MSc Program: Advanced Materials Science

Faculty: Mathematical and Physical Sciences

About this degree:

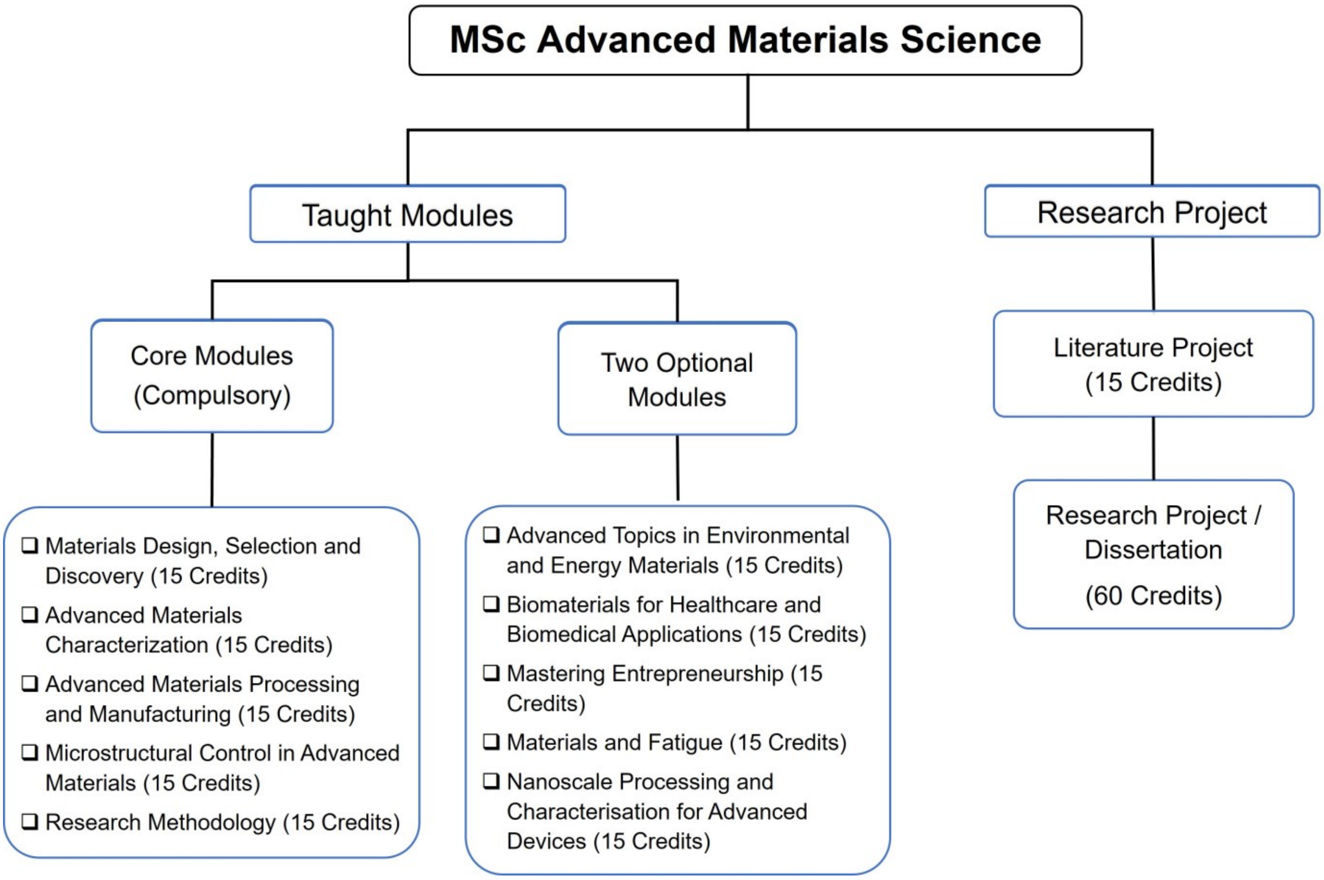
Throughout our MSc program, you will receive the fundamentals of materials science with a focus on cross-team working, real-world scenarios and developing professional skills. You will gain an advanced and comprehensive understanding of the structure, properties and applications of materials in an array of different disciplines, including energy, sustainability, healthcare and products and technology. Students are expected to develop their imagination, critical thinking abilities and laboratory-demonstrating techniques by engaging in a literature survey along with a six-month cutting-edge research project.

Students undertake modules to the value of 180 credits.

