulites and thermal aureoles.

**Geological Mapwork and Orogenic Belts** **GEOL 4005**

Crustal evolution based on integrated analysis of orogenic belts using published geological maps and problem maps and structural, petrological, geochemical and geophysical (including palaeomagnetic) data. Examples include the Lapland-Kola orogen; Caledonian orogen in Ireland, Scotland and Norway; Sveconorwegian orogen in Sweden and Norway.

**Igneous Petrology** **GEOL 4006**

Magmatism at constructive and destructive intra-plate margins and intra-plate settings. Evolution of magmatism through geological time. The origin of komatiites and massif anorthosite and their implications for Precambrian earth evolution. The origin and evolution of carbonatitic magmas. Igneous rocks as tracers of the composition and evolution of the mantle.

**Ore Geology** **GEOL 4007**
The mineralogy, geological setting and origin of metallic mineralisation illustrated by examples of globally important ore deposit types.

**Petroleum Geology** **GEOL 4008**
The principles and application of wireline logging, seismic and sequence stratigraphy and drill stem testing. Basin analysis and petroleum play synthesis with special emphasis on the basins of the Middle East and the Irish offshore.

**Structural Geology** **GEOL 4009**
Derivation of kinematics from structural features. Geometry and growth of normal fault systems. Models for thrusting and gravity sliding. The effects of faults and fractures on fluid flow.

**Tectonics** **GEOL 4010**
Tectonic development and deep crustal structure of the Caledonides and the Variscides. Origin and superimposition of non-plane strains in orogenic belts. Salt and inversion tectonics. Models for extensional basin evolution.

**Field Work in Geology**
Field work is an important part of geological training. In addition to field classes referred to under the First and Second Science courses, Third Year honours students and those taking the single subject BSc (General) degree programme are required to attend an eight day field class in southern UK, southern Spain or Cyprus during the Spring vacation, two weekend field classes in Ireland and occasional one day field classes. Fourth Year Geology students attend an eight day field class in southern Spain or Cyprus in the Spring vacation, a seven day mapping course in Ireland following the Summer Examinations, and occasional weekend and one day field classes in Ireland. Honours students carry out an independent mapping project before the start of the Fourth Year. The costs of field classes in Second, Third and Fourth Years are subsidised by the School but students are required to make a financial contribution to the field classes.

## Geophysical Science – IDSC 4002

Students take the three core units in Experimental Physics and Geology and either of GEOL 3010 or GEOL 4013, whichever has not been taken in Third Year.

**Core Units**

**Applied Geology** **GEOL 3004**
For details of this unit see under Geology

**Sedimentology and Volcanology** **GEOL 3006**
For details of this unit see under Geology

**Structural, Petroleum Geology** **GEOL 3007**
For details of this unit see under Geology

**Topics in Geophysics** **GEOL 4014**
Topics related to current research and state-of-the-art ideas not covered in other units.

**Thermodynamics and Statistical Physics** **EXPH 3006**
For details of this unit see under Experimental Physics

**Optics** **EXPH 3009**
For details of this unit see under Experimental Physics.

**Environmental Radiation and Radioecology** **EXPH 4008**
For details of this unit see under Experimental Physics.

***and either***

**Seismology, Global Geophysics** **GEOL 3010**

***or***

**Data Processing and the Crust** **GEOL 4013**
Time series analysis. Seismic reflection and refraction data processing. Forward modelling techniques and synthetic seismograms. Synthetic random media. Ray tracing. Vertical seismic profiles. P- and S-wave studies of the crust. Reflection seismic data interpretation. Sequence stratigraphy. Petrophysics. Potential field data processing and analysis.

In addition, all fourth year students are required to complete a geophysical field or laboratory project during the course of the year. In the case of field projects, the data is collected in the summer before the start of the Fourth Year. This will be presented in thesis form as part of the Final Degree Examination assessment.

These courses are available to Third Year students in other Schools provided they have an adequate background in Experimental Physics and/or Geology.

## Industrial Microbiology – INDM 4000

The following courses are offered in a range of topics, reflecting the specialist interests of the staff. Students must select their courses in consultation with the Head of Subject. All students are required to undertake a substantial laboratory-based research project. Successful students may opt to undertake a project in a research laboratory in industry or a research institute. On completion of the project it is presented in the form of a thesis, which forms part of the Degree Examination. An oral presentation is also required for assessment. Attendance of students at School seminars is obligatory.

| | |
|---|---|
| INDM 4001 | Topics in Bacteria and Fungi |
| INDM 4002 | Microbial Enzyme Technology |
| INDM 4003 | Microbial Genetics of Pathogenic Microorganisms |
| INDM 4004 | Food Microbiology |
| INDM 4005 | Microbial Fermentation Technology |
| INDM 4006 | Advances in Environmental Microbiology |
| INDM 4007 | Medical Microbiology |
| INDM 4008 | Process Microbiology |
| INDM 4009 | Developments in Biotechnology |
| INDM 4012 | Current Topics in Bacteria |
| INDM 4013 | Current Topics in Fungi |
| INDM 4014 | Bacterial Genetics and Synthetic Biology |
| INDM 4017 | Food Microbiology |
| INDM 4019 | Microbial Biofilms |
| INDM 4020 | Microbial Natural Product Biosynthesis |

## Mathematical Physics – MAPH 4101/4200

Students taking the BSc (Single Honours) Degree must take eight courses and students taking the BSc (Joint Honours) Degree must take four courses. Subject to the approval of the Head/Director of Programme, appropriate Honours courses in Mathematics or Experimental Physics may be taken in place of some of these courses.

