Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Science at Trinity

Faculty of Science, Technology, Engineering and Mathematics (STEM)

TR063
Physical Sciences
Sophister Course Programme 2022- 2023

tcd.ie/science

TR063 Physical Sciences Sophister Booklet

Junior Sophister 2022-2023

Senior Sophister 2023-2024

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Welcome

Dear Students

Congratulations – you are nearing the end of the Freshman years of your degree and are ready to make the important decision about which science Moderatorship you wish to pursue. The Freshman course structure has given you an excellent grounding in your core subject to prepare you for the advanced material you will cover in your Sophister years. You have also had opportunities to take open modules in other science subjects that have given breadth and context to your science education.

Development of educational breadth continues in the Sophister years via the opportunity to take further open modules and also Trinity Electives. Trinity Electives are stand-alone, College-wide modules that enable you to broaden your knowledge outside of your chosen subject. There is a wide range of choice available to you that encompasses languages and cultures, key societal challenges, and Trinity's ground-breaking research activities.

A list of the modules can be found at this link (https://www.tcd.ie/trinity-electives/).

Having the opportunity to develop these broader skills, particularly in communication and presentation, will allow you to derive the greatest benefits from your particular choice of Moderatorship subject and will give you important insights into other subjects and modes of scholarship outside of the sciences.

I wish you the very best in your Sophister years and look forward to seeing your future successes and achievements.

Prof Áine Kelly
Associate Dean of Undergraduate Science Education

Foreword from the Physical Sciences Course Director

Together with the Associate Dean of Undergraduate Science Education, I as Course Director of the Physical Sciences, wish all of the soon-to-be Sophister students well in the final two years of their degree. The choice of your preferred Moderatorship and hence of your preferred degree is, of necessity, a choice that a student makes towards the end of their Senior Freshman year. This Sophister Course booklet is made available to Senior Freshman students at the time of their choice. It reflects the structure of each of the Sophister years in all three of the Moderatorships available within the Physical Sciences course. These three are of course the **Physics** Moderatorship, the **Physics and Astrophysics** Moderatorship and the **Nanoscience** Moderatorship. The structures, modules, practical elements, progression, capstone research projects, and the choices available whether among the Junior Sophister open modules, Junior Sophister Trinity Elective or Senior Sophister optional modules are listed in this handbook.

As the Physical Sciences Moderatorships have been rapidly evolving in light of the Trinity Education project, all of the information here as presented is as accurate as possible at the time of compilation of this document. However, module codes, the module content, the choice or breadth, or timing of available Core, Mandatory, Open or Optional modules and details of examinations are subject to change between this academic year and the beginning of the next when rising Junior Sophister students enter into the Sophister years of the Moderatorships within Physical Sciences. We are very happy for you to be with us on this exciting journey where these three Moderatorships are presented in a way not possible before now with Core components and open modules in Junior Sophister and a new broader range of optional modules in the Senior Sophister year.

Specifically, within each Moderatorship there are opportunities to further tailor your degree through your parallel choice of Trinity Electives in the summer; by subsequent choices within the Junior Sophister year of Junior Sophister Open modules; your preference of your Senior Sophister project, and your selection from among the Senior Sophister Open modules. Whatever your pathway and whatever the Moderatorship ultimately chosen, it will be accredited by the Institute of Physics, the professional body for physicists in Ireland and in the United Kingdom, but further each of our physics degrees gives you a wide range of transferable skills which are valuable whether in research, industry, or business.

Best wishes to all

Prof Cormac McGuinness
Director of the Physical Sciences Course

Introduction

Sophister courses in **Physical Sciences** are organised so that students follow a continuous programme of work over two years leading to a Moderatorship in a particular subject. Each module (whether lecture, tutorial, seminar or practical) has a specified credit value, which is an approximate measure of the workload associated with the module and is in turn reflected in its proportional weighting in assessment. One credit is normally considered to represent a minimum of 20 hours of work on the part of a student. Students take modules to the value of 60 credits in each of the Sophister years.

The Physical Sciences (TR063) Sophister Course Booklet is intended as a detailed and comprehensive guide to all Moderatorships within Physical Sciences. Full module descriptors, course descriptions and reading lists are available from the Undergraduate Handbook of the School of Physics.
https://www.tcd.ie/Physics/study/current/undergraduate/handbook/

While every effort will be made to give due notice of major changes, the School of Physics and the Science Course Office reserve the right to suspend, alter or initiate courses, timetables, examinations, and regulations at any time.

The information in this booklet is accurate at the time of going to print but may be subject to minor changes.

Moderatorship Choice Form

The choice of Moderatorship form is available online: **FORM.** The closing date for submissions is **Friday 29th April 2022.**

Allocation of Places

The Science Course Office coordinates and processes the applications for Junior Sophister and Moderatorship places in the TR063 **Physical Sciences** course. The procedures are documented below to show students that Moderatorship places are allocated in a fair, transparent, and efficient manner.

The numbers of places available in each moderatorship subject is limited by quota. **Allocation is based on the overall mark obtained in the Senior Freshman examinations to include the prerequisite modules** and the order of choice as expressed by the student.
Decisions on places are made by the Science Course Office and students cannot be allocated a place by circumventing the Science Course Office or Physical Sciences Course Director and going to the Course Advisors directly. All enquiries with regard to the allocation of places made to the Course Advisors will be redirected to the Science Course Office science@tcd.ie.

Places will be allocated in the following way until quotas in each Moderatorship are reached:

1. All students **passing their Senior Freshman semester one and semester two examinations** will be ranked in merit order on the basis of their overall mark.
2. Places will be allocated in rank order, with preference given to students who have passed the prerequisite modules of the course.
3. Students failing the Senior Freshman examinations must reapply for the remaining unfilled places until quotas are reached. Second round choice of subject forms will be made available on-line https://www.tcd.ie/Science/TR063/. Click on Junior Sophister on the left menu then click on Moderatorship Choice Form, following publication of the Senior Freshman examination results.
4. The closing date for the online second round form is Friday 24th July 2022.
5. In the event of two or more students having equal overall averages seeking one place, the choice will be made in favour of the student gaining the higher mark in the SF modules that are pre-requisites for the moderatorship in question.
6. Examination results will be available on your personal portal at my.tcd.ie.
7. Publication of the JS places will be available through my.tcd.ie portal by the middle of June 2022.
8. Students are informed by email when the places are published, and the procedures followed are clearly outlined in the email.
9. Students opting to go 'off books' rather than take up the place offered, will be treated as rising JS students in the following year. Places will not be reserved for such students. Students who apply for readmission will be considered for a place in the same way as the year in which they qualified (if a student did not qualify for a place in the first round, they will not be considered in the first round when they apply for readmission to the College).
10. Students who fail their Junior Sophister examinations will be treated ex-quota in relation to that discipline.
11. Students who are given permission by the Senior Lecturer to defer their examinations until the reassessment examination session can defer a place in their **first** preference only. Following publication of the reassessment examinations, students who passed Senior Freshman examinations at the reassessment session will be allocated a place based on the same criteria used in the summer allocation of places. If the student in this category does not qualify for the deferred place, the Science Course Administrator will offer that student a place in one of the subjects available in the second round and the deferred place will be offered to the next qualified student from the first-round allocation.

Special note: Students who have passed their Senior Freshman examinations may not repeat the SF year in order to improve their performance.

Course Advisors

Physics	Professor Cormac McGuinness
Physics and Astrophysics	Professor Brian Espey
Nanoscience	Professor Peter Dunne

Moderatorship Courses and Quotas

To be qualified for a Moderatorship, students must have successfully completed both Freshman years and must have taken the stated prerequisite modules for any Moderatorship for which they wish to be considered. All students in Physical Sciences who have completed both Freshman years are eligible to proceed into the **Physics** or the **Physics and Astrophysics** Moderatorships. In the Physical Sciences course, the only Moderatorship with a prerequisite is **Nanoscience** where a student must have taken in the two Freshman years all 40 credits of Open Chemistry modules.

While every effort will be made to give due notice of major changes in the quotas, the Physical Sciences Course Director reserves the right to alter pre-requisites and quotas, if necessary. In the case of the Nanoscience Moderatorship this will be in conjunction and in consultation with the Chemical Sciences Course Director and the Nanoscience Moderatorship Course Director.

