This handbook applies to all students taking TR061 Chemical Sciences. It provides a guide to what is expected of you on this programme, and the academic and personal support available to you. Please retain for future reference.

The information provided in this handbook is accurate at time of preparation. Any necessary revisions will be notified to students via email and the Science Course Office website (http://www.tcd.ie/Science). Please note that, in the event of any conflict or inconsistency between the General Regulations published in the University Calendar and information contained in course handbooks, the provisions of the General Regulations will prevail.

Produced by: The Science Course Office
Trinity College Dublin 2
Tel: +353 1 896 1970
Web Address: http://www.tcd.ie/Science/
Important information on COVID-19 restrictions and modes of teaching and learning

In order to offer taught programmes in line with government health and safety advice, teaching and learning in Semester 1 for your programme will follow a blended model that combines online and in-person elements to be attended on campus. This blended model will include offering online lectures for larger class groupings, as well as in-person classes for smaller groups: the differing modes of teaching and learning for particular modules are determined by your home School. Information on the modes of teaching and learning in Semester 2 will be available closer to the time.

Trinity will be as flexible as possible in facilitating late arrivals due to travel restrictions, visa delays, and other challenges arising from the COVID-19 pandemic. If you expect to arrive later than 28th September, please alert your course coordinator as early as possible.

For those students not currently in Ireland, according to current Government health and safety guidelines, please note that these students are expected to allow for a 14-day period of restricted movement after arrival and prior to commencement of their studies, and therefore should factor this into their travel plans.

For those students currently on the island of Ireland, we remind you of the Irish Government’s advice that all non-essential overseas travel should be avoided. If you do travel overseas, you are expected to restrict your movements for 14 days immediately from your return, during which time you will not be permitted to come to any Trinity campus. Therefore, as you are required to be available to attend College from the beginning of the new teaching year on 28 September, please ensure you do not return from travel overseas any later than 13 September.
TR061: Chemical Sciences introduction

Welcome to your first year in the TR061 Chemical Sciences degree programme! The Chemical Sciences play a central role among the sciences. Chemistry is the study of matter, that is, the composition, structure and properties of substances and the changes they undergo. Life on Earth owes its origin to a series of these chemical changes. An understanding of molecular structures and properties and how to tailor those through chemical changes is critical in many scientific fields and underpins important technologies we rely on every day.

Chemistry is a dynamic discipline that interfaces constantly with other disciplines. Chemists enjoy analysing, synthesising, and designing new compounds and materials to solve modern societal, medical and environmental challenges. Chemists also engage in the creative process of developing new models and theories to explain the workings of our natural world. As part of your degree you will learn core foundational principles of the chemical sciences but will also be introduced to new areas of chemistry at the frontiers with biology, physics, medicine and computer sciences. Importantly, we will help you acquire proficiency in technical methodologies while supporting the development of effective professional communication skills that are essential for your future career, whether you aspire to becoming a practicing chemist in industry or academia, or to working in business, consultancy or social enterprises.

Formal Chemistry teaching in TCD commenced in August 1711 as part of the new School of Medicine and is now delivered by the staff in the School of Chemistry. The TR061 Chemical Sciences is a new and highly flexible 4-year degree programme that allows you to tailor the focus of your degree through selection of module combinations over the course of your entire undergraduate education. Entry into TR061 gives you the option to choose amongst five Moderatorships as exit routes, namely:

- Chemistry;
- Chemistry with Biosciences;
- Chemistry with Molecular Modelling;
- Medicinal Chemistry;
- Nanoscience.

Junior Freshman module choices recommended and/or required for completing each of the above Moderatorships are discussed in this handbook.

Staff, Research and Facilities in the School of Chemistry

The School of Chemistry currently has 23 academic staff and 15 technical staff. The School has an active research programme, with approximately 100 postgraduate students and postdoctoral researchers. They study a range of subjects such as organic, inorganic, organometallic, physical, theoretical, medicinal, analytical, material, polymer, environmental, and supramolecular chemistry. Research income is earned from national, international and commercial sources and the School has held grants in all relevant research programmes funded by the EU. The College also fosters an interdisciplinary approach to research, with members of the School having strong links with colleagues in the physical, technological and biological sciences both within College, nationally and internationally.
The main building includes two lecture theatres and four recently refurbished research laboratories. A suite of teaching laboratories (the Cocker laboratories) provides facilities for the teaching of preparative inorganic and organic chemistry. The Sami Nasr Institute for Advanced Materials (SNIAM), which was completed in 2000, provides ca. 1500 m² of accommodation for the School of Chemistry. This includes a Physical Chemistry teaching laboratory and six research laboratories to house ca. 40 researchers. Computational Chemistry research is housed in the Lloyd Institute on a multidisciplinary computational-science floor comprising researchers from Mathematics, Physics, Chemistry and High Performance Computing. In addition, chemists play an important role in interdisciplinary research taking place in TCD’s research institutes: (i) the Nanoscience Institute – The Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), which was formally opened in January 2008 and (ii) the Trinity Biomedical Sciences Institute (TBSI), which was inaugurated in July 2011.

As part of your degree you will gain exposure to open ended research thanks to the support of academic staff who work at the cutting-edge of science and through access to state-of-the-art instrumentation. The school is well equipped for its research activities, having Agilent 800 and 400 MHz, and Bruker 600 and 400 MHz high-field multi-nuclear NMR, FTIR, dispersive IR and UV-visible spectrometers, high performance liquid (HPLC) and gas (GC) chromatography equipment, a Rigaku Saturn 724 Diffractometer and Bruker SMART APEX single crystal and Siemens D500 powder diffractometers, Micromass LCTTM (TOF) mass spectrometer, thermogravimetric analysis and differential scanning calorimetry, dynamic light scattering, several spectrofluorimeters for steady-state and time-resolved fluorescence measurements, circular and linear dichroism, and a large range of wave generators and potentiostats for cyclic voltammetry.
TR061 Chemical Sciences overview session and module selection.

Module choices will be made online. Please note that choices you make in Junior Freshman year may influence your choices in the Senior Freshman year.

Please read the following information on pages 3, 4 and 5 and then go to the TR061 Module Choice Form to select your modules. If you feel that you need assistance with your choices, please contact us at jfsco@tcd.ie and we will be happy to help.

In their Junior Freshman year all students must take the 4 core modules for a total of 40 ECTS (20 ECTS per semester) as follows:

<table>
<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHU11101</td>
<td>General and Physical Chemistry</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>CHU11102</td>
<td>Introduction to Inorganic and Organic Chemistry</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>MAU11S01</td>
<td>Mathematics for Scientists 1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>MAU11S02</td>
<td>Mathematics for Scientists 2</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

Students will choose 2 additional modules among those approved for the TR061 programme, for a total of 20 ECTS (10 ECTS per semester). The following two module patterns are available to all students in TR061:

<table>
<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYU11101</td>
<td>From Molecules to Cells</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>PYU11F20</td>
<td>Foundation Physics for Life and Earth Scientists 2</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>Semester</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PYU11P10</td>
<td>Physics 1</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>PYU11P20</td>
<td>Physics 2</td>
<td>2</td>
<td>10</td>
</tr>
</tbody>
</table>
TR061: Chemical Sciences Pathways

In the Junior and Senior Freshman years TR061 students complete a course of study which will qualify students to apply for places in one of the following Moderatorships after their Senior Freshman year:

- Chemistry (C)
- Chemistry with Bioscience; (CB)
- Chemistry with Molecular Modelling (CMM)
- Medicinal Chemistry (MC)
- Nanoscience (N)

The curriculum in the five Moderatorships is tailored and balanced to offer a general Chemistry degree (C), a degree with greater emphasis on computational methods in chemistry, (CB) a degree focusing on the chemicals and chemical reactions involved in biological processes, (CMM), a degree focusing on the synthesis and applications of small drugs for medicinal purposes (MC) and a degree with emphasis on the chemistry and physics of advanced materials and nanomaterials (N). We recommend discussing with the academic staff available during orientation week which of these Moderatorships is best aligned with your current interests. Importantly, students should ensure that module choices over JF and SF years fulfil the requisites to apply for a place in the preferred Moderatorship/s.

The pattern choices outlined in the previous section prepare the student through a different balance in the content of their foundation courses. The credits dedicated to each discipline depending on module pattern choice are outlined below:

<table>
<thead>
<tr>
<th></th>
<th>Pattern JF.1</th>
<th>Pattern JF.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core credits</td>
<td>20 ECTS Chemistry</td>
<td>20 ECTS Chemistry</td>
</tr>
<tr>
<td></td>
<td>20 ECTS Maths</td>
<td>20 ECTS Maths</td>
</tr>
<tr>
<td>Approved credits</td>
<td>10 ECTS Biology</td>
<td>20 ECTS Physics</td>
</tr>
<tr>
<td></td>
<td>10 ECTS Foundation Physics</td>
<td></td>
</tr>
</tbody>
</table>

The Table below summarises which JF module patterns fulfil requisites to apply for each of the four Moderatorships.