**Condensed Matter Theory** **MAPH 4112**

Critical Phenomena; Scaling; Renormalization; Langevin Theory; Dynamical Critical Phenomena; Fermi Liquid Theory; BCS Theory of Superconductivity; Ginzburg-Landau Theory; Vortex Matter; Magnetism; Stoner-Ferromagnetism; Antiferromagnetism; Spin Glasses.

**Quantum Computing** **MAPH 4113**

Introduction to the basics of classical computing. University and a proof of Deutsch's theorem. Quantum parallelism and quantum algorithms. Deutsch's problem and the Deutsch-Jozsa promise problem; Simon's XOR problem; Grover's search algorithm. Introduction to factorisation of numbers and Shor's algorithm.

**Differential Geometry** **MAPH 4120**

An Introduction to Differential Geometry for General Relativity:

Tensor algebra. Differentiable manifolds. Affine connections. Torsion tensor. Curvature tensor of a connection. Pseudo-Riemannian manifolds. Riemann curvature tensor. Bianchi identities, Ricci identities.

**Mathematical Foundations of Quantum Mechanics** **MAPH 4130**

Hilbert spaces. Bounded and unbounded operators. Adjoints of operators. Self-adjoint extensions. Spectral theory. The Spectral Theorem for bounded and unbounded self-adjoint operators. Perturbations of self-adjoint operators. Quadratic forms. Free Quantum Fields. The basic principles of scattering in Hilbert space.

**Quantum Mechanics** **MAPH 4141**

Periodic potential, energy bands. Approximation methods of bound states, Helium atom. Zeeman effect. Angular momentum, Clebsch-Gordon coefficients, Wigner-Eckart theorem. Non-relativistic hydrogen atom with spinning electron. Relativistic theory of the electron. Scattering theory.

**Statistical Mechanics** **MAPH 4151**

*Classical Statistical Mechanics:*

The microcanonical ensemble, time averages, ergodicity. The canonical and grand-canonical ensemble, equivalence of ensembles, the thermodynamic limit and phase transitions. Lattice gases and magnetic systems.

*Quantum Statistical Mechanics:*

Trace class operators, density matrices, Fock space, ideal Bose and Fermi gases, Bose-Einstein condensation, lattice models, the Mermin-Wagner argument.

**Computational Physics** **MAPH 4161**

Parabolic equations in one space variable (Schrödinger equation, Diffusion equation). Parabolic equations in two and three dimensions – ADI methods. Hyperbolic equations – Lax Wendroff scheme, flux-limiter methods (fluid dynamics, wave equation). Consistency, convergence and stability. Elliptic equations (Poisson's equation). Finite element method. Metropolis Algorithm (Ising Model), Quantum Monte Carlo (Molecular dynamics).

**General Relativity** **MAPH 4171**

Einstein's field equations. Physical interpretations of the energy-momentum-stress tensor. Newtonian approximation. The Schwarzschild solution. The Kruskal extension of the Schwarzschild manifold. Experimental tests. Interior Schwarzschild solution. Kinematics of a continuous medium. The Robertson-Walker cosmos. The equation of geodesic deviation. Plane gravitational waves and their interaction with clusters of test particles.

*(This course requires MAPH 4181, or MAPH 3141 and MAPH 3151, and MAPH 4120 as pre/corequisites.)*

**Electromagnetic Theory** **MAPH 4181**

Electrostatics: electrostatic potential; Gauss's law; Poisson's equation; dielectrics; electrostatic energy. Magnetic fields due to steady currents: vector potential; Ampère's circuital law; magnetic materials. Maxwell's equations. Energy and momentum: Poynting vector. Plane waves in non-conducting and conducting media. Wave guides. Radiation from bounded sources. Liénard-Wiechert potentials. Relativistic formulation of electromagnetic theory.

*(This course may only be taken in conjunction with MAPH 4141 or MAPH 4171. Students who have taken modules MAPH 3141 and MAPH 3151 cannot take module MAPH 4181).*

**Theoretical Astrophysics** **MAPH 4190**

The universe observed.

*Stellar Physics*: Star formation, heat transfer, nucleosynthesis. Equations of stellar structure. White Dwarfs, Neutron stars.

*Astrophysical Hydrodynamics*: Basic equations, accretion, shock waves, jump conditions, similarity solutions, supernova remnants. Jets.

*Astrophysical Plasmas*: Debye length, plasma frequency, dispersion measure, pulsars. Faraday rotation. Magnetohydrodynamics, Magnetic virial theorem. Alfven waves.