Moderatorship	**Quotas**
Physics	30
Physics & Astrophysics	24
Nanoscience	10 + 6*

***Note regarding Nanoscience quota.** Nanoscience is a shared course between the Schools of Physics and the School of Chemistry accessible through both Physical Sciences (TR063) and Chemical Sciences (TR061) for students with the appropriate 120 credits of Freshman modules in Physics, Chemistry and Mathematics. Thus the 10 highest ranked students from either Physical Sciences or Chemical Sciences are allocated places in the Nanoscience Moderatorship. Six additional places are available to the highest ranked qualified students from either Physical or Chemical Sciences who have not already been allocated a place in the Moderatorship.

Summary from the Freshman Physical Sciences (TR063) Programme

The Junior and the Senior Freshman years in the Physical Sciences course provide the foundational material that all the Physical Sciences Moderatorships are predicated upon. Further, exposure to these courses allow time for students to determine the career path they wish to follow. In each of the Freshman years, the academic year is divided into Semester 1 (Michaelmas term) and Semester 2 (Hilary term), and all students take selected modules to the value of 60 credits for the year with no more than 30 credits from Semester 1 and 30 credits from Semester 2. In each semester there are 20 credits of Core modules, and 10 credits of Open modules. The details of the Freshman modules are repeated here.

Moderatorships:
As stated in the earlier Physical Sciences Freshman handbooks, in the Junior and Senior Freshman years Physical Sciences TR063 students complete a course of study which will qualify them to compete for a place in one of the following Moderatorships after the Senior Freshman year: **Physics**, **Physics and Astrophysics** or **Nanoscience**.

Core and Open Module Choices in Junior and Senior Freshman Years

Year 1: JUNIOR FRESHMAN	
CORE MODULES – 40 credits 20/20	
Semester 1	**Semester 2**
PYU11P10: Physics 1	PYU11P20: Physics 2
MAU11S01: Mathematics	MAU11S02: Mathematics

Year 2: SENIOR FRESHMAN	
CORE MODULES – 40 credits 20/20	
Semester 1	**Semester 2**
PYU22P10: Physics 3	PYU22P20: Physics 4
MAU22S01: Multi-Variable Calculus for Science	MAU22S02: Vector Calculus for Science
MAU22S03: Fourier analysis for Science	PIU22992: History, Philosophy and Ethics of Science

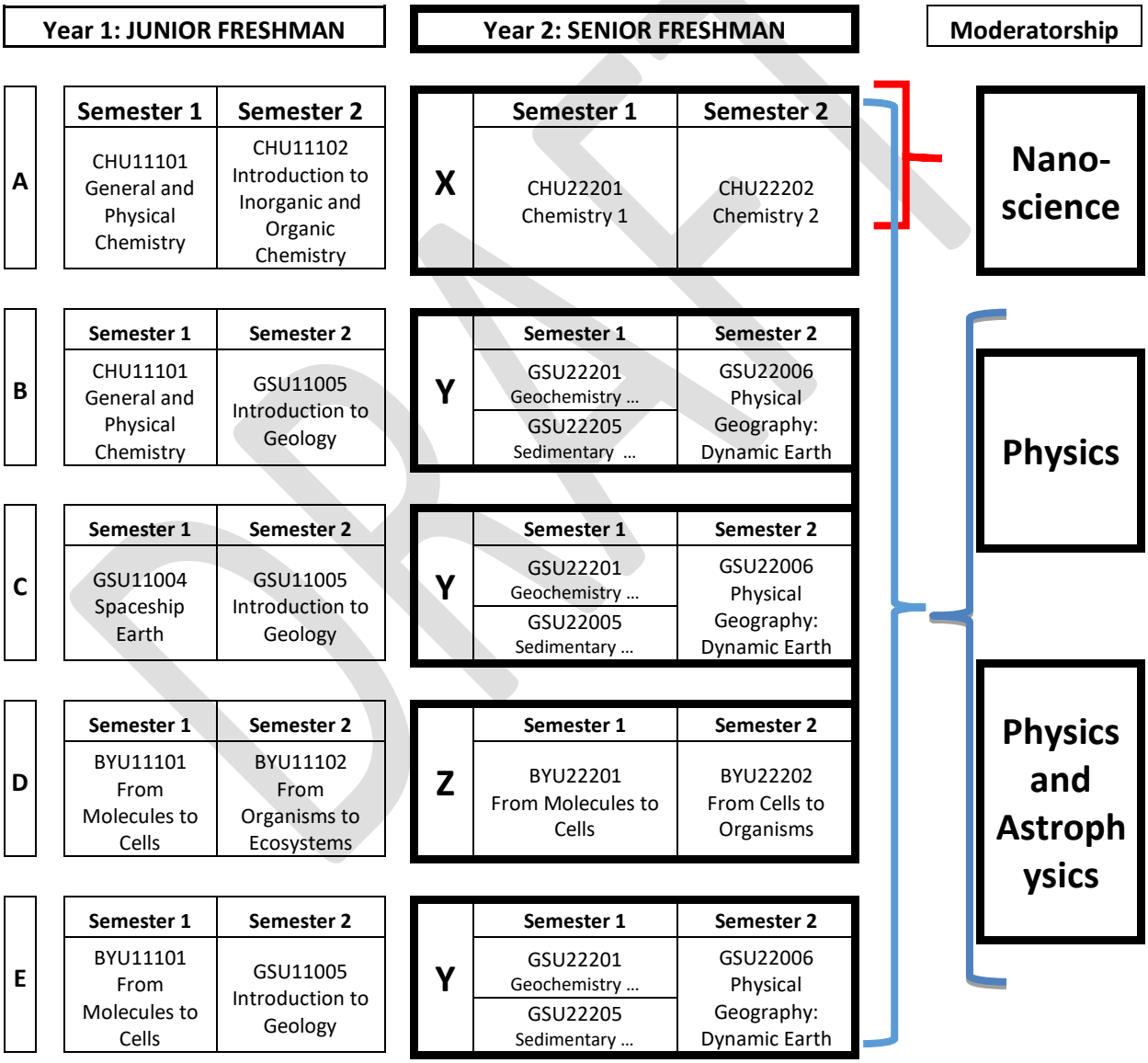
OPEN MODULES – choose 20 credits 10/10	
CHU11101 General and Physical Chemistry	CHU11102 Introduction to Inorganic and Organic Chemistry
GSU11004 Spaceship Earth	GSU11005 Introduction to Geology
BYU11101 From Molecules to Cells	BYU11102 From Organisms to Ecosystems

OPEN MODULES – choose 20 credits 10/10	
CHU22201 Chemistry 1	CHU22202 Chemistry 2
GSU22201 From Atoms to Rocks: Introduction to Geochemistry	GSU22006 Physical Geography: Dynamic Earth
GSU22205 Sedimentary Processes & Environments	
BYU22201 From Molecules to Cells	BYU22202 From Cells to Organisms

TR063: Moderatorships and Open Module Choice Diagram

Moderatorships in **Physics** or in **Physics and Astrophysics** are available to all students regardless of the choice of open modules in the Junior Freshman and Senior Freshman years. To qualify for the Moderatorship in **Nanoscience**, a student must take all available Chemistry open modules in both semesters of the Junior and Senior Freshman years.

Five distinct patterns of open modules are available to students across Junior Freshman and Senior Freshman years. In Junior Freshman these are denoted A, B, C, D and E leading to three distinct module patterns in Senior Freshman, designated as X, Y and Z. The pathways to the possible Moderatorships are indicated in the diagram.



Applications to choose a specific Moderatorship in Sophister years, detailed here occur via a preferred Moderatorship choice form available in Semester 2 of the Senior Freshman year.

Trinity Electives

The Trinity Electives are a unique feature of your Trinity Education. They are stand alone, College-wide 5 credit modules. They cover a broad range of topics in the arts, humanities, sciences, health and social science, and technology. They are designed to allow students to study topics outside of their core discipline and thus to develop breadth within their education. Science students take a minimum of one and a maximum of two Trinity Electives in the Junior Sophister year. Depending on your moderatorship, you will choose a combination of Trinity Electives and Open Modules as described in this handbook.