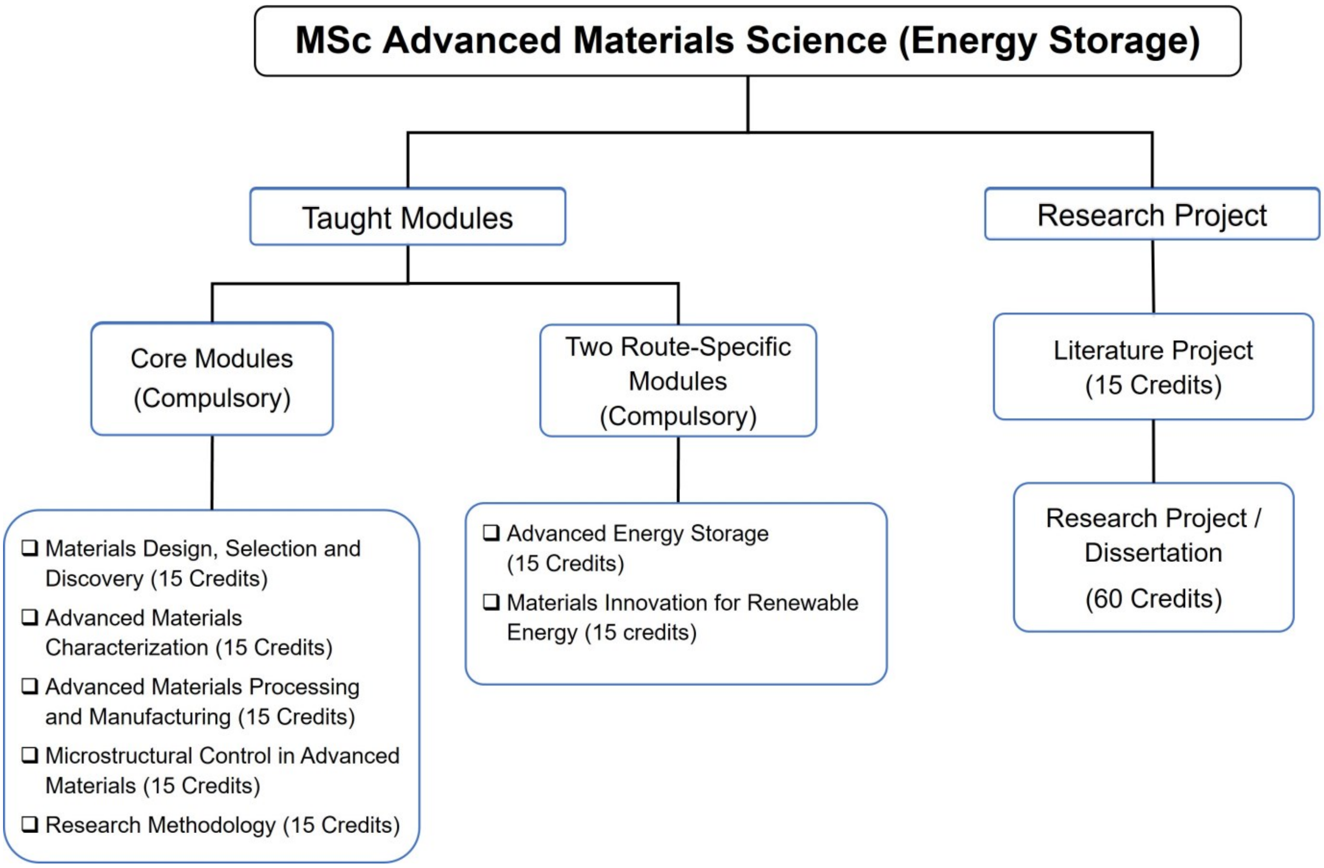
Currently, there are four routes under MSc Advanced Materials Science with specialization in Energy Storage (introduced in the 2019-20 academic year), Sustainability, Data-Driven Innovation, and Materials Innovation and Enterprise (offered for the 2023-24 entry, based at the UCL East Campus). Whichever route you choose to specialize in, you ‘ll be ready to make an impact in the world from the moment you graduate.

The structure for each route is illustrated below:

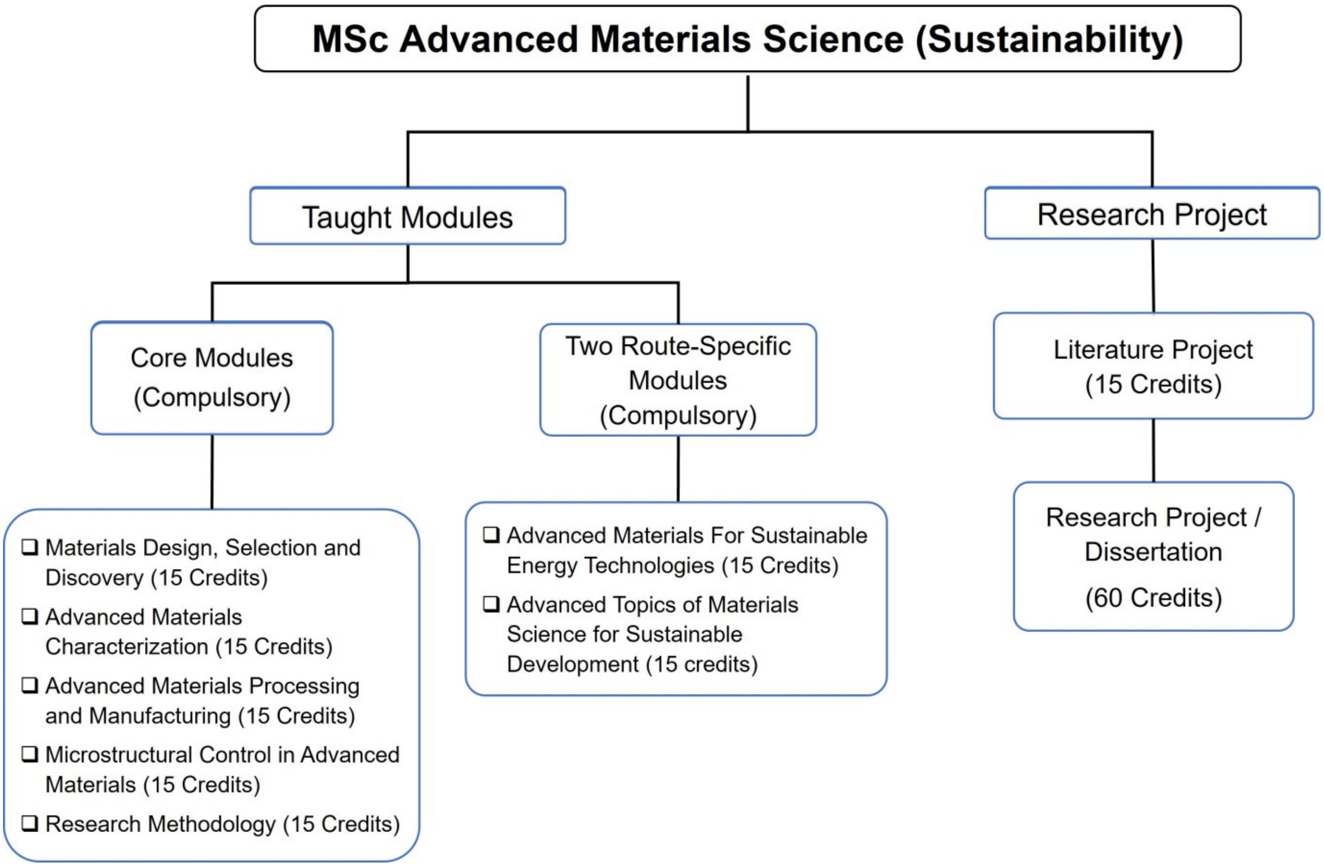
Route 1


MSc Advanced Materials Science
Taught Modules
Research Project
Core Modules (Compulsory)
Two Optional Modules
Literature Project (15 Credits)
Research Project / Dissertation
(60 Credits)
Materials Design, Selection and Discovery (15 Credits)
Advanced Materials Characterization (15 Credits)
Advanced Materials Processing and Manufacturing (15 Credits)
Microstructural Control in Advanced Materials (15 Credits)
Research Methodology (15 Credits)
Advanced Topics in Environmental and Energy Materials (15 Credits)
Biomaterials for Healthcare and Biomedical Applications (15 Credits)
Mastering Entrepreneurship (15 Credits)
Materials and Fatigue (15 Credits)
Nanoscale Processing and Characterisation for Advanced Devices (15 Credits)