**Numerical Analysis*** **MAPH 4211**

Berstein polynomials. Weierstrass approximation theorem. Lagrange and Hermite interpolation polynomials. Cubic splines. Functional iteration. Second order functional iteration. Newton's method. Method of false position. Aitken's method.

Integration. Ordinary differential equations. Introduction to partial differential equations and Poisson's equation in two dimensions. Linear algebraic equations. Iterative methods. Matrix eigenvalues.

**Theoretical Astrophysics** **MAPH 4212**

Advanced topics in stellar astrophysics and the physics of compact objects. Astrophysical hydrodynamics. Accretion flows, Roche lob overflow and thin accretion disks. Stellar winds and jets. Cosmic explosions and shock fronts. Supernova remnants and relativistic flows. Plasma astrophysics. Waves in plasmas. Magnetohydrodynamics. The magnetic virial theorem and magnetised White Dwarfs. Astrophysical radiation mechanisms.

**Special Topics in Mathematical Physics 1** **MAPH 4192**

Further details available from the School of Mathematical Sciences.

**Special Topics in Mathematical Physics II** **MAPH 4193**

Further details available from the School of Mathematical Sciences.

* This course is given jointly with the School of Mathematical Sciences.

**Viscous Flow** **MAPH 4194**

The Navier-Stokes, Helmholtz vorticity and energy equations. Blasius flow, similarity solutions. Dimensional analysis, Reynolds number. Prandtl's boundary layer equations. 2-d viscous flow, Poiseuille flow. Unsteady unidirectional flow. Instability and turbulence. Slow flow, Stokes' flow and the Oseen approximation. Lubrication theory, slider bearing and squeeze film

## Mathematical Science – MATH 4000
**(SCBDF0014)**

Students take the equivalent of twelve units chosen from the courses listed below. The courses in Mathematics and Mathematical Physics are equivalent to 1.5 units and the courses in Statistics are equivalent to one unit. The combination of courses must be approved by the Programme Director.

**Mathematics**

| | |
|---|---|
| MATH 4101 | Ring Theory |
| MATH 4102 | Group Theory |
| MATH 4103 | Combinatorics |
| MATH 4104 | Measure Theory |
| MATH 4105 | Differential Geometry |
| MATH 4106 | Functional Analysis |
| MATH 4107 | Numerical Analysis |
| MATH 4108 | Financial Mathematics |
| MATH 4109 | Topology |
| MATH 4110 | Commutative Algebra |
| MATH 4111 | Several Complex Variables |
| MATH 4112 | Special Topics |

**Mathematical Physics**

| | |
|---|---|
| MAPH 4120 | Differential Geometry |
| MAPH 4130 | Mathematical Foundations of Quantum Mechanics |
| MAPH 4141 | Quantum Mechanics |
| MAPH 4151 | Statistical Mechanics |
| MAPH 4161 | Computational Physics |
| MAPH 4171 | General Relativity |
| MAPH 4181 | Electromagnetic Theory |
| MAPH 4190 | Theoretical Astrophysics |
| MAPH 4192 | Special Topics in Mathematical Physics I |
| MAPH 4193 | Special Topics in Mathematical Physics II |
| MAPH 4194 | Viscous Flow |

**Statistics**

| | |
|---|---|
| STAT 4211 | Data Analysis I |
| STAT 4212 | Applied Statistics I |
| STAT 4213 | Applied Statistics II |
| STAT 4214 | Time Series Analysis |
| STAT 4215 | Multivariate Analysis |
| STAT 4216 | Actuarial Statistics I |
| STAT 4217 | Actuarial Statistics II |
| STAT 4223 | Official Statistics |
| STAT 4231 | Linear Models with Complex Structure |
| STAT 4232 | Topics in Biostatistics |
| STAT 4233 | Nonparametric Statistics |
| STAT 4235 | Survival Analysis |
| STAT 4238 | Data Analysis II |
| STAT 4253 | Models - Stochastic Models |

## Mathematics – MATH 4100/4200

Eight units must be chosen. A student's choice of units is subject to the approval of the Head/Director of Programme.

**Ring Theory** **MATH 4101**

Rings and modules. Noetherian rings. Hilbert's Nullstellensatz. Simple rings and semisimple rings. Artin-Wedderburn theorem. Burnside's theorem.

**Group Theory** **MATH 4102**

Sylow theorems. Advanced topics in the theory of groups: finite p-groups, local analysis, p-nilpotence, the transfer.

**Combinatorics** **MATH 4103**

Recurrence relations and generating functions. Principle of inclusion and exclusion. Ramsey theory. Latin squares. Designs. Finite geometries.

**Measure Theory** **MATH 4104**

Measure spaces and measurable functions. Integrability. Dominated convergence theorem. Product measures. Radon-Nikodym theorem.

**Differential Geometry** **MATH 4105**
Differentiable atlases. Manifolds and submanifolds. Tangent bundles and vector fields. Riemannian manifolds. Curvature and torsion. Dynamical systems.

**Functional Analysis** **MATH 4106**
Topological vector spaces and linear mappings. Hahn-Banach theorem. Banach-Steinhaus theorem. Hilbert spaces. Riesz-Fischer theorem. Geometry of Banach spaces.