Choosing your Trinity Elective

The choice of Trinity Elective is student driven. Almost all Trinity Electives are open to all students; some exceptions may apply to your moderatorship that are outlined in the Trinity Electives webpage (e.g., From Planets to the Cosmos is not available to TR063 Physical Sciences students, for obvious reasons).

Selection will be made through online enrolment which will open in early July 2022, after publication of results and allocation of moderatorships. You will be asked to list your choice(s) of Trinity Elective in order of preference. Places are allocated according to a computer algorithm and are allocated based on student preference and places available in the Trinity Elective. Exam results are not factored into this algorithm.

The Trinity Electives website provides full details of each of the Trinity Electives. A list of the Trinity Electives can be found at https://www.tcd.ie/trinity-electives/

You will need to think carefully about your choice of Trinity Elective as the semester in which you take the module (Semester 1, Semester 2, or both) will affect the Open Modules that you can take – refer carefully to the tables in this handbook. Choose your preferred pattern of Open Modules first and then the semester for your Trinity Elective. Be sure to select a Trinity Elective in the semester that you are making available for it. Please note that you CANNOT change your Trinity Elective so choose carefully!!!

Summary of Process

May: Results are published

June: Moderatorships are allocated.
Students apply for Trinity Electives through an online portal on the Trinity Electives website. Trinity Electives are allocated by computer algorithm.
Students are informed of Trinity Elective allocation. **THERE IS NO CHANGE OF MIND.**

Following this process, students will select their Open modules in Junior Sophister.

Non-Satisfactory Attendance and Coursework

All students must fulfil the course 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.

At the end of the teaching term, students who have not satisfied the school or department requirements, may be reported as non-satisfactory for that term. Students reported as non-satisfactory for the Michaelmas and Hilary terms of a given year may be refused permission to take their semester two assessment/examinations and may be required by the Senior Lecturer to repeat their year https://www.tcd.ie/undergraduate-studies/academic-progress/attendance-course-work.php.
Please refer to your department/discipline handbook for moderatorship regulations.

Junior Sophister Examination Information

Modules are assessed by continuous assessment and/or by examination. The Junior Sophister year carries a total of 60 credits. The scheme of distribution of marks between papers and practical work at the Sophister examinations will be published by individual schools or departments/disciplines.

Calculation of Moderatorship results
The final moderatorship results in Physics, Physics and Astrophysics and in Nanoscience are calculated as a weighted average of the overall result for the Junior and Senior Sophister examination results.
Junior Sophister 30%, Senior Sophister 70%.

Reassessment Regulations
Reassessment is available in all years.
Students may not present for reassessment in a module they have passed.
Capping of marks is not applied for reassessment.

Repeat Year regulations

Students who fail to satisfy the requirements of their year at the Reassessment session are required to repeat the year in full (i.e., all modules and all assessment components).

Students are permitted to repeat any year of an undergraduate programme subject to, not repeating the same year more than once and not repeating more than two academic years within a degree course, except by special permission of the University Council (see calendar https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf page 38.

The option to repeat a year on an 'off-books' basis will be at the discretion of the Senior Lecturer (see Calendar https://www.tcd.ie/calendar/undergraduate-studies/general-regulations-and-information.pdf page 40).

Dates to Note

Date	
15th April 2022	Semester 2 - Hilary Lecture Term ends
29th April 2022	Closing date – Submit choice of Moderatorship forms
3rd May 2022	Semester 2 Examinations begin (TBC)
23rd May 2022	Semester 2 Examination ends (TBC)
late May 2022	Publication of Examination results (TBC)
mid-June 2022	Allocation of JS Moderatorship places
mid-June 2022	Notification of JS Moderatorship places
Friday 24th July 2022	Closing date – 2nd Round Choice Moderatorship Form

N.B. These dates are accurate going to print but may be subject to change.

Physics

Junior Sophister Course Advisor: Prof Cormac McGuinness cmcguin@tcd.ie

The Physics moderatorship covers a range of topics across the spectrum of modern physics, and the experimental, theoretical, and computational techniques used to explore them. It builds on the Physics modules taken in the Freshman years. There is a particular emphasis on condensed matter physics, photonics, and nanoscience, reflecting the importance of these fields as well as reflecting the strength of the School's research expertise in these areas.

Junior Sophisters:

The JS year consists of lectures, tutorials and practicals delivered in modules, as listed below. Within the Junior Sophister year in Nanoscience there are 40 credits of Core modules, the remaining 20 credits are either Open or Elective modules. **All students are required to take a Trinity Elective in either the first or the second semester.** Students receive training in communication skills as part of the cross-semester practical module.

Assessment and Examination Procedures

Each 5-credit lecture module will be examined separately by a 2-hour exam in the relevant end-of-semester examination period, with the exception of PYU33C01 and PYU33P15, which are assessed entirely by continuous assessment. Examined modules may include continuous assessment components. The composition of written papers will be given in the Junior Sophister Physics Booklet issued to rising Junior Sophisters. The JS Physics mark will constitute 30% of the final degree mark.

Continuous assessment of the two practical modules contributes 15 credits. For full details of assessments and modules and module descriptors please see the School of Physics Handbook, https://www.tcd.ie/Physics/study/current/undergraduate/handbook/

Senior Sophisters:

The SS year consists of lectures, tutorials and practical physics delivered in modules, as listed. A major component of the year is an independent capstone research project, which is carried out during the first 9 weeks of Michaelmas term. There are no lectures during this period. The project may be carried out at other international partner institutes. The independent capstone research project may be an experimental, theoretical, or computational project in almost any physics topic.

Core Modules: The capstone research project, problem solving module and several other modules are designated as core modules. These core modules total 40 credits, the remaining 20 credits of the Senior Sophister year in Physics are made up from among a range of several Open 5 credit modules.

Assessment and Examination Procedures

Each 5-credit lecture module will be examined separately in the relevant end-of-semester examination period. The 10-credit lecture modules PYU44P11 and PYU44N02 are examined in the semester 2 examination period. The research project PYU44PP2 is assessed during semester 2. Problem Solving in Physics (PYU44PP5) will be examined at the end of Semester 1. Examined modules may include continuous assessment components. The SS Physics mark will constitute 70% of the final degree mark. For full details of assessments and modules please see the School of Physics Handbook,
https://www.tcd.ie/Physics/study/current/undergraduate/handbook/

Junior Sophister Course Structure Diagram

The Junior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="3">Junior Sophister TR063 – PHYSICS</th></tr>
<tr><th colspan="3">40 Credits core + 20 Credits Open modules or Trinity Elective modules</th></tr>
<tr><td rowspan="5">Core Modules (40 credits)</td><td>Semester 1: Core</td><td>Semester 2: Core</td></tr>
<tr><td>PYU33P01: Quantum Mechanics I
(5 credits)</td><td>PYU33P03: Condensed Matter I
(5 credits)</td></tr>
<tr><td>PYU33P15: Atomic Physics and Statistical Thermodynamics
(5 credits)</td><td>PYU33P04: Semiconductor Physics
(5 credits)</td></tr>
<tr><td colspan="2">PYU33PP3: JS Physics Laboratory (10 credits)</td></tr>
<tr><td>PYU33P02: Electromagnetic Interactions I (5 credits)</td><td>PYU33PP4: JS Physics Laboratory
(5 credits)</td></tr>
<tr><td rowspan="4">Open or Trinity Elective Modules (20 credits)</td><td>Semester 1: Open – choose 2 of 3</td><td>Semester 2: Open – choose 2 of 3</td></tr>
<tr><td>PYU33C01: Computer Simulation I
(5 credits)</td><td>PYU33P07: Experimental Techniques
(5 credits)</td></tr>
<tr><td>PYU33A03: Stellar & Galactic structure
(5 credits)</td><td>PYU33A07: Experimental Techniques for Astrophysics
(5 credits)</td></tr>
<tr><td>Trinity Elective 1
(5 credits)</td><td>Trinity Elective 2
(5 credits)</td></tr>
</table>

A Physics student can choose to take their one required Trinity Elective in either semester but can then take only one of the available Open modules in that semester.

A Physics student can choose to take a second Trinity Elective, one in each semester, but then has a much-reduced choice of taking only one of the available Open modules in each semester. Taking two Trinity Electives severely reduces the Physics content in the degree and can impact on later choice. For example: Computer Simulation II in the SS year will be dependent upon taking Computer Simulation I.