<table>
<thead>
<tr>
<th>Chemistry (C)</th>
<th>Chemistry with Bioscences (CB)</th>
<th>Chemistry with Molecular Modelling (CMM)</th>
<th>Medicinal Chemistry (MC)</th>
<th>Nanoscience (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern JF.1</td>
<td>Pattern JF.1</td>
<td>Pattern JF.1</td>
<td>Pattern JF.1</td>
<td>Pattern JF.2</td>
</tr>
<tr>
<td>OR Pattern JF.2</td>
<td>Pattern JF.1</td>
<td>Pattern JF.1</td>
<td>Pattern JF.1</td>
<td>Pattern JF.2</td>
</tr>
</tbody>
</table>
Studies in your SF year of TR061 will also allow for a choice of open modules, however it is important to note that open SF modules will require the student to have completed the corresponding pre-requisites:

- the BYU11101 module is a pre-requisite to Biology modules in SF year
- the PYU11P10/P20 modules are pre-requisites to Physics modules in SF year

**Semester Structure**

### TR061: CHEMICAL SCIENCES

**CORE MODULES (mandatory) – 20 credits per semester**

<table>
<thead>
<tr>
<th>SEMESTER 1 – Michaelmas term (5th October – 18th December)</th>
<th>SEMESTER 2 – Hilary Term (1st February – 23rd April)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHU11101: General and Physical Chemistry</td>
<td>CHU11102: Introduction to Inorganic and Organic Chemistry</td>
</tr>
<tr>
<td>MAU11S01: Mathematics for Scientists 1</td>
<td>MAU11S02: Mathematics for Scientists 2</td>
</tr>
</tbody>
</table>

**OPEN MODULES (optional): Students choose 10 credits from each semester**

<table>
<thead>
<tr>
<th>BYU11101: From Molecules to Cells</th>
<th>PYU11F20: Foundation Physics for Life and Earth Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>PYU11P10: Physics 1</td>
<td>PYU11P20: Physics 2</td>
</tr>
</tbody>
</table>

**Change of open modules**

If, after a couple of weeks, a student feels that they have perhaps made the wrong choice of open module, they should seek advice immediately from a Tutor, Course Director or the Science Course Office. It may be possible to change from one module to another within your course, subject to permission from the Associate Dean of Undergraduate Science Education. Once a decision has been made to change modules, it should be done quickly - it can be difficult to try to catch up with work in a new module when more than two or three weeks of lectures have been missed. Change of module forms are available from the Science Course Office.
CHU11101: General and Physical Chemistry
Semester 1, 10 credits

Rationale and Aims: To provide a general introduction to chemistry and physical chemistry and equips the student with the knowledge to understand the basic concepts in chemistry, understanding of the building principles of matter, chemical bonding and molecular structure, an introduction to thermodynamics, electrochemistry, acid/base reactions and to the chemistry of liquids, solids and solutions.

Content Layout

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4 (15 L)</td>
<td>Introduction to General Chemistry</td>
</tr>
</tbody>
</table>

- Motivation for studying chemistry; physical states of chemical matter; classification of matter, physical and chemical properties of pure substances and mixtures; extensive and intensive properties; chemical analysis.
- Measurements and units; the international system of units; derived units, the reliability of measurements and calculations; significant figures in simple calculations.
- Structure and building principles of atoms; element symbols; masses and the mole; introduction to the periodic table; brief introduction into the structure of the electron shell; ionisation energy and electron affinity.
- Law of conversation of mass; law of definite composition; bonding in chemical substances; ionic bonding; covalent bonding; weak bonding; molecules and solid state structures; electronegativity; the periodic table.
- Chemical nomenclature of inorganic compounds; stoichiometry; mole, molarity and concentration; interpreting stoichiometric coefficients; example calculations.
- Chemical reactions; symbolizing reactions; balancing equations; limiting reagents and yields; role of water in chemical reactions; important classes of chemical reactions; precipitation reactions; examples of precipitation reactions in chemistry net ionic equations.
- Introduction into acid and base reactions; acid-base titration, introduction into oxidation and reduction reactions; oxidation number and electron transfer; oxidizing and reducing agents; half-reactions.
- Oxidation and reduction reactions, electron transfer; oxidizing and reducing agents; half-equations.
The Electronic Theory of Chemistry

1. Periodic Classification
   - Atoms, Molecules, and Ions.
   - Atomic Structure and the Periodic Table.
   - The spectrum of atomic hydrogen.
   - Wave properties of particles.
   - The structures of many-electron atoms. Orbital energies.
   - The building-up principle.
   - A survey of periodic properties.
   - Periodicity of physical properties.

2. Structure and Bonding
   - Lewis structures of polyatomic molecules.
   - Bond parameters.
   - Charge distribution in compounds.
   - Assessing the charge distribution.
   - Polarization. Ionic and atomic radii.
   - Ionization energy and Electron Affinity.
   - Electronegativity.
   - Dipole moments Polar and non-polar molecules.
   - The Chemical Bond. Ionic bonds.
   - The formation of ionic bonds.
   - Variable valence.
   - Covalent bonds.
   - The electron-pair bond. Lewis acids and bases.
   - The Shapes of Molecules.
   - Valence Shell Electron Repulsion theory.
   - The arrangement of electron pairs.
   - Polar molecules.
   - The orbital model of bonding.
   - Hybridization.
   - Molecular orbitals.
   - Bonding in Period 2 diatomic molecules.
   - A perspective on chemical bonding.

5-12 (24 L) Introduction to Physical Chemistry

- The ideal gas law
- Kinetic molecular theory of ideal gases
- Differences between real and ideal gases
- The First Law of Thermodynamics
- Internal Energy, Enthalpy and Calorimetry
- The Second Law of Thermodynamics: entropy
- The Carnot cycle
- Gibbs’ Free Energy
- Chemical Equilibrium
- Boltzmann’s Factor
- Acids-Bases and Titrations
- Electrochemistry: Nernst equation, electrochemical potential, galvanic cells, electrolysis
- Phases of state
- Intermolecular forces – origin, distance-dependence and effect on properties
- Structure and packing of solid structures and their properties
- Properties of liquids – viscosity, surface tension, vapour pressure
- Water – the universal solvent
- Phase transitions and phase diagrams
- Thermodynamics and phase transitions
- Solutions: liquids in liquids, gases in liquids, solids in liquids
- Thermodynamics of solvation
- Colligative properties

Reading list/ Indicative Resources
- Chemistry & Chemical Reactivity Hardcover by Paul Treichel, John Kotz, John Townsend, David Treichel; Publisher: Brooks Cole; 9 ed.

Methods of Teaching and Student Learning
A mixture of lectures, tutorials and hands-on laboratory practicals are used in the delivery of this module. The practical sessions are formatted in order to further clarify concepts thus reinforcing learning. A weekly hour of tutorial problem solving activities provides an additional opportunity for the lecturer to assess understanding and gauge the knowledge level of the students. All lecture notes and problem sheets and a selection of self-assessment quizzes are available for students on Blackboard.

Learning outcomes
On completion of this module the student should be able to:
- Explain, using appropriate terminology and physical units, basic concepts in chemistry, including precipitation and redox reactions.
- Analyse bonding and atomic molecular structure
- Apply the ideal gas law to calculations of gas properties
- Describe the principles underpinning the kinetic theory of gases
- Analyse and identify the main types of intermolecular forces
- Identify and explain the principal features of the phase diagrams of pure compounds, including pressure dependence of melting and boiling points, triple point and critical point, and variation of vapour pressure with temperature.
- Calculate chemical equilibria and illustrate the key concepts, including variation of components with concentration, temperature and pressure
- Discuss simple acid/base chemistry and apply to solution equilibria
- Illustrate the basic concepts of an electrochemical cell, including half-cell reactions, cell potential and reaction free energy and be able to determine these properties as well as concentration dependence
- Describe the main classes of the solid-state structure; cubic- and hexagonal close packing; body-centred and face-centred cubic structures. Octahedral and tetrahedral holes, coordination numbers, the Born-Haber cycle, lattice energy
- Identify, describe and analyse the factors affecting solubility.
- Define and explain colligative properties, including Raoult’s Law and the calculation of molecular weights
• Understand and apply the concepts underlying the First and Second Laws of Thermodynamics to numerical problems

Assessment details:
This module will be examined via a combination of in-course assessments (25% of the final mark) and a 3 h paper at the end of semester 1 (75% of the final mark).