**Numerical Analysis** **MATH 4107**
Weierstrass approximation theorem. Cubic splines. Functional iteration. Newton's method. Aitken's method. Ordinary differential equations. Partial differential equations and Poisson's equation in two dimensions.

**Financial Mathematics** **MATH 4108**
Rates of interest. Annuities, discount, capital redemption policies. Consumer credit, immunization, stochastic interest rate, mortality.

**Topology** **MATH 4109**
Topological spaces and continuous maps. Compactness, connectedness. Separation axioms. Compactification. Quotient spaces.

**Commutative Algebra** **MATH 4110**
Polynomial algebras and affine varieties. Dimension theory of commutative rings. Localization and completion. Projective varieties and graded algebras. Spectra of rings.

**Several Complex Variables** **MATH 4111**

**Special Topics** **MATH 4112**
Fourth Year Honours students may, with the consent of the Head/Director of Programme, substitute an appropriate course or courses in Mathematical Physics for one or more of their Mathematics courses.

## Pharmacology – PHAR 4100/4200

Advanced courses (nine lectures/tutorials per course) are given in specialised areas of pharmacology. These include:

| | |
|---|---|
| PHAR 4001 | Disorders of Haemostasis |
| PHAR 4002 | Neuropharmacology |
| PHAR 4003 | Cancer Studies |
| PHAR 4005 | Nitric Oxide, Vascular Injury and Angiogenesis |
| PHAR 4009 | Molecular Biology of Steroid Hormone Receptors |
| PHAR 4011 | Renal Pharmacology and Toxicology |
| PHAR 4014 | Developmental Biology/Pharmacology |
| PHAR 4015 | Drug Development/Contemporary Technologies |
| PHAR 4016 | Cytokine Receptors/CNS Dopamine Receptors |

A research project is carried out under the direction of individual academic staff members and the completed project is presented in thesis form for the Degree Examination. Oral presentations of research work are also required.

Students are required to attend at School research seminars and small-group discussion sessions.

## Physiology – PHYS 4001

The following courses are offered in a range of topics reflecting the specialised interests of the staff in the School of Biomolecular and Biomedical Science. Each student must attend all of the courses offered.

**Local Control of Vascular Resistance** **PHYS 4002**
Assessment of arterial myogenic (pressure-dependent) activity. Ionic conductance, membrane potential, intracellular calcium changes and lipid second messenger contributions to the myogenic response.

**Vascular Biology of the Lung** **PHYS 4003**
Specialised features of the normal mammalian, pulmonary circulation, control of blood flow through the normal lung, altered blood flow in the acutely hypoxic lung, hypoxia detection, mechanisms of hypoxic pulmonary vasoconstriction, chronic hypoxia and the lung, hypoxic pulmonary hypertension, vascular remodelling and angiogenesis in the hypoxic lung, molecular and cellular mechanisms of remodelling and angiogenesis, control of blood flow through the chronically hypoxic lung, chronic hypoxic lung disease, adaptation to high altitude.

**Renal Physiology and Electrolyte Homeostasis** **PHYS 4004**
Tubular functions. Renal circulation and metabolism. Transport mechanisms. Endocrine and neural control of electrolyte homeostasis.

**Gastrointestinal Physiology** **PHYS 4005**
Recent advances in gastrointestinal physiology. Physiological barriers to gastro-oesophageal reflux. Regulation of vomiting. Neuroanatomy and electrophysiology of the enteric nervous system. Gastric proton pump.

**Neuromodulation of Respiratory Motor Outputs** **PHYS 4008**
Plasticity in the adult and developing respiratory system. Control of cranial motor output. Serotonergic and noradrenergic modulation of respiratory motor outputs.

**Exercise Physiology** **PHYS 4009**
Recent advances in exercise physiology. Control of ventilation. Gender differences. Exercise limitation in health and disease.

**Circuitry in the CNS** **PHYS 4010**
From synapse to circuit: Chemical transmission in the central nervous system. The neurone. The synapse. The microcircuit, intrinsic circuits and the neural network. Principles of chemical neurotransmission. Principles of microdialysis. The motor circuit. Parallel and serial processing in the basal ganglia. The limbic circuit and schizophrenia.

**Electrophysiology of Ion Channels and Neurotransmission** **PHYS 4011**
Voltage-gated ion channels. Ligand-gated ion channels. Passive membrane properties. Integration of neuronal activity. Pathologies associated with ion channel dysfunction.

**Physiology of Synaptic Plasticity** **PHYS 4012**
Long-term potentiation and long-term depression in the hippocampus, role of glutamate receptors and calcium in synaptic plasticity.

**Physiological Methods** **PHYS 4014**
This unit will discuss methodologies used in physiological measurement reflecting the expertise of individual staff members.

Each student is required to carry out a supervised laboratory-based research project, which has to be presented orally and submitted in minor thesis form as part of the Degree Examination assessment. In addition, students are required to attend School research seminars and discussion groups and undergo continuous assessments.

## Plant Genetic Engineering – BOTN 4100

Each student must attend ten of the following courses and undertake a Research Project in consultation with the Programme Director.