Junior Sophister Core Modules 40 credits

PYU33P01 Quantum Mechanics (S1) **5 credits**
This module covers solution of the Schrödinger Equation in specific topics, such as angular momentum and the hydrogen atom.

PYU33P15 Atomic Physics and Statistical Thermodynamics (S1) **5 credits**
This module covers atomic physics and spectroscopy together with statistical mechanics and thermodynamics.

PYU33P02 Electromagnetic Interactions I (S1) **5 credits**
This module covers the fundamentals of electromagnetic theory together with quantum optics and lasers.

PYU33P03 Condensed Matter I (S2) **5 credits**
This module introduces condensed matter concepts such as crystal structure and thermal and electronic properties of matter.

PYU33P04 Semiconductor Physics (S2) **5 credits**
This module covers the physics of semiconductors and the construction, fabrication and application of semiconductor devices.

PYU33PP3 Practical in Physics (S1 & S2) **10 credits**
PYU33PP4 Practical in Physics (S2) **5 credits**
In modules PYU33PP3 & PYU33PP4 students complete a number of advanced experiments in Physics together with an introduction to data analysis in Physics. The first cross-semester module includes components involving training in communication skills, personal and career development, and requires attendance at School Seminars. The second semester 2 module develops these skills further and ensures that students have a broad experience within a physics laboratory.

Junior Sophister Open Modules and Trinity Electives 20 credits

PYU33C01 Computer Simulation I (S1) **5 credits**
This module provides an introduction to numerical and computational techniques and how they may be used to solve problems in Physics.

PYU33A03 Stellar and Galactic Structure (S1) **5 credits**
This module covers the evolution of stars, from their hydrogen burning until supernova explosion, and the properties of galaxies in the local and distant Universe.

PYU33P07 Experimental Techniques (S2) **5 credits**
This module covers instrumentation with specific examples in imaging techniques together with common device electronics and measurement methods and strategies.

PYU33A07 Experimental Techniques for Astrophysics (S2) **5 credits**
This module covers astrophysical instrumentation, with the astrophysical spectroscopy required to interpret spectra from across the electromagnetic spectrum.

Trinity Elective (S1 or S2) **5 credits**
Details on Trinity Electives are found at: https://www.tcd.ie/trinity-electives/.

Senior Sophister Course Advisor: Prof Cormac McGuinness cmcguin@tcd.ie

Senior Sophister Course Structure Diagram (Subject to change for AY23/24)

The Senior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="5">Senior Sophister TR063 – PHYSICS</th></tr>
<tr><th colspan="5">40 Credits Core modules + 20 Credits Open modules (AY 22/23)</th></tr>
<tr><td rowspan="4">Core Modules (40 credits)</td><td colspan="2">Semester 1: Core</td><td colspan="2">Semester 2: Core</td></tr>
<tr><td colspan="3">PYU44PP2: Capstone Research Project (20 credits) – Assessment in Semester 2</td><td></td></tr>
<tr><td rowspan="2">Project only in first 9 weeks of semester 1</td><td>PYU44PP5: Problem solving (5 credits)</td><td colspan="2">PYU44P05: Electromagnetic Interactions II (5 credits)</td></tr>
<tr><td colspan="3">PYU44P11: Advanced Quantum Mechanics, High Energy Physics and Nuclear Structure (10 credits)</td></tr>
<tr><td rowspan="9">Open Modules (20 credits)</td><td colspan="2">Semester 1: Open modules</td><td colspan="2">Semester 2: Open modules</td></tr>
<tr><td rowspan="8">Take 4 Open modules which total 20 credits</td><td colspan="3">PYU44N02: Nanoscience, complex fluids, and polymers (10 credits)</td></tr>
<tr><td colspan="2">PYU44P13: Magnetism & Superconductivity</td></tr>
<tr><td colspan="2">PYU44P06: Modern Optics</td></tr>
<tr><td colspan="2">PYU44T20: Quantum Optics and Information</td></tr>
<tr><td colspan="2">PYU44A05: Cosmology</td></tr>
<tr><td colspan="2">PYU44C01: Computer Simulation II</td></tr>
<tr><td colspan="2">PYU44P17: Energy Science</td></tr>
<tr><td colspan="2">PYU44P18: Quantum Plasmonics and Metamaterials</td></tr>
</table>

The PYU44PP2 capstone research project takes place in the first nine weeks of Semester 1. The assessment of the research project is in Semester 2. The remaining three weeks of Semester 1 has tutorials associated with the PYU44PP5 Problem Solving module which is examined at the end of Semester 1.

Lectures associated with the core PYU44P11 module and the open PYU44N02 module begin in the last three weeks of Semester 1, but examinations for these modules are at the end of Semester 2. All other modules, whether mandatory or optional, occur wholly within Semester 2 and are examined at the end of Semester 2.

Senior Sophister Core Modules 40 credits

PYU44PP2 Physics Research Project (S1 & S2) 20 credits
This module comprises a 9-week full-time capstone research project in experimental, theoretical, or computational physics, undertaken at the beginning of Semester 1. The project may be undertaken in Trinity, or in another University or Research Institute in Ireland or abroad. Submission of report and presentation of results is in Semester 2

PYU44PP5 Problem Solving in Physics (S1) 5 credits
This module develops techniques and approaches to general problem solving in physics.

PYU44P11 Advanced Quantum Mechanics, High Energy Physics and Nuclear Structure (S1 & S2) 10 credits
The quantum mechanics of this module extends the discussion of quantum physics into multi-electron atoms, time dependent Schrödinger Equation and perturbation theory. It includes nuclear physics, strong nuclear force, nuclear reactions, and nuclear structure and introduces high energy physics theory and experiment, fundamental particles, and the Standard Model.

PYU44P05 Electromagnetic Interactions II (S2) 5 credits
This module covers electromagnetic wave phenomena together with the optical properties of materials.

Senior Sophister Open Modules 20 credits

PYU44N02 Nanoscience, Complex Fluids and Polymers (S1 & S2) 10 credits
This module covers nanoscience, and the modified properties of nanoscale matter, its fabrication, and potential applications together with the rheology and behaviour of liquids as applied to microfluidic systems and a detailed overview of polymer physics.

PYU44P13 Magnetism and Superconductivity (S2) 5 credits
This module covers magnetism, magnetic materials, and introduces superconductivity.

PYU44P06 Modern Optics (S2) 5 credits
This module covers optical communications and nonlinear optics involving lasers.

PYU44A05 Cosmology (S2) 5 credits
This module covers cosmology, deriving its basic equations and using them together with observations to examine the history and future of the Universe. Recent results concerning dark matter and dark energy, and possible future directions are also examined.

PYU44C01 Computer Simulation II (S2) 5 credits
This module provides an introduction to matrix computing and discrete Fourier transforms and partial differential equations through Python and extends the toolkit of numerical and statistical computer simulation techniques.

PYU44P17 Energy Science (S2) 5 credits
This module consists of the physics behind key technologies for energy generation.

PYU44T20 Quantum Optics and Information (S2) 5 credits
This module covers the mathematical treatment of photons, quantized electromagnetic fields entanglement and quantum information or qubits.

PYU44P18 Quantum Plasmonics and Metamaterials (S2) 5 credits
This module covers quantum plasmonics and the fundamentals of photonics of metallic and dielectric nanostructures up to extreme nanoscales and the physics of metamaterials, that is the optics of materials having near-zero and negative refractive index.

Physics Moderatorship Learning Outcomes.

On the successful completion of this programme, a student should be able to:

- demonstrate in written and oral form a comprehensive level of knowledge of physics and the mathematics that underpins this knowledge, together with an awareness of its place within the broader science curriculum.

- apply the core concepts of Classical and Modern Physics across a wide spectrum of topics and applications, such as information technology and materials science.

- perform calculations to solve practical problems, including the use of numerical methods and computing.

- operate sophisticated spectrometers and similar test and evaluation apparatus across a wide spectrum of investigation.

- independently design and carry out an experiment and evaluate critically the data obtained, including appropriate error analysis.

- communicate the results of an experiment or project via dissertation, poster, or oral presentation.

- employ literature search methods to obtain information relevant to research and development.