CHU11102: Introduction to Inorganic and Organic Chemistry
Semester 2, 10 credits

Content Layout

<table>
<thead>
<tr>
<th>Teaching Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8 (28 L)</td>
<td>Introduction to Organic Chemistry</td>
</tr>
<tr>
<td></td>
<td>• Alkanes, isomers, homologous series, IUPAC nomenclature, physical properties and molecular size, the tetrahedral carbon atom, shapes of organic molecules, alicyclic rings, concept of bond strain, conformations of ethane and of the cyclohexane ring, chair and boat forms and their relative stabilities, axial and equatorial bonds.</td>
</tr>
<tr>
<td></td>
<td>• Alkenes, nomenclature, the double bond as an electron rich centre mechanism of electrophilic addition of hydrogen halides, water, and halogens to the double bond, Markownikoff rule, shape of the double bond, geometric isomerism, cis-trans isomers and E-Z nomenclature, catalytic hydrogenation, oxidative cleavage of double bond including ozonolysis.</td>
</tr>
<tr>
<td></td>
<td>• Alkyne reactions treated briefly as a simple extension of alkene reactions, acidity of alkynes and nucleophilic character of the alkyne anion.</td>
</tr>
<tr>
<td></td>
<td>• Alkyl halides, idea of leaving group, introduction to the use of curly arrows in representing mechanism, idea of nucleophiles and electrophiles, nucleophilic substitutions, SN1 and SN2 mechanisms, carbocations, dehydrohalogenation, elimination mechanisms E1 and E2 emphasising common intermediate for SN1 and E1, direction of elimination, Saytzeff rule, organo lithium and Grignard reagents as carbon nucleophiles.</td>
</tr>
<tr>
<td></td>
<td>• Alcohols, hydrogen bonds, differences between primary secondary and tertiary, amphoteric nature of the OH group, alkoxides, mechanism of dehydration, oxidation.</td>
</tr>
<tr>
<td></td>
<td>• Amines as bases and as nucleophiles.</td>
</tr>
<tr>
<td>9-12 (14 L)</td>
<td>Chemistry of the Elements</td>
</tr>
<tr>
<td>-------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>• Hydrogen and the s-Block Elements. Some important hydrogen compounds. Group I: the alkali metals. Group II: the alkaline earth metals. Some important Group II compounds.</td>
<td></td>
</tr>
<tr>
<td>• The d-Block Elements. Important properties of d-block elements and their compounds. Trends in physical properties. Reactions of d-block complexes.</td>
<td></td>
</tr>
</tbody>
</table>

**Reading list/ Indicative Resources**

- Chemistry & Chemical Reactivity Hardcover by Paul Treichel, John Kotz, John Townsend, David Treichel; Publisher: Brooks Cole; 9 ed.
- Organic Chemistry, by Jonathan Clayden and Nick Greeves; Publisher: OUP Oxford; 2 ed.

**Methods of Teaching and Student Learning**

A mixture of lectures, tutorials and hands-on laboratory practicals are used in the delivery of this module. The practical sessions are formatted in order to further clarify concepts thus reinforcing learning. A weekly hour of tutorial problem solving activities provides an additional opportunity for the lecturer to assess understanding and gauge the knowledge level of the students.

**Learning outcomes**

On completion of this module the student should be able to:

- Identify and explain bonding, hybridisation and mechanisms.
- Describe and explain the chemistry of functional groups (alkanes, alkenes and alkynes, aromatics, alkylhalides, alcohol, aldehydes, ketones and amines) and their applications.
- Analyse and discriminate between mechanisms in terms of the inherent reactivity/polarisation etc. of the two reaction components.
- Identify and classify chiral centres in organic molecules.
• Describe the chemical and physical properties of elements as a function of their position in the periodic table.
• Determine and explain the origin of the trends within groups and across periods of the properties of elements in the periodic table.
• Describe the typical structures of some common compounds of the main group elements.
• Classify elements as metallic/metalloid/non-metallic and contrast their characteristic properties.
• Explain the practical and industrial uses of key elements and compounds, and relate these to their properties.

Module Prerequisite:
CHU11101 General and Physical Chemistry (First Semester)

Assessment details:
This module will be examined via a combination of in-course assessments (25% of the final mark) and a 3 h paper at the end of semester 2 (75% of the final mark).

Course Director:
Professor Eoin Scanlan  
E-mail: eoin.scanlan@tcd.ie  
Phone: 01 896 2514

Coordinator Freshman Teaching
Dr Noelle Scully  
E-mail: jfchem@tcd.ie  
Phone: 01 896 1972

Senior Executive Officer
Ms Ann-Marie Farrell  
E-mail: farrea25@tcd.ie  
Phone: 01 896 1726
MAU11S01: Mathematics for Scientists 1

Semester 1, 10 credits

Contact hours:
11 weeks, 6 lectures + 2 tutorials per week
This is the first semester module of a two semester sequence. It leads on to module MAU11S02 in the second semester.

Module Personnel
Prof. Kirk Soodhalter and Prof. Anthony Brown

Learning outcomes:

On successful completion of this module students will be able to

- Manipulate vectors to perform algebraic operations on them such as dot products and orthogonal projections and apply vector concepts to manipulate lines and planes in space R3 or in Rn with n≥4.
- Use Gaussian elimination techniques to solve systems of linear equations, find inverses of matrices and solve problems which can be reduced to such systems of linear equations.
- Manipulate matrices algebraically and use concepts related to matrices such as inevitability, symmetry, triangularity, nilpotence.
- Manipulate numbers in different bases and explain the usefulness of the ideas in computing.
- Use computer algebra and spreadsheets for elementary applications.
- Explain basic ideas relating to functions of a single variable and their graphs such as limits, continuity, inevitability, even/odd, differentiability and solve basic problems involving these concepts.
- Give basic properties and compute with a range of rational and standard transcendental functions, for instance to find derivatives, antiderivatives, critical points and to identify key features of their graphs.
- Use a range of basic techniques of integration to find definite and indefinite integrals.
- Apply techniques from calculus to a variety of applied problems.

Module content:
The content is divided in two sections, one for each lecturer.

**Calculus with applications for Scientists**
The lecturer for this part will be Prof. Anthony Brown. The main textbook will be [Anton] and the syllabus will be approximately 7 Chapters of [Anton] (numbered differently depending on the version and edition)

Chapter headings are

- Before Calculus (9th Ed) {was `Functions' in the 8th edition};
- Limits and Continuity;
- The Derivative;
- The Derivative in Graphing and Applications;
- Integration;
- Exponential, Logarithmic and Inverse Trigonometric Functions;
Discrete Mathematics for Scientists
The lecturer for this part will be Prof. Kirk Soodhalter.
The order of the topics listed is not necessarily chronological. Some of the topics listed below linear algebra will be interspersed with linear algebra.

- **Linear algebra**
  The syllabus for this part will be approximately chapters 1, 3 and parts of 10 from [AntonRorres].
  - Vectors, geometric, norm, vector addition, dot product
  - Systems of linear equations and Gauss-Jordan elimination;
  - Matrices, inverses, diagonal, triangular, symmetric, trace;
  - Selected application in different branches of science.

- **Computer algebra.**
  An introduction to the application of computers to mathematical calculation. Exercises could include ideas from calculus (graphing, Newton’s method, numerical integration via trapezoidal rule and Simpson’s rule) and linear algebra. We will make use of the computational software Mathematica which is used in many scientific applications.

- **Spreadsheets.** A brief overview of what spreadsheets do. Assignments based on Google docs.

- **Numbers.** An introduction to numbers and number systems e.g. binary, octal and hexadecimal numbers and algorithms for converting between them.

Recommended reading list:

[Anton]
Or
Single variable edition.

[AntonRorres]

Assessment details:
This module will be examined in a 3 hour **examination** in Trinity term. Assignments and tutorial work will count for 20% of the marks. There will be final examination in April/May counting for the remaining 80%. For supplementals, if required, the supplemental exam will count for 100%.

Module Coordinators for MAU11S01

Professor Kirk Soodhalter E-mail: ksoodha@maths.tcd.ie
ph. 01/896 8515
Professor Anthony Brown E-mail: anthony.brown@ucd.ie
General enquires: E-mail: mathdep@maths.tcd.ie
MAU11S02: Mathematics for Scientists 2

Semester 2, 10 credits

Contact hours:
11 weeks, 6 lectures + 2 tutorials per week

Module personnel
Dr. Miriam Logan and Dr. Colm O‘Dunlaing

Learning outcomes:

On successful completion of this module students will be able to:

• Apply definite integrals to various geometric problems.
• Apply various methods of integration.
• Use the concept of differential equations and methods of their solution.
• Use the concept of infinite series and their convergence; Taylor series.
• Use the concepts of parametric curves and polar coordinates.
• Define and calculate determinants by cofactor expansion and through upper triangular form.
• Use Cramer’s Rule to solve linear equations.
• Use the Adjoint Matrix to invert matrices.
• Construct bases for row space, column space, and nullspace of a matrix.
• Construct orthonormal bases in three dimensions.
• Calculate the matrices of various linear maps.
• Compute linear and quadratic curves matching data through least squared error criterion.
• Calculate eigenvalues and eigenvectors for 2x2 matrices, with applications to differential equations.
• Derive probability distributions in simple cases.
• Apply the Binomial Distribution.
• Compute the conditional probability $P(A_i | D)$ given $P(D|A_i)$.
• Apply the Poisson distribution to traffic-light queuing problems.
• Apply continuous distributions, Normal, chi-squared, Student’s t-distribution.
• Obtain confidence intervals for mean and standard deviation.
• Apply the Central Limit Theorem to approximate the binomial distribution for large $n$.
• Perform basic hypothesis testing.