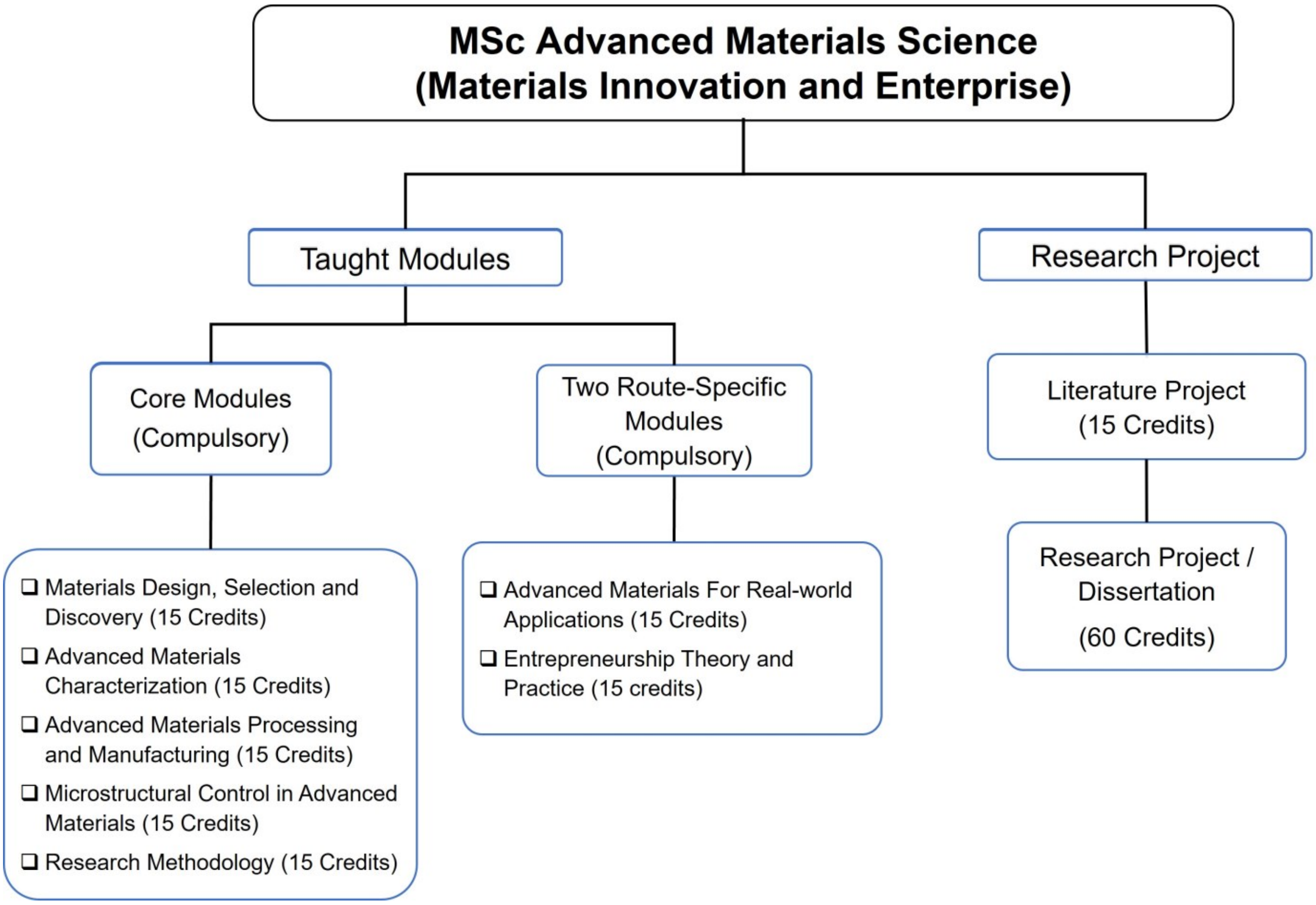
Route 2


MSc Advanced Materials Science (Energy Storage)
Taught Modules
Research Project
Core Modules (Compulsory)
Two Route-Specific Modules (Compulsory)
Literature Project (15 Credits)
Materials Design, Selection and Discovery (15 Credits)
Advanced Materials Characterization (15 Credits)
Advanced Materials Processing and Manufacturing (15 Credits)
Microstructural Control in Advanced Materials (15 Credits)
Research Methodology (15 Credits)
Advanced Energy Storage (15 Credits)
Materials Innovation for Renewable Energy (15 credits)
Research Project / Dissertation
(60 Credits)