- act effectively as an individual or as a member of a team in professional, educational, and industrial settings.

- update personal knowledge with a high degree of autonomy, whether in the workplace or in the context of further study.

Physics and Astrophysics

Junior Sophister Course Advisor: Prof Brian Espey Brian.Espey@tcd.ie

Physics and Astrophysics combines the core modules from the moderatorship in Physics with specialist modules in astrophysics theory and practice. This moderatorship reflects a curriculum for those with an increasing interest in astronomy and space science as well as reflecting the strength of the School's research expertise in these areas.

Junior Sophisters:
The JS year consists of lectures, tutorials and practicals delivered in modules, as listed below. Within the Junior Sophister year in Physics and Astrophysics there are 40 credits of Core modules, the remaining 20 credits are either Open or Elective modules. **All students are required to take a Trinity Elective in either the first or the second semester.** Students receive training in communication skills as part of the practical modules.

Assessment and Examination Procedures
Each 5-credit lecture module will be examined separately by a 2-hour exam in the relevant end-of-semester examination period, with the exception of PYU33C01 and PYU33P15 which are assessed entirely by continuous assessment. Examined modules may include continuous assessment components. The composition of written papers will be given in the Junior Sophister Physics and Astrophysics Booklet issued to rising Junior Sophisters. The JS Physics and Astrophysics mark will constitute 30% of the final degree mark. Continuous assessment of the two practical modules contributes 15 credits. For full details of assessments and modules and module descriptors please see the School of Physics Undergraduate Handbook, https://www.tcd.ie/Physics/study/current/undergraduate/handbook/

Senior Sophisters:
The SS year consists of lectures, tutorials and practical physics delivered in modules, as listed. A major component of the year is an independent capstone research project, which is carried out during the first 9 weeks of Michaelmas term. There are no lectures during this period. The independent capstone research project may be in either an astrophysics topic or in a physics topic.

Core Modules: The research project, problem solving module and several other modules are designated as core modules. These core modules total 50 credits, but the remaining 10 credits of the Senior Sophister year in Physics and Astrophysics are made up from among several Open modules.

Assessment and Examination Procedures
Each 5-credit lecture module will be examined separately in the relevant end-of-semester examination period. The 10-credit lecture modules PYU44P11 and PYU44A03 are examined in the semester 2 examination period. The research project PYU44PP2 is assessed during semester 2. Problem Solving in Physics (PYU44PP5) will be examined at end of Semester 1. Examined modules may include continuous assessment components. The SS Physics mark will constitute 70% of the final degree mark. For full details of assessments and modules and module descriptors please see the School of Physics Handbook: https://www.tcd.ie/Physics/study/current/undergraduate/handbook/

Junior Sophister Course Structure Diagram

The Junior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="3">Junior Sophister TR063 – PHYSICS AND ASTROPHYSICS</th></tr>
<tr><th colspan="3">40 Credits core + 20 Credits Open modules or Trinity Elective modules</th></tr>
<tr><td rowspan="5">Core Modules (40 credits)</td><td>Semester 1: Core</td><td>Semester 2: Core</td></tr>
<tr><td>PYU33P01: Quantum Mechanics I (5 credits)</td><td>PYU33P03: Condensed Matter I (5 credits)</td></tr>
<tr><td>PYU33A03: Stellar & Galactic Structure (5 credits)</td><td>PYU33A07: Experimental Techniques for Astrophysics (5 credits)</td></tr>
<tr><td colspan="2">PYU33AP3: JS Physics Laboratory (10 credits)</td></tr>
<tr><td>PYU33P02: Electromagnetic Interactions I (5 credits)</td><td>PYU33AP4: JS Astrophysics Laboratory (5 credits)</td></tr>
<tr><td rowspan="4">Open or Trinity Elective Modules (20 credits)</td><td>Semester 1: Open – first is core then choose 1 of 2</td><td>Semester 2: Open – choose 2 of 3</td></tr>
<tr><td>*PYU33P15: Atomic Physics and Statistical Thermodynamics [Mandatory] (5 credits)</td><td>PYU33P04: Semiconductor Physics (5 credits)</td></tr>
<tr><td>PYU33C01: Computer Simulation I (5 credits)</td><td>PYU33P07: Experimental techniques (5 credits)</td></tr>
<tr><td>Trinity Elective 1 (5 credits)</td><td>Trinity Elective 2 (5 credits)</td></tr>
</table>

A Physics and Astrophysics student can choose to take their one required Trinity Elective in either semester, but in Semester 1 students can only take the additional core PYU33P05 module and cannot take the PYU33C01 module. If taking the one required Trinity Elective in Semester 2, then both Physics and Astrophysics open modules in Semester 1 are taken and the student takes only one of the available open modules in Semester 2.

A Physics and Astrophysics student can choose to take a second Trinity Elective, one in each semester, but then has a much-reduced choice between the two available Open modules in semester 2 and not being able to take Computer Simulation I in Semester 1. Further, taking one Trinity Elective in Semester 1 or taking two Trinity Electives severely reduces the Physics and Astrophysics content in the degree, and can impact on the benefit of later modules.

In particular, **not taking PYU33C01 Computer Simulation I** in the JS year **will be detrimental** to your performance in many of the typical SS Astrophysical capstone research projects in astrophysics topics involving simulation, even though the JS Astrophysics laboratory also contains relevant astrophysical data analysis and programming.

Junior Sophister Core Modules 40 credits

PYU33P01 Quantum Mechanics I (S1) **5 credits**
This module covers solution of the Schrödinger Equation in specific topics, such as angular momentum and the hydrogen atom.

PYU33P02 Electromagnetic Interactions I (S1) **5 credits**
This module covers the fundamentals of electromagnetic theory together with quantum optics and lasers.

PYU33A03 Stellar and Galactic Structure (S1) **5 credits**
This module covers the evolution of stars, from their hydrogen burning until supernova explosion, and the properties of galaxies in the local and distant Universe.

PYU33P03 Condensed Matter I (S2) **5 credits**
This module introduces condensed matter concepts such as crystal structure and thermal and electronic properties of matter.

PYU33A07 Experimental Techniques for Astrophysics (S2) **5 credits**
This module covers astrophysical instrumentation, with the astrophysical spectroscopy required to interpret spectra from across the electromagnetic spectrum.

PYU33AP3 Practical in Physics and Astrophysics (S1 & S2) **10 credits**
PYU33AP4 Practical in Astrophysics data analysis (S2) **5 credits**
In modules PYU33AP3 and PYU33AP4 students complete a number of advanced experiments in Physics together with an introduction to computer methods in Astrophysics. The first includes components involving training in communication skills, personal and career development, and requires attendance at School Seminars. The second module specializes in astrophysical data analysis and trains the students in the appropriate data analysis methods and software.

Junior Sophister Open Modules and Trinity Electives 20 credits

PYU33C01 Computer Simulation I (S1) **5 credits**
This module provides an introduction to numerical and computational techniques and how they may be used to solve problems in Physics.

PYU33P15 Atomic Physics and Statistical Thermodynamics (S1) **5 credits**
This module covers atomic physics and spectroscopy together with statistical mechanics and thermodynamics. (This is a mandatory module.)

PYU33P07 Experimental Techniques (S2) **5 credits**
This module covers instrumentation with specific examples in imaging techniques together with common device electronics and measurement methods and strategies.

PYU33P04 Semiconductor Physics (S2) **5 credits**
This module covers the physics of semiconductors and the construction, fabrication, and application of semiconductor devices.

Trinity Elective (S1 or S2) **5 credits**
Details on Trinity Electives (TEs) are found at: https://www.tcd.ie/trinity-electives/. If a TE is taken in Semester 1 then the chosen TE must replace PYU33C01 as PYU33P15 is required for all JS Physics and Astrophysics students.