**Evolution in Plant Populations** **BOTN 4003**
For details of this unit see under Botany.

**Eukaryotic Genome** **BOTN 4006**
For details of this unit see under Botany.

**Plant – Pathogen Interactions** **BOTN 4008**
For details of this unit see under Botany.

**In Vitro Techniques** **BOTN 4009**
For details of this unit see under Botany.

**Critiques of Scientific Papers** **BOTN 4011**
For details of this unit see under Botany.

**Science and Society** **BOTN 4013**
For details of this unit see under Botany.

**Developmental Plant Genetics** **BOTN 4014**
For details of this unit see under Botany.

**Plant Transformation** **BOTN 4016**
Agrobacteria-mediated transformation, direct gene transfer, selection, screening, use of transgenics in modifying plant metabolism and development. Co-supression and anti-sense strategies.

**Plant Food Safety** **BOTN 4017**
Testing procedures for dietary compatibility of modified plant proteins, lectins, haemagglutinines. Consequences of alteration of enzyme activities in metabolic cassettes.

**GMOs in the Environment** **BOTN 4018**
The release of GMOs and their consequences. Regulatory procedures.

**Molecular Biology and Plant Breeding** **BOTN 4019**
RFLP, PAPD, microsatellite and repeated sequences in genotyping and haplotyping, varietal identification and pathogen detection. Transformation and genetic engineering in plant breeding. Identification of differentially expressed genes.

**Immunobiology** **CELB 4002**
For details of this unit see under Cell and Molecular Biology.

## Psychology – PSY 4200

(Available only to those students taking Honours Psychology. All Honours students take PSY 4201 – PSY 4215 inclusive and select two Optional Units from PSY 4216 – PSY 4224.)

**Core Units:**

| | |
|---|---|
| PSY 4201 | Neuropsychology |
| PSY 4202 | Advanced Cognitive Psychology |
| PSY 4203 | Social: Social Cognition |
| PSY 4204 | Social: Group Theory and Processes |
| PSY 4205 | Social: Constructivism and Gender |
| PSY 4206 | Aspects of Self and Identity |
| PSY 4207 | Applied Psychology & Work |
| PSY 4208 | Language: Symbols to Societies |
| PSY 4209 | Perspectives on Development |
| PSY 4210 | Applied Developmental |
| PSY 4211 | Intelligence |
| PSY 4212 | Current Debates in Psychology |
| PSY 4213 | Philosophical Psychology |
| PSY 4214 | Advanced Stats/Computer Analysis |

**Research Project** **PSY 4215**

Honours Psychology students are required to undertake a research project and to write a minor thesis under the direction of individual academic staff members for the Degree Examination. In addition, students are required to attend School research seminars and discussion groups.

**Optional Units:**

| | |
|---|---|
| PSY 4216 | History and Psychology |
| PSY 4217 | Behavioural Paediatrics |
| PSY 4218 | Counselling and Psychotherapy |
| PSY 4219 | Psychology and Education |
| PSY 4220 | Reading |
| PSY 4221 | Comparative Psychology |
| PSY 4222 | Attachment Theory |
| PSY 4223 | Emotions and Mind |
| PSY 4224 | Organisational Psychology |

***Notes for Final Year Students:***

- Students are required to attend tutorials and School seminars, and to submit essays.
- Practical work may also be required in certain courses.
- Up to 25% of the marks allocated to any unit may be awarded for practical work.
- Some courses may not be offered in a particular year.

## Statistics – STAT 4200

**Data Analysis I** **STAT 4211**

**Applied Statistics I** **STAT 4212**

Design and Analysis of Experiments. Complete Block Designs (Randomized Block and Latin Square Designs). Incomplete Block Designs. Factorial Designs. Confounding and Fractional Factorial Designs. Statistical Software.

**Applied Statistics II** **STAT 4213**

Introduction to Sample Surveys. Contingency Table Analysis. Logistic Regression. Log-linear Models. Statistical Computing.

**Time Series Analysis** **STAT 4214**

Characteristics of time series. Autocorrelation and cross-correlation function. Stationary time series. Autoregressive and moving average processes. Nonstationary time series. Model specification and estimation. Model diagnostics. Forecasting. Special topics.

**Multivariate Analysis** **STAT 4215**

Random vectors. Multivariate Normal Distribution, Correlation and Regression. Hotelling's $T^2$ Statistic. Discriminant Analysis. Canonical Correlation. Principal Components Analysis. Multivariate Analysis of Variance.

**Actuarial Statistics I** **STAT 4216**

Economics of Uncertainty. Risk Theory and Utility. Jensen's Inequality. Sums of Random Variables and Convolutions. Loss Distributions. Reinsurance. Risk Models. Mixtures of Random Variables and Mixtures of Distributions.

*This unit is not available to students who have taken STAT 3216.*

**Actuarial Statistics II** **STAT 4217**

Ruin theory. Lundberg's Inequality. Credibility Theory. No Claims Discounting. Applications in Insurance.