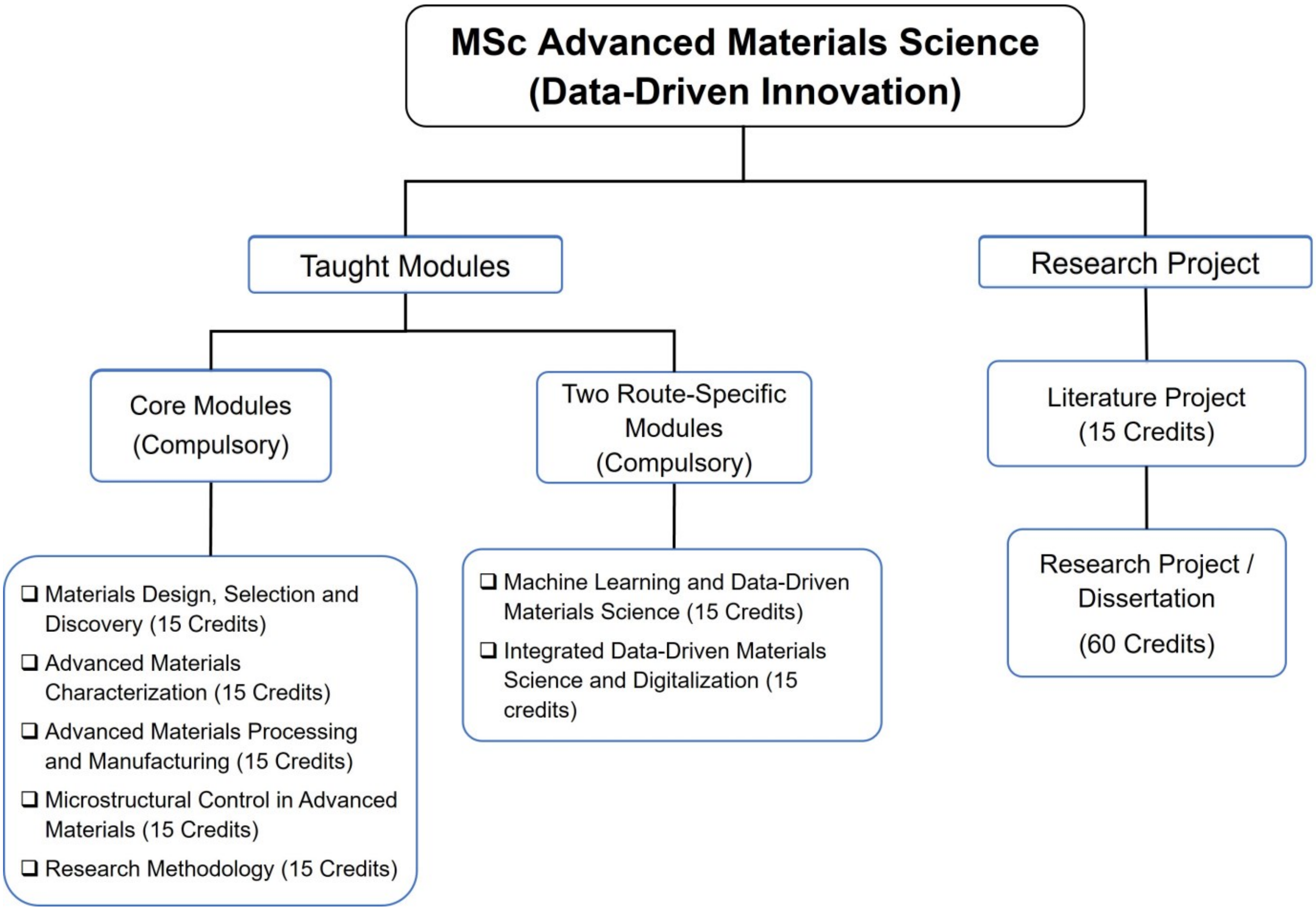
Route 3


MSc Advanced Materials Science (Sustainability)
Taught Modules
Research Project
Core Modules (Compulsory)
Two Route-Specific Modules (Compulsory)
Literature Project (15 Credits)
Materials Design, Selection and Discovery (15 Credits)
Advanced Materials Characterization (15 Credits)
Advanced Materials Processing and Manufacturing (15 Credits)
Microstructural Control in Advanced Materials (15 Credits)
Research Methodology (15 Credits)
Advanced Materials For Sustainable Energy Technologies (15 Credits)
Advanced Topics of Materials Science for Sustainable Development (15 credits)
Research Project / Dissertation
(60 Credits)

Route 4


MSc Advanced Materials Science
(Materials Innovation and Enterprise)
Taught Modules
Research Project
Core Modules
(Compulsory)
Two Route-Specific
Modules
(Compulsory)
Literature Project
(15 Credits)
Materials Design, Selection and Discovery (15 Credits)
Advanced Materials Characterization (15 Credits)
Advanced Materials Processing and Manufacturing (15 Credits)
Microstructural Control in Advanced Materials (15 Credits)
Research Methodology (15 Credits)
Advanced Materials For Real-world Applications (15 Credits)
Entrepreneurship Theory and Practice (15 credits)
Research Project /
Dissertation
(60 Credits)

Route 5


MSc Advanced Materials Science (Data-Driven Innovation)
Taught Modules
Research Project
Core Modules (Compulsory)
Two Route-Specific Modules (Compulsory)
Literature Project (15 Credits)
Materials Design, Selection and Discovery (15 Credits)
Advanced Materials Characterization (15 Credits)
Advanced Materials Processing and Manufacturing (15 Credits)
Microstructural Control in Advanced Materials (15 Credits)
Research Methodology (15 Credits)
Machine Learning and Data-Driven Materials Science (15 Credits)
Integrated Data-Driven Materials Science and Digitalization (15 credits)
Research Project / Dissertation
(60 Credits)

Core compulsory modules (All core modules are taught by Institute for Materials Discovery at UCL Bloomsbury Campus)

NSCI0009: Microstructural Control in Advanced Materials (15 credits)

The aim of this course is to allow students from various scientific backgrounds (materials, chemistry, physics, engineering, chemical engineering and other relevant science and engineering disciplines) to discover that their prior knowledge can be applied in materials science to good effect and the benefit of the subject and its industries. To achieve this, the course emphasizes the microstructural factors that control properties and demonstrates tactics for developing such microstructures. The course also aims to provide academic broadening for students from science and engineering disciplines who wish to explore how their subject-specific skills can be applied in the wider context of materials science.

The module is also intended to consolidate the understanding and knowledge of microstructural control tactics with cases studies of recent technological advances in materials surface processing, additive manufacturing and severe plastic deformation, and to equip the students' transferable skills to advance materials processing and manufacturing technologies for developing a new generation of advanced materials.

Assessment: Term 1, 40% coursework (problem sheets and short essays) and 60% written exam

NSCI0012: Materials Design, Selection and Discovery (15 credits)

This module aims to equip students with general knowledge of the principles and the process of materials selection in application- and market-driven scenarios. In particular, materials selection rules and the corresponding concepts (e.g., material indices and material property charts, and Ashby diagrams) developed by M. F. Ashby will be discussed in detail. Understanding of these threshold concepts and skills will be consolidated by a discussion on case studies in small tutorial groups, putting theory into practice. It also aims to provide students from a broad scientific / engineering background with fundamental knowledge of Materials Science in the context of materials selection and product design. In particular, structure-property relationships (incl. phase diagrams and transitions) of engineering materials will be discussed. The module highlights the forces of change (e.g. emerging energy and environment constraints) in materials selection and product design, and how novel materials and related technologies offer opportunities in developing innovative solutions to meet global demand.

Assessment: Term 1, group design project format, two presentations (idea pitching and final design presentation) as well as final report (2,000 each student).