Module content:

The content is divided in two sections, one for each lecturer.

**Calculus with applications for Scientists**
The lecturer for this part will be Dr. Miriam Logan

• Application of definite integrals in geometry (area between curves, volume of a solid, length of a plane curve, area of a surface of revolution).
• Methods of integration (integration by parts, trigonometric substitutions, numerical integration, improper integrals).
• Differential equations (separable DE, first order linear DE, Euler method).
• Infinite series (convergence of sequences, sums of infinite series, convergence tests, absolute convergence, Taylor series).
• Parametric curves and polar coordinates.

Discrete Mathematics for Scientists
The lecturer for this part will be Dr. Colm O Dunlaing
Module Content:
Linear Algebra
• This reference for this part of the course will be (AntonRorres). The syllabus will be approximately chapters 2, 5, section 4.2 and a selection of application topics from chapter 11 of (AntonRorres).
• Determinants, Evaluation by Row Operations and Laplace Expansion, Properties, Vector Cross Products, Eigenvalues and Eigenvectors;
• Introduction to Vector Spaces and Linear Transformations. Least Squares Fit via Linear Algebra;
• Differential Equations, System of First Order Linear Equations;
• Selected Application in Different Branches of Science;

Probability
• Basic Concepts of Probability; Sample Means; Expectation and Standard Deviation for Discrete Random Variables; Continuous Random Variables; Examples of Common Probability Distributions (binomial, Poisson, normal) (sections 24.1 - 24.3, 24.5 - 24.8 of (Kreyszig).

Recommended reading lists:

(Stewart)

(Anton)
• Combined edition:
  or
• Single variable edition.

(AntonRorres)

Recommended References:

(Kreyszig)
• Erwin Kreyszig, Advanced Engineering
Module Prerequisite:
MAU1S001 Mathematics for Scientists 1 (First Semester)

Assessment details:
This module will be examined in a 3 hour examination in Trinity term. Continuous assessment in the form of weekly tutorial work will contribute 20% to the final grade at the annual examinations, with the examination counting for the remaining 80%. For supplementals if required, the supplemental exam will count for 100%.

Module Coordinators for MAU1S02

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TR061 Chemical Sciences - Open Modules
BYU11101: From Molecules to Cells I

Semester 1, 10 credits

Module learning aim:
This module aims to provide an introduction to molecular and cellular biology, and will therefore include key topics in Cell Biology, Biochemistry, Genetics, and Microbiology. A description of the possible origin of life, from the abiotic world to single-celled and multicellular organisms will be given, and the ultrastructure of the prokaryotic and eukaryotic cells will be covered in detail. The properties and functions of the major classes of biochemicals found in living systems (carbohydrates, lipids, proteins and nucleic acids) will be described, the structure and function of membranes and organelles, and the chemical basis of metabolism and energy transfer in the cell. Students will then be introduced to basic concepts in Genetics, how the information contained in DNA (genes) is expressed, replicated and inherited. Finally, the sheer diversity of life forms, from viruses to prokaryotic and eukaryotic microorganisms, to more complex plant and animal life forms will be described. Students will also study cell and virus structure, cell growth and viral replication, agents of infectious diseases, and host immunity.

Learning outcomes:

On successful completion of the module, students will be able to:
1. Provide an account of the cellular basis of life: from its origins in the abiotic world, to the evolution of unicellular and multicellular organisms.
2. Describe the diversity of life forms: including viruses, prokaryotes (bacteria), archaea, and eukaryotes (unicellular organisms, animals and plants).
3. Provide an account of the chemical basis of life and the biochemistry on which living systems depend: the properties and functions of the major classes of biomolecules, the structure and function of membranes and organelles, and the chemical basis of metabolism and energy transfer.
4. Describe how the information contained in DNA (genes) directs the construction and growth of an organism, and how this information is replicated and transmitted from one generation to the next (inheritance; genetics).
5. Employ a range of laboratory techniques, demonstrating the development of practical scientific skills, knowledge of experimental design and the interpretation of results.
6. Apply the scientific method as a fundamental approach to experiment-based investigations, critical analysis of data, and problem solving.

Module content:

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Topic and Content</th>
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<tr>
<td>Lecture 1: Module: Introduction, objectives and overview.</td>
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Module Coordinator (Professor Tony Kavanagh) |
| Section 1: Origin of Life - Cellular basis of life - Diversity of Life Forms: | 
Lecture 2 and 3: Origin of Life (Professor Luke O’Neill) |
| - What is Life? How did it arise? | 
- The Origin of Life from a chemical and cellular perspective. The abiotic world |
| - The prebiotic world. Miller-Urey experiment. The first cell | 
- Photosynthesis and oxygen – mass extinction. Origin of first eukaryotic cell |
| - Multicellular life. Cell specialization |
Lecture 4 – 6: Cellular basis of life (Professor Fred Sheedy)
- Cell structure – prokaryotes, archaea, eukaryotes - animal and plant
- Organelles & their prokaryotic origin – mitochondria, chloroplasts
- mitosis and meiosis – cell division – regulation of cell division (introduction)

Lecture 7 – 12 - Diversity of Microbial Life (Professor Alastair Fleming)
Lecture 7: The Tree of Life (Professor Alastair Fleming)
- Cell structure, morphology, function and habitat.
Lecture 9- Fungi & Protists (Professor Alastair Fleming)
- Fungal cell structure, morphology, function and habitat.
- Protist cell structure, morphology, habitat and lifecycles: extreme cell diversity
Lecture 10: The Archaea (Professor Alastair Fleming)
- A third way of life; features of both prokaryotes and eukaryotes: cell structure, morphology and function. Extremophiles
Lecture 11: Viruses (Professor Alastair Fleming)
- Alive? Structure, function and habitat
Lecture 12 – Relationship between life forms: (Professor Alastair Fleming)
- The good, the bad and the ugly. Concepts of symbiosis and parasites. Plant and animal diseases

ONLINE ASSESSMENT via MCQ
Section 2: Chemistry of Life:
Lecture 13 - Introduction to biochemistry: Structural principles for small molecules (Professor Luke O’Neill)
- Elements and chemical groups commonly found in nature
- Bonds, bond energies, bond lengths in nature
- Asymmetry: right and left-handed molecules etc.
- Typical forces between molecules and chemical groups in nature
- Four basic classes of Biomolecules: amino acids, nucleotides, carbohydrates & lipids
Lecture 14: Nucleotides, Amino acids and peptides (Professor Luke O’Neill)
- Classes of nucleic acids (DNA, RNA), Chromatin and chromosome structure, Properties of amino acids: chemical features and physical properties of the R-groups
- The peptide unit and peptide bond
- Introduction to polypeptides & concept of folding
Lecture 15: Proteins and protein structure (Professor Ken Mok)
- Concept that shape dictates function
- Hierarchical organization of protein structure: concept of primary, secondary, tertiary and quaternary structure.
- Introduction to forces that stabilize protein structure
Lecture 16: Protein function (Professor Ken Mok)
- Major functional classes of protein
- Introduction to bioinformatics: Proteins and evolution; relationships between proteins: similarity and identity.
Lecture 17 and 18: Enzymes: the catalysts of life (Professor Vincent Kelly)
- Enzyme structure & function
- Enzyme reaction mechanism (co-factors and vitamins)
- Enzyme kinetics
- Regulation of enzyme activity
Lecture 19: Lipids and membranes (Professor Vincent Kelly)
- Lipid structures: fatty acids, phospholipids etc
- Membranes: chemical and physical properties
- Membrane proteins
- Transport across membranes
- Concept of compartmentation and membrane traffic

**Lecture 20 and 21: Metabolism & major metabolic pathways** (Professor Vincent Kelly)
- The starting point: introduction to carbohydrates and fatty acids
- Organization, energetic principles, key steps and links between the main metabolic pathways.
- Glycolysis, TCA cycle, beta oxidation
- Outline of the reversing catabolic pathways: gluconeogenesis and fatty acids synthesis.