*This unit is not available to students who have taken STAT 3217.*

**Official Statistics** **STAT 4223**

Collection of official statistics including macro-economics, business, demographic and social statistics. Accessing official statistics and their applications. Estimation, imputation and seasonal adjustment.

**Statistics – Laboratory Assays** **STAT 4230**

**Linear Models with Complex Structure** **STAT 4231**

Analysis of unbalanced data from surveys and experiments. Partitions of data in orthogonal designs. Means model. Estimation of variance components in unbalanced mixed and random effect models. Methods for the analysis of repeated measures data.

**Topics in Biostatistics** **STAT 4232**

This course covers specialised applications of statistics in biology. Topics include the following: Pharmaceutical statistics, ecological statistics, medical and epidemiological statistics.

**Nonparametric Statistics** **STAT 4233**

Distribution-free statistics; statistics utilizing counting and ranking; Wilcoxon statistics; Kruskal-Wallis statistic. Friedman statistic; Spearman's statistics; Permutation procedures; Power functions and asymptotic distribution. Nonparametric regression.

**Regression Theory** **STAT 4234**

Simple and Multiple Linear Regression. Weighted Least Squares. Lack of Fit. F tests. Residuals and Influence. Model Building.

**Survival Analysis** **STAT 4235**

Censoring. Life tables. Kaplan Meier estimate. Mantel-Haenzel statistics. Parametric methods. Cox's proportional hazards model. Goodness-of-Fit.

**Statistical Computing** **STAT 4236**
Fixed point and floating point arithmetics. A review of programming style. Random number generators. Monte Carlo applications. A review of maximum likelihood. Unconstrained nonlinear optimizations. Accessing Fortran libraries.

**Data Analysis II** **STAT 4238**

**Data Mining** **STAT 4240**

**Models - Stochastic Models** **STAT 4253**
Principles of modelling. Main classes of stochastic processes. Markov chains. Marko jump processes. Monte Carlo simulation.

## Theoretical Physics – MAPH 4100
**(SCBDF0012)**

Students take the equivalent of twelve units. These are chosen from the courses listed below. The courses in Group A are equivalent to 1.5 units and the courses in Group B are equivalent to one unit.

**Group A**

| | |
|---|---|
| MAPH 4120 | Differential Geometry |
| MAPH 4130 | Mathematical Foundations of Quantum Mechanics |
| MAPH 4151 | Statistical Mechanics |
| MAPH 4161 | Computational Physics |
| MAPH 4171 | General Relativity |
| MAPH 4191 | Theoretical Astrophysics |
| MAPH 4192 | Special Topics in Mathematical Physics I |
| MAPH 4193 | Special Topics in Mathematical Physics II |
| MAPH 4194 | Viscous Flow |

**Group B**

| | |
|---|---|
| EXPH 4002 | Quantum Mechanics and Nuclear Physics |
| EXPH 4004 | Atomic and Molecular Physics |
| EXPH 4005 | High Energy Particle Physics |
| EXPH 4009 | Perspectives in Modern Astrophysics |
| EXPH 4010 | Atomic Structures and Spectra |
| EXPH 4013 | Condensed Matter Physics |
| EXPH 4016 | Interdisciplinary Computational Physics |
| EXPH 4017 | Experimental Laboratory Option |

Also, at most 1.5 units may be in a more advanced topic, which will normally be in one of the following areas.

- Quantum Field Theory
- Quantum Gravity
- Advanced Mathematical Statistical Mechanics
- Advanced General Relativity
- Advanced Theoretical Astrophysics

## Zoology – ZOOL 4000/4200

Students must choose and attend seven units. Units will only be offered if sufficient students choose to take them. Each student undertakes a research project which is written and presented as a thesis. Each student must give an oral presentation based on their research project. In addition, students are required to write a literature review and an essay on an assigned topic. Attendance at Research Seminars is obligatory.

**Environmental Impact Assessment** **ENVB 4002**
For details on this unit, see under Environmental Biology.

**Biodiversity** **ZOOL 4001**
Evolution and maintenance of biodiversity within systems. Equilibrial and nonequilibrial models of community organisation. Global patterns of species diversity. Functional redundancy. The Irish fauna.

**Ecology of Tropical Rainforests** **ZOOL 4005**
The paradox of tropical luxuriance: climate, soil, vegetation and nutrient cycling. Biodiversity in tropical forests. Rainforests as a vanishing resource with emphasis on ethnopharmacology. Accounts of expeditions to West Central Africa and Amazonia. Models for sustainable use.

**General Zoology** **ZOOL 4012**
This is the coding for the examination paper on general zoology in the Final Examination.

**Prion Diseases** **ZOOL 4014**
This course examines the current research into the agents responsible for the animal and human Transmissible Spongiform Encephalopathies. It includes the nature of the agent, its genetics, cell biology and epidemiology.

**Marine Community Ecology** **ZOOL 4016**
Patterns of community structure in benthic marine habitats, such as rocky shores, sandy beaches and kelp forests. Spatial and temporal scales of variation. Interactions between physical factors and biological processes such as recruitment, competition and predation. Detecting and reducing human impacts in a variable world.