NSCI0013: Advanced Materials Characterisation (15 credits)

The course seeks to equip the students with the required knowledge to understand and undertake materials characterization of solid systems. You will cover all the major methods of microscopic, nanoscopic and chemical characterization of materials. The course emphasizes the basic principles behind the characterization techniques as well as equipment design and operation, sample preparation and data analysis. The techniques you will cover are optical microscopy, SEM, Powder X-ray, TEM, AFM, STM, EDS/WDS, PES, SIMS, FTIR/Raman and neutron scattering.

Assessment: Term 2, 40% essay coursework (1200 words) and 60% written exam

NSCI0014: Advanced Materials Processing and Manufacturing (15 credits)

This module presents the process principles and practical knowledge in advanced materials processing and manufacturing, including (a) industrial processing of materials, (b) surface engineering and (c) additive manufacturing, highlighting materials properties and performance during in-service, as well as life cycle design. The understanding of the processing of materials will be reinforced by hands-on laboratory experience in selected materials processing and surface coating technology. Students will also be exposed to industrial guest speakers giving seminars on the use of industrial processing and manufacturing methods of commercial products and devices, essential for a successful career in advanced material development and manufacturing. The knowledge and skills of this module will be enhanced via laboratory demonstration and real experiments, as well as discussion of case studies during tutorials and exposure to guest lectures from the industry. Students will be given the opportunity to synthesise their knowledge and express themselves via a coursework presentation on a selected topic of materials processing and manufacturing.

Assessment: Term 2, 40% presentation/written coursework and 60% written exam

NSCI0015: Research Methodology (15 credits)

The aim of the module is to equip students with the necessary skills and experience to conduct cutting-edge research programs. This includes literature survey methods, critical thinking and analysis skills for identification of novel research topics, experimental design/structuring effective research investigations, data processing and analyzing, scientific report writing, and effective communication via report writing and verbal presentation.

Assessment: Term 1, Innovation Report of 2,000 words, 80%; Statistic problems sheets, 20%.

NSCI0016: Literature Project (15 credits)

The literature project aims to equip students with the skills of performing a scientific literature search, effective generalization and critical analysis of the research landscape of a specific area relevant to advanced materials and related technologies. It also aims to train their communication skills, in particular writing skills, in the context of academic research. The module prepares the students to work on their research projects by engaging them in elucidating the research landscape around the chosen topic and how their research fits in this big picture.

Assessment: Term 1, 100% written essay of 3,000 words

NSCI0017: Research Project (60 credits)

This module, as a research-based learning module, aims to equip the students with the critical and analytical skills required in scientific research by engaging them in 6-month research projects. It nurtures their creativity, perseverance, initiative as well as basic project management skills by exposing them to state-of-the-art research environments guided by experienced researchers in the fields. Students will also gain knowledge and technical skills on specific topics related to their projects. They will also be trained in giving oral presentations and writing a dissertation in an academic style. The module also aims to prepare the students for further studies as a PhD or working as a researcher in industry.

Assessment: Terms 2 & 3 and through the summer term, 10% oral presentation and viva voce for interim project progress monitoring, 20% oral presentation and viva voce for final project report, and 70% for research project dissertation of 10,000 - 12,000 words.

Route-specific Compulsory and Optional Modules

NSCI0008: Biomaterials for Healthcare and Biomedical Applications (15 credits) (Taught by Institute for Materials Discovery at UCL Bloomsbury Campus)

This course aims to provide the students with knowledge and understanding of the range of biomaterials used in healthcare and biomedical applications, the design and selection of biomaterials based on clinical needs, the structure/property/application relationships, biological constraints on them and their clinical applications, regulatory affairs, ethical issues and exploitation of biomaterials, R&D and advancement of biomaterials.

Assessment: Term 2, 40% coursework and 60% written exam.

NSCI0020: Advanced Energy Storage (15 credits) (Taught by Institute for Materials Discovery at UCL Bloomsbury Campus)

This module aims to provide fundamental knowledge on energy storage mechanisms, to gain the ability to design electrode materials for batteries and supercapacitors, to acquire a good understanding of electrochemistry and electrochemical characterization techniques, to develop skills in electrochemical energy storage device assembly, to highlight the environmental and societal challenges in meeting energy demands, and to appreciate emerging solutions for tackling energy-relevant challenges.

Assessment: Term 1, 40% coursework and 60% written exam.

NSCI0021: Advanced Materials for Sustainable Energy Technologies (15 credits) (Taught by Institute for Materials Discovery at UCL East Campus)

In this module, you will study the current state of innovations in renewable energy sciences with an overview of the major energy conversion types such as mechanical, magnetic, gravitational, electric, chemical and others, understanding their theories, their roles and impacts in our modern society, with a critical evaluation of their true sustainability based on lifecycle analysis. You will be given a historical background, and details on materials and processes of different energy technologies with implications for addressing societal, environmental and global challenges. After this module, you should develop a broad knowledge of the key concepts of current and emerging energy conversion systems at large- and micro-scales such as thermoelectric, solar, wind, geothermal, biomass, heat engines, wave power, electric generators and others. This interdisciplinary course details the scientific concepts and challenges concerning energy generation, conversion and usage. The course aims to develop knowledge of the basic principles governing renewable energy materials and devices. You will learn the impact, roles and current needs for sustainable energy transformation in modern power generation, heating, and transmission as well as scavenging waste energy for a variety of purposes. You will develop a wide range of different abilities and skills, well preparing for future employment in related areas of the energy industry or further studying at a doctoral level.