**Lecture 22: Mitochondria & Respiration** (Professor Vincent Kelly)
- Mitochondria, redox reactions and energy transduction
- Electron transport and the electron transport chain
- Oxidative phosphorylation
- Coupling of oxidation to phosphorylation: chemiosmotic view of energy transduction (in brief).

**Lecture 23: Chloroplasts and Photosynthesis** (Professor Vincent Kelly)
- Chloroplasts: architecture and function
- Overview of the light and dark reactions of photosynthesis

**ONLINE ASSESSMENT via MCQ**

**Section 3: Biological Information: Genetics, Heredity and DNA**

**Lecture 24: Introduction to Genetics** (Professor Jane Farrar)
- Introduction to the course content: An outline of some core concepts from classical genetics to the present will be presented. A whistle stop tour of key discoveries in the history of genetics.

**Lecture 25: Mendelian Genetics** (Professor Jane Farrar)
- Mendel’s laws: the 1st law of segregation and the 2nd law of independent assortment using monohybrid and dihybrid crosses; concepts relating to genetic analysis and the use of model systems will be described. Inheritance patterns for single gene disorders will be presented - pedigree analysis.

**Lecture 26 and 27: Linkage and recombination** (Professor Jane Farrar)
- Meiosis and the role of ‘crossing over’ in gene mapping (meiosis covered in detail elsewhere). A brief recap regarding Mendelian genetics – for example, highlighting that genetic linkage breaks Mendel’s 2nd law of independent assortment (refer back to L27)
- Outline of key concepts underlying the generation of genetic maps. Reference will be made to some classical work by Sturtevant / Morgan.

**Lecture 28: Identification of DNA as hereditary material** (Professor Jane Farrar)
- Key experiments establishing DNA as the genetic material; bacterial transformation and its significance (Griffith / Avery, McLeod & McCarthy / Hershey-Chase); the concept of horizontal gene transfer (mechanisms transformation, conjugation, transduction).
- Differences in vertical and horizontal gene transfer.

**Lecture 29: Quantitative Genetics** (Professor Jane Farrar)
- An overview of some concepts relating to discrete variation versus continuous variation. Experiments demonstrating that quantitative traits are inherited.
- Examples of some quantitative traits in humans. Concepts regarding the use of GWAS to elucidate the genetics architecture of complex traits using an example of one or more disorders.

**Lecture 30: DNA, Structure and Function** (Professor Tony Kavanagh)
- The double helix - discovery of the structure of DNA – DNA composition - DNA replication – semi-conservative replication, replication forks, leading and lagging strand synthesis, DNA polymerases
- DNA replication in prokaryotes and eukaryotes.
Lecture 31-33: Information flow in the cell - The Central Dogma (Professor Tony Kavanagh).
- Transcription, RNA Polymerases in prokaryotes and eukaryotes.
- Promoters, repressors, terminators – the lac operon; transcription factors, enhancers.
- Decoding the information in mRNA:
- Translation (Protein synthesis).
- Ribosomes in prokaryotes and eukaryotes, tRNAs and aminoacyl tRNA synthetases, the genetic code; translation;
- Introduction to the regulation of gene expression – positive and negative regulation

Lecture 34: DNA – Mutation and its consequences (Professor Tony Kavanagh)
- Mechanisms by which mutations are generated - including errors in DNA replication; the action of chemical and physical mutagens; and errors in chromosome construction and distribution.
- An outline of the different types of mutation (missense, nonsense, frameshift mutations) and their molecular consequences in relation to gene expression and protein function. Mutations causing inherited diseases and cancer.
- DNA repair – mechanisms of DNA repair; repair deficiency and disease.

ONLINE ASSESSMENT via MCQ

Recommended reading lists:

(1) Campbell Biology, 11th Edition By Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece (Published by Pearson (2019))

Contact Hours/Methods of Teaching and Student Learning.

65 hours consisting of a mixture of lectures, tutorials and hands-on laboratory practicals. The practical sessions are formatted in order to further clarify concepts thus reinforcing learning. A tutorial in essay writing will help students prepare for the examination.
Method of assessment

Continuous assessment 50%
• Laboratory practical assessment: Four components: engagement = 5% of module, Assignment 1 (open book) covering practicals 1 to 5 inclusive = 5% of module, Assignment 2 (open book) covering practicals 6 to 8 inclusive = 5% of module, end of module online assessment of all practicals (closed book) = 20% of module.
• There will be three online open book assessments of lecture material each worth 5%

Written Examination 50%
One written examination paper of 1.5-hour duration.
There will be three sections on the examination paper:
• Section 1 will have two questions on Section 1 (Origin of Life) you are required to answer one question from this section
• Section 2 will have two questions on Section 2 (Chemistry of Life) you are required to answer one question from this section
• Section 3 will have two questions on Section 3 (Biological Information) you are required to answer one question from this section
• All questions carry equal marks

Contacts

Module Coordinator: Molecules to Cells 1

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Executive Officer
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PYU11F20: Foundation Physics for Life and Earth Sciences

Semester 2, 10 credits

Foundation Physics for the Life and Earth Sciences is a foundation module (10 credits) in physics. It is available as an open 10 credit module for TR060 and TR062 students, all of whom are taking Maths, Stats, & Computation (10 credits); as well as for TR061 students (if not taking Physics 1 or Physics 2) who take both Mathematics 1 (10 credits) and Mathematics 2 (10 credits). It is available in both semesters for TR060 and TR062 students, (but cannot be taken twice); it is only available in semester 2 for TR061 students.

Module Content: This foundation module comprises lectures, practical work and tutorials, providing an introduction to: physics of motion, biomechanics, physics of hearing and seeing, electricity, magnetism and bioelectricity, radioactivity, nuclear physics and related medical applications, heat, pressure, as well as fluids and their biological, geological and medical applications.

Module Learning Outcomes:
On successful completion of this module, students should be able to:

- Demonstrate the application of Classical Physics within the biomedical and earth sciences
- Connect the study of wave phenomena and electromagnetism with ultrasound diagnostics and vision
- Relate basic knowledge of atomic and nuclear physics to radiation diagnostics and therapy, and to geological applications
- Prepare a brief report, including error analysis, on a simple physical experiment
- Through homework: (i) identify the appropriate concepts, principles, and relations that apply to the problem; (ii) provide a reasonable and appropriate explanation of why they apply; and (iii) solve physics problems at a foundation level.

Module Structure:

Contact Hours: 42 lectures/tutorials, three-hour practical laboratories, online homework.

Module Personnel: Lecturers: Prof. Lewys Jones; Prof. Martin Hegner; Prof. Matthias Möbius

Summary of Laboratory Practicals: In the Foundation Physics for Earth and Life Sciences students complete a minimum of three of the available bench experiments in the semester. The emphasis in the laboratory practical is on learning to make physical measurements, record keeping in laboratory notebooks and estimating uncertainties in measurements, while using these estimates in analysing data in order to make a quantitative measurement of a physics property. Differing students will attempt a differing set of experiments from those available. There may also be differing availability of experiments on the bench in both semesters. Students are required to record all data and information related to experiments in a hardback practical laboratory notebook which is assessed.

Laboratory Practicals: Experiments are selected from among but are not limited to: Pendulum, Thin Lenses, Density and the Principle of Archimedes, Surface Tension, Electrical Resistance, Collisions and Momentum Transfer, Resonance Tube, Leslie’s Cube, Geiger Counter, and Photoelectric Effect among others.

Assessment of the laboratory: Student’s experiments are assessed through both at-the-bench laboratory notebook assessment and through submission of written experimental reports. These must include and require a complete data analysis, description and concise report of the outcomes of the experiment, and any inferences or conclusions that can be drawn from the outcome.
**Reading List:** Required reading: "Physics for the Life Sciences" - Authors: M. Zinke-Allmang et al - It is a requirement that students purchase the mandatory e-textbook which includes student access to online homework assignments.


**Online Assignments:** Online assignments are submitted through the Cengage system where electronic access is associated with the required text book.

https://www.cengagebrain.co.uk/shop/index.html

**Methods of Teaching and Student Learning:**
A mixture of lectures, hands-on laboratory practicals, lecture demonstrations and weekly on-line assignments based on both numerical and conceptual questions from the textbook are used in the delivery of this module. The lecture course follows the material in the textbook very closely with reading assignments clearly indicated to students as the lecture course progresses.

The practical sessions are structured to provide a firm introduction to the process of physical measurements, as well as an introduction to estimations of uncertainty (error) and propagation of errors as applied to physics experiments. Each experiment has its own specific learning outcomes and is structured in order to further clarify concepts met in the textbook and lectures thus reinforcing learning.