**Genomic imprinting, chromatin and epigenetics** **ZOOL 4018**
Parent of origin-dependent gene expression in mammals: molecular mechanisms, evolution and implications for embryonic development, cancer and animal cloning.

**Bioassessment of Freshwaters** **ZOOL 4019**
Contemporary bioassessment approaches using fish, invertebrates and plants, ecosystem integrity, stress factors, reference conditions, typologies, biological indicators, analyses and interpretation of data, biotic metrics and indices, predictive models.

**Human Evolution** **ZOOL 4020**
Biology and diversity of the order Primates. Assessment of rate, timing and sequence of evolution of humans through genetic analyses, fossil record and paleogeograpgy. Current controversies in evolutionary psychology will be discussed.

**Insect-plant interactions** **ZOOL 4022**
This course examines interactions between insects and plants and the mechanisms that underpin both antagonistic and mutually beneficial relationships. Key topics addressed include coevolution, modes of herbivory, feeding mechanisms and host plant defence, applied perspectives and molecular approaches to the age-old problem of food production.

**Biodiversity Collections Research** **ZOOL 4023**
This course offers hands-on experience in the use of zoological collections in collaboration with Dublin's Natural History Museum and includes a workshop component. Topics covered include: systematics and the reconstruction of evolutionary relationships; biodiversity and conservation of global faunas; zoological specimen collection and curation; identification, zoological nomenclature and taxonomy.

**Molecular Phylogenetics – Powers and Pitfalls** **ZOOL 4024**
Dobzhansky (1973) argued that "*Nothing in biology makes sense except in the light of evolution.*" However, evolution only makes sense in light of a robust and resolved phylogenetic tree. Originally phylogenies were constructed using morphological data, but now, in the post-genomic era, the majority of phylogenies are created using molecular data. 'Molecular phylogenetics' is an extremely powerful tool that is increasingly used in the fields of molecular zoology, systematics, biogelgraphy, comparative genomics, conservation genetics, virology, epidemiology, molecular evolution, paleontology and forensics. This course focuses on the main philosophies and methods used in molecular phylogenetic analyses. It explores the pros and cons of both morphological and molecular phylogenetic techniques.

**Fish Population Biology** **ZOOL 4025**
Ecology and evolution of marine fish populations. Fisheries genetics. Spatial ecology. Lagoon ecology. Conservation and management of aquatic resources.

# Part Time Degree Programme

## BSc Degree in Occupational Safety and Health Management (SCBDP0012)

1. Applicants to this part time BSc Degree course must have completed and achieved a high standard in the NUID Diploma in Safety, Health and Welfare at Work or equivalent. Applicants should also have at least two years' relevant work experience.
2. A limited number of places are available on the course. Applications should be made in writing to: Centre for Safety and Health at Work, NovaUCD, University College Dublin, Belfield, Dublin 4. Closing date for receipt of applications is 30 April each year.
3. The Degree course is a part time course and will normally be completed in two years.
4. The foundation unit, SHWW 3201 Research Methods, Data Processing and Analysis, is offered each year. This unit is compulsory for students in the first year of the programme. Thereafter each core and elective unit is offered once every second year to both First and Second Year students who attend lectures together.
5. Project work is based on individual work placements in industry (which may be in the student's own workplace), which takes place over both first and second years of the Degree programme.
6. Examinations will be held each year in Summer with repeat examinations in Autumn.

**Core Units**

**Research Methods, Data Processing and Analysis** **SHWW 3201**
Introduction to programme, its objectives and knowledge and skills needed to carry out workplace placement and research project. Builds on and adds to Epidemiology and Statistics in the Diploma course. Use of software packages for data analysis, and report/thesis writing skills.

**Risk Management** **SHWW 3202**
Advanced risk management techniques relating to management of safety and health in the workplace, including cost benefit analysis, claims investigation and analysis, practical legal issues that relate to risk management and stages of litigation process.

**Applied Management for Occupational Safety and Health** **SHWW 3203**
Practical management skills, communication skills, strategic planning and project management. Relevant industrial relations and human resource issues relating to occupational safety and health in organisations. Builds on Ergonomics and Behavioural Science and Safety and Health Legislation in the Diploma course.

**Occupational Safety and Health and Environmental Management SHWW 3204**
Legislative and practical links between management of occupational safety and health and management of workplace environmental issues. Addresses needs of occupational safety and health professionals whose brief includes environmental issues. Explores roles of organisations involved in managing health and safety and the environment.

**Safety Management and Quality Auditing** **SHWW 3205**
Quality Auditing and Standard Setting: how these principles can be applied to Occupational Safety and Health Management. Existing standards, contemporary trends and legislative requirements. Safety Management Systems are addressed in detail.

**Industrial Placement** **SHWW 3209**

**Project SHWW** **3210**

**Elective Units**

Students must choose one of the following units:

**Occupational Hygiene – the Working Environment** **SHWW 3206**
Occupational Hygiene practice, including personal and environmental monitoring in workplace. Builds on Occupational Hygiene in the Diploma course.