Assessment: Term 1, 40% coursework and 60% written exam.

NSCI0022: Advanced Materials for Real-World Application (15 credits) (Taught by Institute for Materials Discovery at UCL East Campus)

This module will provide a very detailed overview of various categories of functional materials and emerging advanced devices for real-world applications in high-tech sectors. The course will start with an overview of the necessary concepts of materials science fundamentals that will enable students to interpret the principles of materials selection, product design, device fabrication, characterization techniques, materials translation and life cycle analysis. This module will bridge the gap between fundamental material science knowledge and industrial product design and manufacturing. The module will go on to illustrate in detail the different classes of functional materials, including various types of dielectrics (piezoelectrics, pyroelectrics, ferroelectrics, relaxors and antiferroelectrics), materials with multiferroic properties, thermoelectrics, superlattices, metamaterials and phase change materials, with a particular focus on their implementation in real-world applications, including electronic devices (e.g. solar cells, light emitting diodes, transistors and capacitors), energy storage systems, and solid fuel oxide cells, among others. Furthermore, a number of industrial case studies based on real-world applications of novel functional materials will be delivered. This module will develop a wide range of different abilities and skills in the students enabling them to be well-prepared for future employment in industries, as well as pursuing further studies at a doctoral level.

Assessment: Term 2, 40% project report, 30% oral presentation, and 30% design demonstration.

NSCI0028: Machine Learning and Data-driven Materials Science (15 credits) (Taught by Institute for Materials Discovery at UCL East Campus)

The module on Machine Learning and Data-driven Materials Science consists of a comprehensive exploration of the most effective data-driven techniques to solve problems in the field of regression, classification, dimension-reduction, feature extraction and clustering with particular applications to Materials Science. It provides students with the essential state-of-art of machine learning techniques such as foundations of deep learning, supervised learning (on/off-line learning, linear ridge regression, neural networks, support vector machines, kernel, Bayesian Learning) unsupervised learning (clustering, granular computing, dimensionality reduction) and data feature extraction. The applications of fundamental knowledge from machine learning will be demonstrated through case studies in materials science using data from real experiments and public materials data repositories.

Assessment: Term 2, 50% coursework, 40% written examination, and 10% oral presentation.

NSCI0030: Materials Innovation for Renewable Energy (15 credits) (Taught by Institute for Materials Discovery at UCL Bloomsbury Campus)

In this module, students will learn the current state of renewable energy with a focus on mainstream and emerging renewable energy technologies, understanding the role and impact of materials innovations on the actual sustainability of renewable energy technologies and global challenges for achieving net zero carbon emissions targets through life-cycle analysis. The module will include an overview of renewable energy, materials challenges appreciation and materials innovation approaches for ensuring that mainstream and emerging renewable energies (e.g. hydropower, wind, solar, marine energies) achieve market competitiveness and are truly sustainable. This module will also introduce the innovative through-life engineering principles to renewable energy technologies and services, equipping students with a critical awareness of through-life engineering principles from conception, through design, manufacture and operational life, to end-of-life disposal of any mainstream and emerging renewable energy technologies. This module will also develop students with a wide range of different abilities and skills in communication and teamwork, enabling them to be well-prepared for future employment in relevant industries as well as further studies at a doctoral level.

Assessment: Term 1, 10% group project idea pitching, 30% group project final presentations, and 60% individual report (1,500 words).

NSCI0031: Advanced Topics in Materials Science for Sustainable Development (15 credits) (Taught by Institute for Materials Discovery at UCL East Campus)

In this module, students will learn current materials research advancements based on global sustainability needs for achieving net zero carbon emissions targets, as well as creating a sustainable future with a lower environmental impact and higher durability of goods. The focus will be given to the impact, role, and present needs for sustainable transformations in modern societal technologies. This will include an overview of sustainable resource management, advancements in materials processing and manufacturing, also consideration of the use and disposal of goods. Other topics include materials for waste heat recovery using the thermoelectric effect; carbon capture, storage, and utilization; energy conversion, transmission, and storage; heritage materials for a historic future; and data-driven materials discovery. This module embraces sustainability with a perspective from the design stage and therefore, students should develop broad knowledge with a critical awareness of emerging technologies for sustainable development. A wide range of different abilities and skills will be gained, suitably preparing for employment in related areas of industry or further studying at a doctoral level.

Assessment: Term 2, 20% induvial presentation, 10% individual executive summary (200-300 words), 60% group report (2,400 words), and 10% peer assessment.