Weekly homework assignments, typically alternating between topics, are submitted by students through an online system and corrected, with some limited feedback to the student available through the online system post deadline. The lecturer has oversight of the scores and responses to each assignment and can address these in subsequent lectures and tutorials. Finally, a number of lecturers use class based polling of student responses to questions using the available “clicker” technologies.

**Methods of Assessment:**
Assessment is by a combination of examination and continuous assessment and will include multiple choice tests (MCQs) examination paper; laboratory practical work; and online tutorial homework assignments.

**Module website:** See links at: http://www.tcd.ie/Physics/study/current/undergraduate/

**Foundation Physics Course Coordinator:**
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Helen O’Halloran  
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PYU11P10: Physics 1

Semester 1, 10 credits

The most fundamental foundational aspects of any physics education concern the motion of objects due to forces and how to mathematically describe these motions. Collective motions in response to forces lead to propagating physical waves, where similar mathematics can then describe electromagnetic waves or light. The first semester of your Physical Sciences education has an in-depth study of motion, forces, oscillation and light as the key physical concepts upon which to build. Of equal importance to the mathematical description of how the world we live in behaves, as described by a physical law, is an ability to make a measurement to verify or otherwise test the action of a physical law. Hence the physics laboratory plays a key role in the Physical Sciences education where the techniques of physical measurements are introduced together with the fundamentals of the experimental method and the manner in which the results of any experiment can be analysed.

Structure and contact hours
Lectures (4-5 hrs per week); practical laboratory (3hrs per week); online assignments (1 per week) and small group tutorials (1 hr every second week)

Lecture Topics
Introduction to Physics - 1 lectures (M. Möbius)
The Physics of Motion - 22 lectures (M Ferreira)
Waves and Optics I - 20 lectures (L Bradley)
Statistics - 10 lectures (M. Möbius).

Learning outcomes
On successful completion of this module students should be able to:
- Express in mathematical language the motion of a body under the action of forces.
- Describe wave motion and relate it to basic phenomena in light and sound.
- Understand sources of errors in measurements and calculate their propagation.
- Prepare a brief report, which includes an error analysis, of a simple physical experiment.

Syllabus

Introduction to Physics: 1 lecture

An introduction to the School of Physics and the JF Physics course.

The Physics of Motion: 22 lectures

Kinematics: velocity, acceleration, representation of motion through graphs, projectile motion, circular motion; Statics: forces, torque, equilibrium; Dynamics: Force-motion relations, Newton’s laws, work, energy, linear and angular momenta, impulse, collisions, conservation laws
Waves and Optics I: 20 lectures

Statistics: 10 lectures
Systematic and random errors. Discrete and continuous distributions such as binomial, Poisson, Gaussian and Lorentzian. Moments of a distribution. Histograms and probability densities. Estimation of mean and standard deviation in a measurement. Error propagation and transformation of variables in probability distributions. Linear regression analysis, method of least squares, goodness of fit (Chi squared) and plotting techniques. Introduction to programming basics in Python

Methods of Teaching and Student Learning:
A mixture of lectures, small group tutorials, hands-on laboratory practicals and weekly on-line assignments based on both numerical and conceptual questions from the textbook are used in the delivery of this module. The lecture course follows the material in the textbook very closely with reading assignments clearly indicated to students as the lecture course progresses.

The practical sessions are structured to provide an introduction to the process of measurement, estimations of uncertainty (error) and propagation of errors as applied to physics experiments as well as introducing students to programming and data analysis through Python based computational physics experiments. Each experiment has its own specific learning outcomes and is structured to further clarify concepts met in the textbook and lectures thus reinforcing learning. Weekly homework assignments, typically alternating between topics, are submitted by students through an online system and corrected, with some limited feedback to the student available through the online system post deadline. The lecturer has oversight of the scores and responses to each assignment and can address these in subsequent lectures and tutorials.

Small group tutorials – in groups of 6-8 – meet with assigned academics every second week to introduce and practice the concepts of physics problem solving and the use of mathematics in physics and to develop physics insight in the students. These small group tutorials try to emphasise peer learning within the tutorial format and these problem solving activities provides an additional opportunity for the assigned academic to assess understanding and gauge the knowledge level of the students.

Finally, a number of lecturers use class based polling of student responses to questions using the available “clicker” technologies.

Methods of Assessment and Weighting
Examination – Written examination paper 60%; Laboratory Practical work 30%; online tutorial homework assignments 10%.
Reading List:
- University Physics - extended version with Modern Physics, by Hugh D. Young and Roger A. Freedman, Addison-Wesley, 2016, 14th end.

Students do NOT buy this book - further information at first lecture of term.

Online Assignments:
Online assignments are submitted through the Mastering Physics system where electronic access is associated with the required/provided text book.
https://www.masteringphysics.com/site/login.html

Online Resources:
Software used in the practical laboratory – Logger Pro; as well as examples of Python code for analysis of data in the practical laboratory are available through the School of Physics website:
https://www.tcd.ie/Physics/study/current/undergraduate/Software-and-online-resources/

Module Website:
Visit http://www.tcd.ie/Physics/study/current/undergraduate for links to all Physics modules and to Blackboard for each module.
The motion and response of electrons due to electric and magnetic forces as well as the energies of electrons in atoms, molecules or metals determine almost all our interactions with our surroundings. The technological era is predicated on the motion of free electrons in electrical circuits, the coupling of motion to electric current and vice versa via magnetic interactions. The behaviour of electrons in atoms, molecules, metals and semiconductors is described by quantum theory which also describes electrons participating in the interaction of light and matter. An introduction to the quantum physics and quantum mechanics of light and electrons in atoms are the next foundational aspects of any physics education and are the heart of the second semester of your Physical Sciences education. Finally, our understanding and ability to observe the universe around us is through the interaction of light and matter, with the structure of the universe governed by the interaction of matter with matter. Gravitational and rotational dynamics determine the structure of the solar system and of the universe, and our knowledge of the universe is through the light we observe across all energy ranges. This is the last of the topics introduced in this first year of your education in the Physical Sciences. The physics laboratory continues in its key role in the Physical Sciences education with further training in experimental methods, analysis techniques and refining of your ability to describe the outcomes of an experiment.

Structure and contact hours:
Lectures (4-5 hrs per week); practical laboratory (3hrs per week); online assignments (1 per week) and small group tutorials (1 hr every second week)

Lecture Topics:
- Electricity and Magnetism - 20 lectures (J. Groh)
- Quantum Physics - 18 lectures (J. Pethica)
- Gravitation and Astrophysics - 12 lectures (A Vidotto)

Learning Outcomes:
On successful completion of this module students should be able to:
- Solve steady state time-varying electric current and electric potential problems
- Solve electrostatic problems using Gaussian Surfaces
- Describe how physics of matter and radiation is underpinned by quantum physics
- Develop the ideas of Newton's Law of Gravitation, with emphasis on it being an inverse square law
- Describe observational insights into the structure and evolution of the Universe

Syllabus:
Electricity and Magnetism I: 20 lectures
Electrostatics: electric charge, Coulomb's law, electric field, electric dipoles, Gauss's law, electric potential energy, voltage, electric polarization, capacitance, dielectrics, Electric current, resistance, Ohm's law, electromotive force, power in electric circuits, Kirchoff's laws, RC circuits. Magnetism, magnetic field lines and flux; Lorentz force on moving charge; Energy of and torque on a current loop in a magnetic field; Biot-Savart Law illustrated by magnetic fields of a straight wire and circular loop; forces between current-carrying straight wires; Ampere’s Law in integral form.
Quantum Physics: 18 lectures

Gravitation and Astrophysics: 12 lectures
Motion of the planets: early models of the solar system, Newton's law of gravitation, gravitational potential energy, motion of satellites, Kepler's laws and the motion of planets (derivation of the orbit equation, conservation of angular momentum, properties of the ellipse), apparent weight and the earth's rotation, escape velocity. Our solar system - the planets: physical properties, composition, terrestrial planets, gas giants. Extrasolar planets: detection methods. Observing the universe: refracting telescopes, reflecting telescopes, space telescopes, radio observations. The Sun: physical properties, solar interior, solar surface and atmosphere. Stars: constellations, magnitudes, distances, size of stars, the Hertzsprung-Russell Diagram, introduction to stellar evolution. Galaxies: the Milky Way, other galaxies, dark matter. Origin and evolution of the universe: the expansion of the universe, age of the universe, big bang models, cosmic microwave background.

Methods of Assessment and Weighting:
Examination – Written examination paper 60%; Laboratory Practical work 30%; online tutorial homework assignments 10%.