Senior Sophister Course Structure Diagram (Subject to change for AY23/24)

The Senior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="4">Senior Sophister TR063 – PHYSICS AND ASTROPHYSICS</th></tr>
<tr><th colspan="4">50 Credits Core modules + 10 Credits Open modules (AY 22/23)</th></tr>
<tr><td rowspan="5">Core Modules (50 credits)</td><td colspan="2">Semester 1: Core</td><td>Semester 2: Core</td></tr>
<tr><td colspan="2">PYU44PP2: Capstone Research Project (20 credits) – Assessment in Semester 2</td><td></td></tr>
<tr><td rowspan="3">Project only in first 9 weeks of semester 1</td><td>PYU44PP5: Problem solving (5 credits)</td><td>PYU44P05: Electromagnetic Interactions II (5 credits)</td></tr>
<tr><td colspan="2">PYU44P11: Advanced Quantum Mechanics, High Energy Physics and Nuclear Structure (10 credits)</td></tr>
<tr><td colspan="2">PYU44A01: Planetary and Space Science and Cosmology (10 credits)</td></tr>
<tr><td rowspan="5">Open Modules (10 credits)</td><td colspan="2">Semester 1: Open modules</td><td>Semester 2: Open modules</td></tr>
<tr><td colspan="2" rowspan="4">Take 2 Open modules which total 10 credits</td><td>PYU44P13: Magnetism & Superconductivity</td></tr>
<tr><td>PYU44P06: Modern Optics</td></tr>
<tr><td>PYU44C01: Computer Simulation II</td></tr>
<tr><td>PYU44P17: Energy Science</td></tr>
</table>

The PYU44PP2 capstone research project takes place in the first nine weeks of Semester 1. The assessment of the research project is in Semester 2. The remaining three weeks of Semester 1 has tutorials associated with the PYU44PP5 Problem Solving module which is examined at the end of Semester 1.

Lectures associated with the core PYU44P11 module and the core PYU44A01 module begin in the last three weeks of Semester 1, but examinations for these modules are at the end of Semester 2. All other modules, whether mandatory or optional, occur wholly within Semester 2 and are examined at the end of Semester 2.

Senior Sophister Core Modules 50 credits

PYU44PP2 Physics Capstone Research Project (S1 & S2) 20 credits
This module comprises a 9-week full-time research project in astrophysics, physics, or computational physics, undertaken at the beginning of Semester 1. The project may be undertaken in Trinity, or in another University or Research Institute in Ireland or abroad. Submission of report and presentation of results is in Semester 2

PYU44PP5 Problem Solving in Physics (S1) 5 credits
This module develops techniques and approaches to general problem solving in physics.

PYU44P11 Advanced Quantum Mechanics, High Energy Physics and Nuclear Structure (S1 & S2) 10 credits
The quantum mechanics of this module extends the discussion of quantum physics into multi-electron atoms, time dependent Schrödinger Equation and perturbation theory. It includes nuclear physics, strong nuclear force, nuclear reactions, and nuclear structure and introduces high energy physics theory and experiment, fundamental particles, and the Standard Model.

PYU44A03 Planetary and Space Science and Cosmology (S1 & S2) 10 credits
This module covers advanced concepts in planetary astrophysics, including the properties of solar system planets and exoplanets, their interiors, and atmospheres. In addition, this module covers cosmology, deriving its basic equations and using them together with observations to examine the history and future of the Universe. Recent results concerning dark matter and dark energy, and possible future directions are also examined.

PYU44P05 Electromagnetic Interactions II (S2) 5 credits
This module covers electromagnetic wave phenomena together with the optical properties of materials.

Senior Sophister Open Modules 10 credits

PYU44P13 Magnetism and Superconductivity (S2) 5 credits
This module covers magnetism, magnetic materials, and introduces superconductivity.

PYU44P06 Modern Optics (S2) 5 credits
This module covers optical communications and nonlinear optics involving lasers.

PYU44C01 Computer Simulation II (S2) 5 credits
This module provides an introduction to matrix computing and discrete Fourier transforms and partial differential equations through Python and extends the toolkit of numerical and statistical computer simulation techniques.

PYU44P17 Energy Science (S2) 5 credits
This module consists of the physics behind key technologies for energy generation.

Note that a further open module in astrophysics may be expected to be in place in the academic year 2023/2024.

Physics and Astrophysics Moderatorship Learning Outcomes.

On the successful completion of this programme, a student should be able to:

- demonstrate in written and oral form a comprehensive level of knowledge of physics and astrophysics and the mathematics that underpins this knowledge, together with an awareness of its place within the broader science curriculum.

- apply the core concepts of classical and modern Physics across a wide spectrum of topics and applications, such computer modelling of astrophysical phenomena.

- perform calculations to solve practical problems, including the use of numerical methods and computing.

- understand the operation of modern astronomical instruments, such as electronic cameras and optical and radio telescopes.

- independently design and carry out experiments and evaluate critically the data obtained, including appropriate error analysis.

- communicate the results of an experiment or project via dissertation, poster, or oral presentation.

- employ literature search methods to obtain information relevant to research and development.

- act effectively as an individual or as a member of a team in professional, educational, and industrial settings.

- update personal knowledge with a high degree of autonomy, whether in the workplace or in the context of further study.

Nanoscience

Junior Sophister Course Advisor: Prof. Peter Dunne P.W.Dunne@tcd.ie

Nanoscience is a moderatorship taught jointly by the Schools of Physics and Chemistry. Building on the foundation courses taken in the Freshman years, students follow in-depth courses across the spectrum of modern physics, physical chemistry, materials science, and nanoscience while reflecting the strength of Trinity's research expertise in these areas.

Junior Sophister:
The Junior Sophister year consists of lectures, tutorials and practicals delivered in modules, as listed below. Within the Junior Sophister year in Nanoscience there are 40 credits of Core modules, with the remaining 20 credits comprising either Open or Elective modules. **All students are required to take a Trinity Elective in the first semester.** Students receive training in communication skills within the practical modules.

Safety:
To reinforce and extend laboratory skills rising Junior Sophister students are required to attend a day-long workshop on Chemical and Laboratory Safety to be held in Freshers' Week (i.e., the week before lectures start) of Michaelmas Term. Attendance at this workshop is compulsory.

Core Modules: The Core modules, one Trinity Elective and two Open modules specified below are mandatory. In the second semester, students have the choice of taking a second Trinity Elective or one of the specified Chemistry or Physics Open modules**.**

Assessment and Examination Procedures:
Modules may be assessed by end-of-semester examination and/or continuous assessment. Further information relating to the assessed components and composition of written papers will be given in the Junior Sophister Nanoscience Booklets issued to rising Junior Sophisters. Examined modules may include continuous assessment components. Junior Sophister marks contribute 30% of the final degree Moderatorship mark.

Senior Sophisters:
The Senior Sophister year consists of lectures, tutorials, and a capstone research project, as listed below. The independent capstone research project is pursued during the first nine weeks of the first semester, in an internationally recognised laboratory that specialises in aspects of nanoscience, physics, chemistry or advanced materials, either on campus or in a facility off-campus. Projects external to Trinity College are either hosted by cognate universities or research institutes. Projects are also hosted by the Schools of Chemistry and Physics and by CRANN and Principal Investigators within AMBER.

Core Modules: The research project and several other modules are designated as core modules. These core modules total 45 credits, but the remaining 15 credits of the Senior Sophister year in Nanoscience are made up from among several Open modules of either 5 or 10 credits in size.

Assessment and Examination Procedures:
Modules may be assessed by end-of-semester examination and/or continuous assessment. Further information relating to the assessed components and composition of written papers will be given in the Senior Sophister Nanoscience Booklets issued to rising Senior Sophisters. Assessment of the full-time research project (PYU44NP2) will be performed in Semester 2. Problem Solving in Nanoscience (PYU44NP5) will be examined at the end of Semester 1. Examined modules may include continuous assessment components. Senior Sophister marks contribute 70% of the final degree Moderatorship mark.