**Occupational Health** **SHWW 3207**
Issues that relate to occupational health practice; skills required to run an occupational health deparrtment; legislation; the occupational health professional as part of multidisciplinary team; models of occupational health and occupational health nursing; and contemporary issues in occupational health practice.

**Ergonomics** **SHWW 3208**
Ergonomic issues in contemporary work setting: the person, the environment, the equipment and the job. Legislation; the ergonomist as part of multidisciplinary team; ergonomic assessment; job and task analysis; analytical tools; and contemporary issues in workplace ergonomics.

**Toxicology** **PHAR 3004**
For details of this unit see under Pharmacology.

# BSc Honours Degree in Medical Subjects for Medical Students or Graduates (SCBDF0010)

The Degree of BSc with Honours in Medical subjects may be conferred in any one of the following subjects: (a) Anatomy, (b) Biochemistry, (c) Medical Microbiology, (d) Pathology, (e) Pharmacology, (f) Physiology.

1. Students who have passed the appropriate University Examination in Medicine in the corresponding subjects at a standard of at least Second Class Honours are eligible to take the BSc Degree in that subject. To be eligible to pursue the Degree of BSc in Anatomy or Biochemistry, students must have passed the University Examination of the Second Year of Medicine with Honours and must also have passed the University Examination of the Third Year of Medicine.
2. Candidates who hold the Degrees of MB, BCh and BAO may be recommended by the College for admittance to the Honours Degree courses in any one of the subjects (a) to (f).
3. For admission to the Honours Degree Examination in subjects (a) to (f), candidates must have attended the prescribed courses for at least one academic year.
4. Particulars of the prescribed courses are given in the Medicine booklet. At the discretion of the Professors/Heads of Schools concerned, special instruction in related subjects may be arranged.
5. Students will only be admitted to this programme subject to the approval of the relevant Heads of Schools.

## Postgraduate Programmes

The following postgraduate programmes are offered by the Schools:

**Degree of Doctor of Philosophy (PhD)**
(research and thesis)

**Degree of Master of Science (MSc)**
Mode I (research and thesis)
Mode II or Mode III (course and examination)

**Degree of Master of Applied Science (MApplSc)**
(course and examination)

**Higher Diploma**

**Diploma**

**Certificate**

Further information on all postgraduate programmes is available in the separate publication**, Science Postgraduate Programmes Booklet.**

# European Credit Transfer System (ECTS)

**Credit Scheme for the Undergraduate Degree Programme in Science for Visiting Students from European Universities**

| Year | Subjects | Unit Courses | Credits | Total Per Year |
|---|---|---|---|---|
| Second Science | 3 | 12 | 5 per unit | 60 credits |
| Third Science | * | 10 | 6 per unit | 60 credits |
| Fourth Science | * | - | 60 per year | 60 credits |

See regulations for Single Honours, Joint Honours, Topical, One-Subject General and Two-Subject General Degrees for number of subjects involved.

**ECTS for Fourth Science Subjects**

| Subject | Credits | Comments |
|---|---|---|
| **Biochemistry** | 40 Credits for Lecture Course (4 credits per unit)*<br>20 Credits for course work as follows: -<br>Project: 18 Credits**; Essay/Seminar: 2 Credits** | *10 units taken of which 1 Unit = Problem Paper (Unit BIOC 4017 – Compulsory, but only available to 4th Year Honours Biochemistry Students);<br>**Only available to 4th Year Honours Biochemistry Students. |
| **Botany** | Theory 4.2 per unit (total 42 credits); Final year essay 1.8; Seminar series 1.2; Final year research project 15.0 | |
| **Chemistry** | 42 credits for 5 x 3-hour papers; 18 credits for 2 x research projects | |
| **Computer Science** | Final Year Project = 18 credits; 5.25 credits per course unit | These ECTS credit ratings apply to both Fourth Year of the BSc (Honours) Computer Science Degree programme and Fourth Year BSc (Honours) Computer Science [denominated entry programme] |

| Subject | Credits | Comments |
|---|---|---|
| **Experimental Physics** | 40 credits for lecture courses; 10 credits per semester for laboratory work | |
| **Geology** | 4.5 credits per taught unit; field courses = 5 credits; mapping project = 10 credits | |
| **Industrial Microbiology** | 6 credits per unit; Project = 18 credits | |
| **Mathematical Physics** | 7.5 credits per unit | |
| **Mathematics** | 7.5 credits per unit | |
| **Pharmacology** | Project 12 credits; 9 taught modules each worth 5.33 credits | |
| **Physiology** | Project = 28 credits<br>Paper 1= 8 credits<br>Paper 2= 8 credits<br>Paper 3= 8 credits<br>Paper 4= 8 credits | The courses to be examined in each paper may vary. Please contact Physiology for the modules currently examined in each paper. |
| **Psychology** | Research Project = 15 credits; 2 Taught modules with 5 credits each; 14 Taught modules with 2.5 credits each | |
| **Statistics** | 6 credits per unit in the Single Honours Programme; 5 credits per unit in the Joint Honours programme | |
| **Zoology** | 4.5 credits per unit; 18 = Project and accompanying literature review; 4 = Essay; 2 = Statistics course | |