Reading List:

Online Assignments:
Online assignments are submitted through the Mastering Physics system where electronic access is associated with the required/provided text book.
https://www.masteringphysics.com/site/login.html

Online Resources:
Software used in the practical laboratory – Logger Pro; as well as examples of Python code for analysis of data in the practical laboratory are available through the School of Physics website: https://www.tcd.ie/Physics/study/current/undergraduate/Software-and-online-resources/

Module Website:
Visit http://www.tcd.ie/Physics/study/current/undergraduate for links to all Physics modules and to Blackboard for each module.
Summary of Laboratory Practicals:

Across Physics 1 and Physics 2 modules students complete 2 computational physics experiments (using Python) and 16 out of 20 available bench experiments for a total of 18 experiments performed by the student in the academic year. Many of the laboratory experiments are available on the bench in both semesters and thus the progress of students through the experiments differs from student to student with the exception of the computational physics experiments which all students complete. Students are required to record all data and information related to experiments in a hardback practical laboratory notebook which is assessed.

Laboratory Practicals
Introduction to Python
Python lab 1: Monte Carlo Approximation
Python lab 2: The Trajectory of a Projectile with Friction
Experiment 1: The Pendulum
Experiment 2: Energy Conservation
Experiment 3: Thin Lenses
Experiment 4: Density and the Principle of Archimedes
Experiment 5: Surface Tension
Experiment 6: Electrical Resistance
Experiment 7: DC Circuits
Experiment 8: Charging/Discharging a Capacitor
Experiment 9: Collisions and Momentum Transfer
Experiment 10: The Resonance Tube
Experiment 11: Leslie’s Cube
Experiment 12: Faraday’s Law
Experiment 13: Aperture and Depth of Field
Experiment 14: Interference and Diffraction
Experiment 15: The Geiger Counter
Experiment 16: Centripetal Acceleration
Experiment 17: The Photoelectric Effect
Experiment 18: The Bandgap of Germanium
Experiment 19: The Spectrometer
Experiment 20: AC circuits

Online Resources:
Software used in the practical laboratory – Logger Pro; as well as examples of Python code for analysis of data in the practical laboratory are available through the School of Physics website: https://www.tcd.ie/Physics/study/current/undergraduate/Software-and-online-resources/
Assessment of the laboratory

Half of a student’s experiments are assessed through an at-the-bench laboratory notebook assessment – the rest of the students experiments are assessed through written reports of the experiment. In all experiments both the laboratory notebook and the submitted experimental reports must include and require a complete data analysis, error estimation and statistical analysis and description and concise report of the outcomes of the experiment, and any inferences or conclusions that can be drawn from the outcome. A similar assessment requirement applies to the python based computational physics experiments, with the addition of assessment of the code used by the student.

Junior Freshman Physics Coordinator  E-mail: mobiusm@tcd.ie
Professor Matthias Moebius  Ph: 01 896 1055
Dates to Note:

Freshers Orientation Week: 28th September 2020 – 2nd October 2020

Academic Year Structure 2020/21

Key Dates:

Freshers/Orientation Week: Monday 28th September to Friday 2nd October 2020
Semester One 2020 (Michaelmas Term 2020): Monday 5th October 2020 to Friday 18th December 2020
Trinity week: Monday 26th April to Friday 30th April 2021
Semester 2 (Hilary Term): Monday 1st February 2021 – Friday 23rd April 2021
Study/Review Week: Monday 15th March to Friday 19th March 2021

Formal Assessment weeks
*Semester 1 examinations: Monday 11th January to Friday 22nd January 2021
*Semester 2 examinations: Monday 10th May to Friday 21st May 2021

*Extra contingency days may be required outside of the formal assessment / reassessment weeks.
College Registration
The Academic Registry issue an ‘Invite to Register’ email to all new entrant and continuing students eligible to register for the forthcoming academic year. This communication is issued via the my.tcd.ie portal and your institutional (TCD issued) email address.

On receipt of the emailed invitation, you should log in to the my.tcd.ie to complete the registration steps.

All information regarding College registration is available at the following links:
https://www.tcd.ie/academicregistry/registration/how-to-register/
http://www.tcd.ie/academicregistry/registration/

Closing Dates for Course Transfer
If you decide to transfer out of your course altogether, you must submit an application for transfer of course to the Academic Registry, following discussion with your tutor. Decisions are based on a) the availability of places, and b) the entry qualifications of the transfer applicant. It may not be possible to permit transfers to subjects which already have a full complement of students. Further details are available on the following link:
http://www.tcd.ie/study/apply/making-an-application/undergraduate/index.php

Students may not register or attend a course until their application to transfer has been formally approved by the Senior Lecturer

Progression and Awards
Information on progression and awards can be found via the following webpage:
https://www.tcd.ie/TEP/assets/Docs/factsheet_students_progression_awards.pdf

Attendance
All students should enter into residence in or near Dublin and must begin attendance at the College not later than the first day of teaching term, and may not go out of residence before the last day of teaching term, unless they have previously obtained permission from the Senior Lecturer through their tutor.

Students must attend College during the teaching term. They must take part fully in the academic work of their class throughout the period of their course. Lecture timetables are published through my.tcd.ie and on school or department notice-boards before the beginning of Michaelmas teaching term. The onus lies on students to inform themselves of the dates, times and venues of their lectures and other forms of teaching by consulting these timetables.

The requirements for attendance at lectures and tutorials vary between the different faculties, schools and departments. Attendance is compulsory for Junior Freshman in all subjects. The school, department or course office, whichever is relevant, publishes its requirements for attendance at lectures and tutorials on notice-boards, and/or in handbooks and elsewhere, as appropriate.
Absence from College – Medical and Absence Certificates

Medical Certificates
Where a student misses an assigned laboratory practical class through illness, they should (a) submit a Medical Certificate to the Science Course office on the day of their return to College and (b) inform the laboratory practical supervisor of their absence at the next session.

- Science Medical Certificate Form (use with med cert from doctor) – Available from Science Course Office

For periods of illness of three days or less (but no more than seven days in any year) a student may ‘self-certify’ their illness on the forms supplied, again to the Science Course Office on the day of their return to College.

- Science Medical Self Certification Form (use for 3 days med not covered by doctor) – Available from the Science Course Office

Other Absences
Students who require to be absent from a laboratory practical classes (with or without an associated assessment) for any other reason, such as a sporting event, should inform the appropriate module coordinator well in advance of the event (preferably a week beforehand).

- Science Absence from College Form, Sport or Other – Available from the Science Course Office

Where possible they will be assigned to an alternative laboratory practical session, but if that is not possible, and the justification for the absence is considered legitimate, they may be treated in the same manner as students submitting medical certificates (i.e. assigned an alternative assessment for one missed or awarded a pro-rata/pass mark). This is decided by the individual Disciplines concerned (i.e. Biology, Chemistry, Physics etc.) not the Science Course Office.

Excuses for absence, presented after the event, will not be entertained. Students who anticipate that their sporting commitments may necessitate more than the occasional absence from College (e.g. Sport Scholars, etc.) should discuss their situation with their tutor and the Associate Dean of Undergraduate Science Education (ADUSE).

Non-satisfactory attendance and course work
All students must fulfil the requirements of the school or department, as appropriate, with regard to attendance and course work. Where specific requirements are not stated, students may be deemed non-satisfactory if they miss more than a third of their course of study or fail to submit a third of the required course work in any term. Further information on non-satisfactory attendance and course work may be found via the following webpage:

https://www.tcd.ie/undergraduate-studies/academic-progress/attendance-course-work.php
Plagiarism- 2020/2021

It is important to emphasise that all students, i.e., undergraduate, postgraduate, new entrants and existing students, will be required to complete the online tutorial ‘Ready, Steady, Write’. Students must ensure that the cover sheets they complete when submitting assessed work, contain the following declaration:

I have read and I understand the plagiarism provisions in the General Regulations of the University Calendar for the current year, found at: http://www.tcd.ie/calendar

I have also completed the Online Tutorial on avoiding plagiarism ‘Ready, Steady, Write’, located at http://tcd-ie.libguides.com/plagiarism/ready-steady-write

Students should read the items listed below to ensure that they understand plagiarism.

2. The 2020-21 Calendar entry on plagiarism; Plagiarism
3. Guidelines on the appropriate methodology for the kind of work that students will be expected to undertake. Providing discipline specific examples of good academic practice for referencing is very helpful for students. We would like to draw your attention to the 2020-21 Calendar entry on plagiarism which states that “all Schools and departments must include in their handbooks or other literature given to students, guidelines on the appropriate methodology for the kind of work that students will be expected to undertake”;
4. A statement informing all students that they must complete the online tutorial on avoiding plagiarism ‘Ready, Steady, Write’, located at http://tcd-ie.libguides.com/plagiarism/ready-steady-write
5. The template of the coversheet/s which students must complete and attach to work submitted in hard or soft copy or via Blackboard. NB. The coversheet must include the declaration noted above.

Trinity Tutorial Service

The Tutorial Service is unique, confidential and available to all undergraduate students offering student support in all aspects of College life. The Tutorial Service is supported and co-ordinated by the Senior Tutor’s Office which is located on the ground floor in House 27.