Junior Sophister Course Structure Diagram

The Junior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="3">Junior Sophister TR063 – NANOSCIENCE</th></tr>
<tr><th colspan="3">40 Credits core + 20 Credits Open modules or Trinity Elective modules</th></tr>
<tr><td rowspan="5">Core Modules (40 credits)</td><td>Semester 1: Core</td><td>Semester 2: Core</td></tr>
<tr><td>PYU33P01: Quantum Mechanics I
(5 credits)</td><td>PYU33P03: Condensed Matter I
(5 credits)</td></tr>
<tr><td>CHU33405: Analytical and Computational Methods
(5 credits)</td><td>CHU33307: Solid State Materials and Modelling (5 credits)</td></tr>
<tr><td colspan="2">PYU33NP3: Nanoscience Physics Laboratory (10 credits)</td></tr>
<tr><td>CHU33609: Analytical and Computational Methods Workshops Nanoscience (5 credits)</td><td>CHU33603: Practical in Physical Chemistry and Nanoscience
(5 credits)</td></tr>
<tr><td rowspan="5">Open or Trinity Elective Modules (20 credits)</td><td>Semester 1: Open modules both core</td><td>Semester 2: Open – first is core then choose 1 of 3</td></tr>
<tr><td>* Trinity Elective 1 (Nanoscience students obliged to take a TE in S1)</td><td>* CHU33107: Organometallics and Coordination Chemistry (5 credits)</td></tr>
<tr><td>* PYU33P02: Electromagnetic Interactions I
(5 credits)</td><td>PYU33P04: Semiconductor Physics
(5 credits)</td></tr>
<tr><td></td><td>CHU33105: Chemistry of Polymers and Macromolecules (5 credits)</td></tr>
<tr><td>* Indicates a mandatory selection</td><td>Trinity Elective 2
(5 credits)</td></tr>
</table>

A Nanoscience student must take their **one required** Trinity Elective in Semester 1 along with the Mandatory module PYU33P02. Of the Open modules in Semester 2 the CHU33107 module is also Mandatory. If taking only one Trinity Elective, the only choice between Open modules is between PYU33P04 (Semiconductor Physics) and CHU33105 (Chemistry of Polymers and Macromolecules).

If a Nanoscience student chooses to take a second Trinity Elective, one in each semester, they must take the Mandatory Open modules in each semester. Taking two Trinity Electives severely reduces the Physics and Chemistry content in the degree, and may impact on later career choices, or on the choice of Capstone research project.

Junior Sophister Core Modules 40 credits

PYU33P01 Quantum Mechanics (S1) 5 credits
This module covers solution of the Schrödinger Equation in specific topics, such as angular momentum and the hydrogen atom.

CHU33405 Analytical and Computational Methods (S1) 5 credits
This module deals with both the fundamental principles and application of spectroscopic and other characterisation techniques. Topics such as analytical chemistry, organic spectroscopy and structural methods in inorganic chemistry will be covered.

PYU33P03 Condensed Matter I (S2) 5 credits
This module introduces condensed matter concepts such as crystal structure and thermal and electronic properties of matter.

CHU33307 Solid State Materials and Modelling (S2) 5 credits
This model introduces the student to the fundamental aspects of solid-state materials and the modelling of them. It will focus on the electronic structure and defects and how these can be used to influence the properties of materials and hence create functional materials.

CHU33609 Analytical and Computational Methods Workshops Nanoscience (S1) 5 credits
In this module students complete a range of experiments in advanced chemical analysis, spectroscopic and other characterisation techniques which are applied to nanoscience.

CHU33603 Practical in Physical Chemistry and Nanoscience (S2) 5 credits
In this module students complete several nanoscience and physical chemistry experiments.

PYU33NP3 Practical in Nanoscience (S1 & S2) 10 credits
In this module students complete several advanced experiments in Nanoscience and Physics together with a practical training in Advanced Nanoscience. It also includes components involving training in communication skills, personal and career development, and requires attendance at Nanoscience related School Seminars in Schools of Physics and Chemistry.

Junior Sophister Open Modules and Trinity Electives 20 credits

PYU33P02 Electromagnetic Interactions I (S1) **5 credits**
This module covers the fundamentals of electromagnetic theory together with quantum optics and lasers. (This is a mandatory module.)

Trinity Elective (S1) or also in (S2) **5 credits**
Details on Trinity Electives are found at: https://www.tcd.ie/trinity-electives/.
Nanoscience students **must** take a TE in S1. If taking a second TE in S2 it is with CHU33107.

CHU33107 Organometallic, Coordination Chemistry & Inorganic chemistry (S2) **5 credits**
The aim of this module is to develop an understanding of the main methods of synthetic organometallic chemistry, fundamental structure-reactivity relationships, and concepts of bonding and structure, functional group chemistry, thermodynamics, and kinetics. (This module is mandatory as a prerequisite for SS Nanoscience modules.)

PYU33P04 Semiconductor Physics (S2) **5 credits**
This module covers the physics of semiconductors and the construction, fabrication, and application of semiconductor devices.

OR

CHU33105 Chemistry of Polymers and Macromolecules (S2) **5 credits**
This module introduces the student to polymer and macromolecular chemistry. Polymer-based materials are an important component of many devices and products.

Senior Sophister Course Advisor: Prof. Peter Dunne P.W.Dunne@tcd.ie

Senior Sophister Course Structure Diagram (subject to change for AY23/24)

The Senior Sophister course structure is diagrammatically illustrated below:

<table>
<tr><th colspan="5">Senior Sophister TR063 – NANOSCIENCE</th></tr>
<tr><th colspan="5">45 Credits Core modules + 15 Credits Open modules (AY 22/23)</th></tr>
<tr><td rowspan="5">Core Modules (45 credits)</td><td colspan="2">Semester 1: Core</td><td colspan="2">Semester 2 Core</td></tr>
<tr><td colspan="3">PYU44NP2: Capstone Research Project (20 credits) – Assessment in Semester 2</td><td></td></tr>
<tr><td rowspan="3">Project only in first 9 weeks of semester 1</td><td>PYU44NP5: Problem solving (5 credits)</td><td colspan="2">CHU44304: Physical Chemistry (5 credits)</td></tr>
<tr><td colspan="3">PYU44N02: Nanoscience, complex fluids, and polymers (10 credits)</td></tr>
<tr><td></td><td colspan="2">CHU44004: Inorganic chemistry (5 credits)</td></tr>
<tr><td rowspan="8">Open Modules (15 credits)</td><td colspan="2">Semester 1: Open modules</td><td colspan="2">Semester 2: Open modules</td></tr>
<tr><td colspan="2" rowspan="7">Take 2 or 3 Open modules which total 15 credits</td><td colspan="2">PYU44P13: Magnetism & Superconductivity (5 credits)</td></tr>
<tr><td colspan="2">PYU44P06: Modern Optics (5 credits)</td></tr>
<tr><td colspan="2">PYU44P05: Electromagnetic Interactions II (5 credits)</td></tr>
<tr><td colspan="2">PYU44P17: Energy Science (5 credits)</td></tr>
<tr><td colspan="2">CHU44167: Advanced Physical Chemistry (10 credits)</td></tr>
<tr><td colspan="2">CHU44005: Advanced Inorganic Chemistry (10 credits)</td></tr>
<tr><td colspan="2">CHU44705: Advanced Computational Chemistry (10 credits)</td></tr>
</table>

The PYU44NP2 capstone research project takes place in the first nine weeks of Semester 1. This may be extended to 12 weeks in some circumstances, pending approval by the course director. The assessment of the research project is in Semester 2. The remaining three weeks of Semester 1 has tutorials associated with the PYU44NP5 Problem Solving module which is examined at the end of Semester 1. Lectures associated with the core PYU44N02 module begin in the last three weeks of Semester 1, but examinations for this module is at the end of Semester 2. All other modules, whether mandatory or optional, occur wholly within Semester 2 and are examined at the end of Semester 2.

Senior Sophister Core Modules 45 credits

PYU44NP2 Nanoscience Research Project (S1 and S2) 20 credits

This module consists of a 9-week independent research project (this may be extended to 12 weeks in some circumstances, pending approval by the course director). The project is pursued in an internationally recognised laboratory that specialises in aspects of nanoscience, advanced materials, or semiconductor processing. The project may be hosted within the School of Chemistry, School of Physics, CRANN, or at an approved international host institution. Submission of report and presentation of results is in Semester 2.

PYU44NP5 Problem Solving in Nanoscience (S1) 5 credits

This module involves general problem-solving and scientific comprehension in nanoscience, advanced materials, or semiconductor processing.

PYU44N02 Nanoscience, Complex Fluids and Polymers (S1&S2) 10 credits

This module covers nanoscience, and the modified properties of nanoscale matter, its fabrication, and potential applications together with the rheology and behaviour of liquids as applied to microfluidic systems and a detailed overview of polymer physics.