NSCI0032: Integrated Data-Driven Materials Science and Digitalisation (15 credits) (Taught by Institute for Materials Discovery at UCL East Campus)

This module provides students with state-of-the-art knowledge and expertise in integrated materials modelling and methods and modern practical cloud-based tools to find and create needed materials and process data for applications in advanced data-driven and machine-learning workflows. It covers contemporary topics in digitalization based on the ontology of materials and processes and connection to manufacturing (digital twins), high throughput computations and characterization, and multiscale, and multi-equation physics-based modelling, including electronic density functional theory (DFT), atomistic molecular dynamics (MD), mesoscopic coarse-grained molecular dynamics (CGMD), granular media (GM) and continuum structural mechanics and computational fluid mechanics (CFD) modelling, enabling modelling technological applications on all relevant scales. Advanced modern tools include cloud-based open e-science materials digitalization and modelling platforms such as https://nanohub.org, https://materialsproject.org, https://www.nomad-coe.eu/the-project/nomad-repository, https://www.materialscloud.org/work/ aiidalab and other emerging platforms.

Assessment: Term 1, 50% essay coursework (1,500 words), and 50% 2-hour in 24-hour window take-home examination.

CHEM0067: Advanced Topics in Environmental and Energy Materials (15 credits) (Taught by the Department of Chemistry at UCL Bloomsbury Campus)

Students gain advanced knowledge of materials science as it applies to energy and environmental technologies and research skills including information and literature retrieval, critical interpretation and analysis, and effective communication. They can benefit from modules in chemistry, physics, chemical engineering, or mechanical engineering, thus offering future employers a wide-ranging skills base. Graduates will be well qualified to deal with the problems of energy decision-making and the implications for the environment.

Assessment: Term 1, 100% coursework.

MSIN0053: Mastering Entrepreneurship (15 credits) (Taught by School of Management at UCL Bloomsbury Campus)

Right from the start of the program, you will learn the skills and gain the tools to start an innovative, high-impact, new business. From the first few weeks, you will be interviewing prospective customers, learning how to do ‘rapid prototyping, using the tools of ‘lean’ entrepreneurship, and pitching new ideas. Using UCL’s networks and reputation as a starting point to access London’s thriving entrepreneurship scene, you will find or develop a founding

team and learn how to raise investor finance, or ‘bootstrap’ your business. This course was the first of its kind in Europe, for its single-minded focus on giving you the knowledge, skills, and network to start up a business successfully. We pride ourselves on our rate of successful start-up creation, and every year work to launch more successful start-ups.
Assessment: Terms 1, 60% Group coursework essay (3000 words), and 40% Individual coursework essay (4000 words).

MSIN01443: Mastering Entrepreneurship (15 credits) (Taught by School of Management at UCL East Campus)

This is UCL's principal Entrepreneurship course for students who are actively seeking to develop and test a new business idea. It is most relevant to those who are considering forming their own business but is also valuable for “intrapreneurs” promoting new initiatives within existing organizations.
Through the study of existing high-potential ventures and the development of a business feasibility plan, the course provides deep insights regarding critical success factors (desirability feasibility and viability) along with strategies to attract and retain the necessary resources (personal, technical and finance) to launch a new venture.
In doing so the course seeks to develop the entrepreneurial skills, behaviours and attitudes that are essential for individuals seeking to create and capture value through innovative business activities.
Assessment: Terms 1, 50% Group coursework essay, 40% Individual coursework essay, and 10% Peer Assessment.

MECH0055: Materials and Fatigue (15 credits) (Taught by the Department of Mechanical Engineering at UCL Bloomsbury Campus)

To build upon a basic theory of materials as would be given in the first years of an undergraduate program and to examine specific areas of materials science which are not normally taught as part of a basic materials curriculum. The course also aims to cover the fundamentals of fracture mechanics, and the theory of fatigue failure in engineering materials, principally from an analytical perspective.
Assessment: Terms 1 and 2, 70% for the written exam, and 30% for coursework (3 quizzes, 5% for each quiz; and 15% for a poster).

ELEC0031: Nanoscale Processing and Characterisation for Advanced Devices (15 credits) (Taught by the Department of Electronic and Electric Engineering at UCL Bloomsbury Campus)

Engineering in Nanotechnology is concerned with developing, providing and maintaining infrastructure, products, processes and services for society. Engineering in Nanotechnology addresses the complete life-cycle of a product, process or service in the field of Nanotechnology, from conception, through design and manufacture, to decommissioning and disposal, within the constraints imposed by economic, legal, social, cultural and environmental considerations. Engineering in Nanotechnology relies on three core elements, namely scientific principles, mathematics and 'realization'. Scientific principles clearly underpin all engineering, while mathematics is the language used to communicate parameters, model and optimise solutions. Realization encapsulates the whole range of creative abilities which distinguish the engineer from the scientist; to conceive, make and bring to fruition something which has never existed before. This creativity and innovation to develop economically viable and ethically sound sustainable solutions is an essential and distinguishing characteristic of engineering, shared by the many diverse, established and emerging disciplines within engineering.

Assessment: Term 1, 100% coursework.

Teaching and Learning

Teaching is delivered by lectures, interactive tutorials, case studies and seminar talks. Assessment is by a combination of ongoing coursework, presentations, a group project and/or a written examination, a dissertation, and a viva voce.

NOTE: This information is for guidance only and is subject to changes. It should not be construed as advice nor relied upon and does not form part of any contract.