Opening Hours
The Senior Tutors Office is open Monday - Friday from 9am - 5.30pm. Closed for lunch from 1-2pm.

Appointments
If you require specific advice or would like a confidential meeting with the Senior Tutor, you can make an appointment by telephoning +353 1 896 2551 or by emailing stosec@tcd.ie

What is a Tutor?
A Tutor is a member of the academic staff who is appointed to look after the general welfare and development of the students in his/her care. Whilst the Tutor may be one of your lecturers, this is not always the case as the role of the College Tutor is quite separate from the teaching role.

When should I go to see my Tutor?
Whenever you are worried or concerned about any aspect of College life or your personal life, in particular if it is affecting your academic work. Everything you say to your Tutor is in strict confidence. Unless you give him/her permission to do so, s/he will not give any information to anybody else, whether inside College or outside (to your parents/family for example). Your Tutor can only help you if s/he knows you are facing difficulties, so if you are worried about anything go and see your Tutor before things get out of hand.

Further information on the Senior Tutors Office and College Tutors may be found via the following webpage: Senior Tutor's Office - https://www.tcd.ie/seniortutor/students/undergraduate/

Disability Services

The Disability Service aims to provide appropriate advice, support and information to help students and staff with disabilities. The Disability Service has in place a range of supports to ensure that students with disabilities have full access to the same facilities for study and recreation as their peers. Most students registering with the Disability Service request access to a range of supports that help the student reach their full potential while studying. Most students’ needs are accommodated through these supports. The student decides what level of support they require.

For contact information or to make an appointment please contact the Disability Services – contact details are available via the following webpage:

https://www.tcd.ie/disability/contact/
Student Counselling

The Student Counselling Service is here to help you to manage any difficulties you are experiencing so you can enjoy and fully participate in your time here at College.

If you wish to make an appointment with the Student Counselling Service, please consider one of the options below. If you have any other queries you can call into reception on the 3rd floor of 7-9 South Leinster Street or contact us on:

Phone: (01) 8961407
Email: student-counselling@tcd.ie

For further information visit the following webpage:
https://www.tcd.ie/Student_Counselling/

Useful College Websites:

Orientation – Student Life
https://www.tcd.ie/students/orientation/

In the first few weeks at College, you will hear an array of abbreviations, titles and place names. So visit the jargon buster page: https://www.tcd.ie/students/jargon-buster/

Student life offers information on Supports and Services, Clubs and Societies, Student Unions etc., https://www.tcd.ie/students/

For information on Registration, Fees, Grants, ID Cards etc. visit the Academic Registry (AR) in the Watts Building or the visit the AR website: https://www.tcd.ie/academicregistry/
## TR061: Chemical Sciences

### Contact details:

<table>
<thead>
<tr>
<th>Role</th>
<th>Contact Information</th>
</tr>
</thead>
</table>
| Course Director TR061: Chemical Sciences       | **Professor Eoin Scanlan**  
E-mail: eoin.scanlan@tcd.ie  
Phone: 01 896 2514 |
| Coordinator Freshman Teaching                  | **Dr Noelle Scully**  
E-mail: fjchem@tcd.ie  
Ph: 01 896 1972 |
| Senior Executive Officer                       | **Ms. Anne Marie Farrell**  
Ph: 01 896 1726 |
| Science Course Office                          | **Professor Áine Kelly**  
Ph: 01 896 2025  
**Associate Dean of Undergraduate Science Education** |
| Science Course Administrator                   | **Ms Anne O’Reilly**  
E-mail: science@tcd.ie  
Ph: 01 896 2023 |
| Senior Executive Officer                       | **Ms Ann Marie Brady**  
E-mail: sfesco@tcd.ie  
Ph: 01 896 2829 |
| Senior Executive Officer                       | **Ms Lucy Martin**  
E-mail: martinl3@tcd.ie  
Ph: 01 0896 2022 |
| Senior Executive Officer                       | **Ms. Agnes Gogan**  
E-mail: gogana@tcd.ie  
Ph: 01 896 2022 |
| Senior Executive Officer                       | **Ms. Mary Pat O’Sullivan**  
E-mail: mpsullvn@tcd.ie  
Ph: 01 8961970 |
| Global Officer, Life and Geosciences            | **Ms Eva Page**  
E-mail: eva.page@tcd.ie  
Ph: 01 896 2799 |
**Teaching Term Dates 2020-2021**

<table>
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<tr>
<th>Michaelmas Term</th>
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<tr>
<td><strong>Monday 28th Sept 2020 - Friday 18th Dec 2020</strong></td>
<td><strong>Monday 1st February 2021 - Friday 23rd April 2021</strong></td>
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<tr>
<td>Teaching wk 1</td>
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<td>Week 05</td>
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<td>28th Sept – 2nd Oct</td>
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<td>5th Oct – Oct 9th</td>
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<td>Week 09</td>
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<td>*26th Oct – 30th Oct</td>
<td>1st Mar – 5th Mar</td>
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<td>Week 16</td>
<td>Week 34</td>
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<td>14th Dec – 18th Dec</td>
<td>19th Apr – 23rd Apr</td>
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* Monday 26th October 2020 Bank Holiday - College closed

** Wednesday 17th March 2021 St Patricks Day - College closed

***Monday 5th April 2021 - Easter Monday - College Closed
Graduate Attributes

The Trinity Graduate Attributes represent the qualities, skills and behaviours that you will have the opportunity to develop as a Trinity student over your entire university experience, in other words, not only in the classroom, but also through engagement in co- and extra-curricular activities (such as summer work placements, internships, or volunteering).

The four Trinity Graduate Attributes are:

- To Think Independently
- To Act Responsibly
- To Develop Continuously
- To Communicate Effectively

Why are the Graduate Attributes important?

The Trinity Graduate Attributes will enhance your personal, professional and intellectual development. They will also help to prepare you for lifelong learning and for the challenges of living and working in an increasingly complex and changing world.

The Graduate Attributes will enhance your employability. Whilst your degree remains fundamental, also being able to demonstrate these Graduate Attributes will help you to differentiate yourself as they encapsulate the kinds of transversal skills and abilities, which employers are looking for.

How will I develop these Graduate Attributes?

Many of the Graduate Attributes are ‘slow learned’, in other words, you will develop them over the four or five years of your programme of study.

They are embedded in the curriculum and in assessments, for example, through undertaking independent research for your final year project, giving presentations and engaging in group work.

You will also develop them through the co-curricular and extra-curricular activities. If you help to run a club or society you will be improving your leadership skills, or if you play a sport you are building your communication and team-work skills.
### Appendix 1

<table>
<thead>
<tr>
<th>ITEM</th>
<th>REFERENCE/Source</th>
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<tr>
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|                        | https://www.tcd.ie/Science/assets/documents/PDF/Foundation-Scholarship-
### Appendix 1: General Information

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<td>Mature Student Office</td>
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<td>DUCAC: <a href="https://www.tcd.ie/Sport/student-sport/ducac/?nodeId=94&amp;title=Sports_Clubs">https://www.tcd.ie/Sport/student-sport/ducac/?nodeId=94&amp;title=Sports_Clubs</a></td>
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| Information on TCDSU and GSU, Including | TCDSU | https://www.tcdsu.org/ |
## Appendix 1: General Information

### Student Representative Structures

<table>
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<tr>
<th>TCDSU Student Representation Overview</th>
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<td>GSU - Student Representation Overview</td>
<td><a href="https://www.tcdgsu.ie/becomearep/">https://www.tcdgsu.ie/becomearep/</a></td>
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</table>

### Emergency Procedure

In the event of an emergency, **dial Security Services on extension 1999**

Security Services provide a 24-hour service to the college community, 365 days a year. They are the liaison to the Fire, Garda and Ambulance services and all staff and students are advised to always telephone extension 1999 (+353 1 896 1999) in case of an emergency.

Should you require any emergency or rescue services on campus, you must contact Security Services. This includes chemical spills, personal injury or first aid assistance.

It is recommended that all students save at least one emergency contact in their phone under ICE (In Case of Emergency).

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**NOTE**: All of the information contained in this booklet is accurate at time of publication. However, the Science Course Office reserves the right to modify information, dates and times as necessary. Students will be notified of any changes via e-mail and the Science webpage.
Science Course Office

Faculty of Engineering, Mathematics and Science Trinity College Dublin 2, Ireland.

Oifig na gCúrsai Éolaíochta Dámh na hinne-altóireachta, na Matamaitce agus na hÉolaíochta Ollscoil Átha Cliath, Coláiste na Trionóide Baile Átha Cliath 2. Éire.

PH: +353 1 896 1970
E-mail: science@tcd.ie
Web: www.tcd.ie/Science