CHU44304: Physical Chemistry (S2) 5 credits

The student will be introduced to statistical thermodynamics and its applications in chemistry, integrating this topic with kinetics, classical thermodynamics and quantum chemistry covered in previous years. The second part of the module will cover elements of soft matter and macromolecular and colloid chemistry.

CHU44004: Inorganic Chemistry (S2) 5 credits

The student will be introduced to advanced synthetic methods in materials chemistry. The module focuses on the understanding of the fundamental concepts of structure-property relationships to design materials for specific applications (e.g., alloys, ceramics, glasses, inorganic polymers, and various composite materials). The second part of the module will introduce the students to the molecular chemistry of the f-block elements (lanthanides and actinides).

Senior Sophister Open Modules — Options must total 15 credits

PYU44P13 Magnetism and Superconductivity (S2) **5 credits**
This module covers magnetism, magnetic materials, and introduces superconductivity.

PYU44P06 Modern Optics (S2) **5 credits**
This module covers optical communications and nonlinear optics involving lasers.

PYU44P05 Electromagnetic Interactions II (S2) **5 credits**
This module covers electromagnetic wave phenomena together with the optical properties of materials.

PYU44P17 Energy Science (S2) **5 credits**
This module consists of the physics behind key technologies for energy generation.

CHU44167 Advanced Physical Chemistry (S2) **10 credits**
The student will be introduced to advanced topics in physical chemistry that integrate and build on core concepts of kinetics, thermodynamics and quantum chemistry covered in core physical chemistry modules. Topics will include: (a) electrochemistry and its applications to energy devices for sustainability, (b) photochemistry and spectroscopy, and (c) surface and interfacial chemistry, including catalysis for the environment.

CHU44005 Advanced Inorganic Chemistry (S2) **10 credits**
This module covers aspects of advanced coordination, organometallic and bioinorganic chemistry. It focuses on structure-property relationships and outlines characterisation techniques for bioinorganic systems. In addition, the module will cover the synthesis, structural chemistry, and physicochemical properties of (i) molecular crystals and (ii) copper oxide superconductors, emphasizing the interplay between composition, structure, and properties.

CHU44705 Advanced Computational Chemistry (S2) **10 credits**
This module will cover the main computational quantum chemistry methods and computational techniques, including optimisation and molecular dynamics, used in the modelling of structure, chemical reactivity and electronic properties of molecular systems and solid crystals. The performance and suitability of these methods for different applications will also be analysed and discussed. In addition, lectures will be complemented with computational practicals to see the direct application of these methods to specific scientific questions.

Nanoscience Moderatorship Learning Outcomes

On successful completion of this programme students should be able to:

- Articulate in written and oral form a foundation level of knowledge and understanding of Physics, Chemistry and Mathematics.

- Apply key concepts in Physics and Chemistry of Nanomaterials.

- Design, perform and analyse the results obtained from experiments in materials physics and chemistry, using modern physical and chemical experimental methodologies and instrumentation, with particular reference to materials and nanomaterials.

- Demonstrate skills in problem-solving, critical thinking and analytical reasoning, and be able to effectively communicate the results of their work to chemists, physicists, material scientists and others, both verbally and in writing.

- Use modern library searching and retrieval methods to obtain information pertinent to the identification and solution of problems in the physics and chemistry of materials, and the exploration of new research areas.

- Work effectively and safely in a laboratory environment operating within the proper procedures and regulations for safe handling and use of chemicals and instruments.

- Design and perform appropriate experiments to address materials physics, chemistry and nanoscience problems and analyse the results.

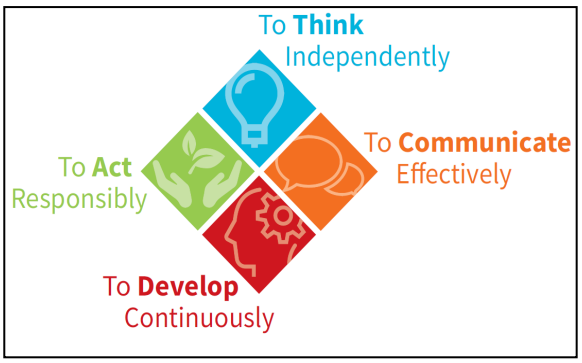
- Update their knowledge and be able to undertake further study with a high degree of autonomy.

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

Item	Reference/Source
Statement onGeneral Regulations	Calendar, Part II, General Regulations and Information, Section II, Item 12 Calendar, Part III, GeneralRegulations, Section I
Student SupportsCo-curricular activities TCDSU, GSU & student representationstructures	Student Supports
EmergencyProcedure	**Standard Text:** In the event of anemergency, **dial Security Serviceson extension 1999** Security Services provide a 24-hourservice 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 alwaystelephone 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 studentssave at least one emergency contact in their phone under ICE (In Case of Emergency).
Data Protection	Data Protection for StudentData
Research Ethics	Policy on Good ResearchPractice
Key Locations for students: Include Programme Offices, Laboratories, Online Learning Environments, Libraries, AcademicRegistry, Places of Faith/Prayer Rooms, Photocopiers, and any relevant introductory information on these locations	Blackboard Academic Registry

Item	Reference/Source
Plagiarism & Referencing Guidance	Calendar, Part II, General Regulations and Information, Section II, Items 95-102 Calendar, Part III, General Regulations & Information, Section I 'Plagiarism' Plagiarism Policy Library Guides - AvoidingPlagiarism Plagiarism Declaration
Explanation of ECTS Weighting	ECTS Weighting
Health and SafetyStatements	Faculty of Science Engineering, Mathematics and Science website - https://www.tcd.ie/stem/undergraduate/health-safety.php School Handbooks will have School/Discipline information on Health and Safety.
COVID-19 Information	TCD Coronavirus TCD Phased reopening plansHSE Coronavirus
Foundation Scholarships	Calendar, Part II, Foundationand Non-Foundation Scholarships
Prizes, medals, and other scholarships	Provided by School/Discipline handbooks.
Absence fromExaminations	Calendar, Part II, General Regulations and Information, Section II, Item 35 Calendar, Part III, Section III,'Examinations, Assessment and Progression' Academic Policies
Reference to Relevant University Regulations	Academic Policies Student ComplaintsProcedure Dignity & Respect PolicyEquality Policy
General Information for students teaching assessment etc. May include Programme Offices, Laboratories, Online Learning Environments, Libraries, Academic Registry, Places of Faith/Prayer Rooms, Photocopiers, and any relevant introductory information on these locations	Blackboard Academic Registry

Item	Reference/Source
Timetable for students	My TCD
Internships/ Placements forCredit	Provided by School/Discipline Handbooks
Teaching &Learning Study Abroad	Contact School/Discipline
Teaching &Learning Coursework Requirements	Student LearningDevelopment
Marking Scale	Calendar, Part II, General Regulations & Information, Section II, Item 30
ProgressionRegulations	Calendar, Part II, General Regulations & Information Calendar, Part II, Part C Calendar, Part III, Section III 'Examinations, Assessment and Progression' and 'Assessment and ProgressionRegulations'
Awards	National Framework forQualifications Trinity PathwaysTrinity Courses
Professional andStatutory Body Accreditation	Provide by School/Discipline Handbooks
Careers Information & Events	https://www.tcd.ie/Science/careers/ For further information refer to School/Discipline Handbooks.
External Examiner	Procedure for the transfer ofstudents assessed work to external examiners
Learning Outcomes	Provided in JF, SF & JS Handbooks on the Science Course Website https://www.tcd.ie/Science/#menu. Also available in School/Discipline Handbooks.

Item	Reference/Source
Capstone (UG Programmes)	Capstone website Policy on Good ResearchPractice
Attendance Requirements	Calendar, Part II, General Regulations and Information, Section II, Items 17-23 Calendar, Part III, General Regulations and Information, Section I 'Attendance and Off-Books'; Section II 'Attendance'; Section III 'Attendance, Registration, Extensions'; Section IV
Examination Attendance	'Attendance andExaminations'
Feedback andEvaluation	Student Evaluation andFeedback Student Partnership Policy Procedure for the conduct ofFocus Groups
Registration(UG only)	Students in TR060, TR061, TR062 & TR063 will find handbooks and information on the Science Course website https://www.tcd.ie/Science/#menu and in School/Discipline Handbook.