Imperial College London

Programme Specification (2022-23)

Programme Information		
Programme Title	Programme Code	HECoS Code
Geo-Energy with Machine Learning and Data Science (GEMS)	G16H2	For Registry Use Only

Award	Length of Study	Mode of Study	Entry Point(s)	Total Credits	
				ECTS	CATS
MSc	1 calendar year (12 months)	Full-time	Annually in October	90	180
PG Diploma	9 months	Full-time	N/A	60	120
PG Certificate	3 months	Full-time	N/A	30	60
The PG Certificate/PG Diploma are intermediate awards and are not available for entry. All students must apply to and join the MSc.					

Ownership			
Awarding Institution	Imperial College London	Faculty	Faculty of Engineering
Teaching Institution	Imperial College London	Department	Earth Science and Engineering
Associateship	Royal School of Mines	Main Location(s) of Study	South Kensington Campus
External Reference			
Relevant QAA Benchmark Statement(s) and/or other external reference points		Masters Awards in Engineering	
FHEQ Level		7	
EHEA Level		2nd Cycle	
External Accreditor(s) (if applicable)			
External Accreditor 1:	N/A		
Accreditation received:	N/A	Accreditation renewal:	N/A
Collaborative Provision			
Collaborative partner	Collaboration type	Agreement effective date	Agreement expiry date
N/A	N/A	N/A	N/A

Specification Details	
Programme Lead	Prof. Martin Blunt
Student cohorts covered by specification	2022-23 entry
Date of introduction of programme	October 22
Date of programme specification/revision	March 21

Programme Overview

You will study subsurface geoscience and engineering with application to carbon dioxide storage, water management, hydrocarbon recovery, geothermal energy and other subsurface processes. The course will provide you with the knowledge essential for developing a sustainable energy economy and tackling the climate crisis, The unique feature of the programme is the development and application of skills in data science and machine learning. An emphasis is placed on developing and applying numerical, analytical and computational concepts. The programme is intended to educate geoscientists and engineers to acquire advanced computational, data science, machine learning and numerical skills relevant to working on various aspects of the energy transition.

Prior coding experience is not a requirement of the course, but you will be expected to be familiar with computer programming using Python at the start of the formal programme – there will be a mandatory pre-sessional training course in programming. The programme will introduce coding from scratch. We will develop your knowledge through advanced programming classes. We will assess your programming ability at interview and on entry to the programme, and provide support throughout the year with developing coding skills. The pre-sessional training material will be available online so that you can continue to review and refresh your knowledge. We will provide support throughout the course to help you with coding, through the provision of online resources, and dedicated study space and teaching assistants.

You will also learn data science, numerical methods and machine learning. Throughout the programme you will apply these concepts to problems in subsurface geoscience and engineering, including geological data collection and analysis, fluid flow in porous media, geomechanics, as well as targeted analysis of topics relevant to the energy transition. You will work alongside other students working on applied computer science and computations, and data science and machine learning, in your classes and project work. For your summer research project, there will be the opportunity to take up optional placements in industry.

The programme is aimed at three groups of potential students:

- those with strong methodological backgrounds in mathematics or physical sciences who are wishing to move to, or specialise in, an applied field with an emphasis on subsurface geoscience and engineering;
- those with a more applied background in geoscience and engineering, wishing to learn about data science and machine learning (the underlying theory/algorithms and how to implement/use them in code) and how these can be used as modern data-driven problem-solving and analysis tools;
- those with a background in computer science wishing to expand their knowledge of applied data science, machine learning and associated computational and observational techniques in the context of subsurface energy and storage, and to gain experience in the ways in which these can be used to solve large-scale subsurface geoscience and engineering problems.

The programme consists of taught modules and project work delivered over the first two terms of the academic year, followed by a research project. The taught modules will cover geoscience and engineering applied to subsurface energy and storage. This will be integrated with the development of skills in data science, machine learning, programming and modelling. Each module will explore examples and applications to subsurface geo-energy geoscience and engineering problems.

The programme will be based at Imperial's main South Kensington Campus in the Royal School of Mines. You will be taught by faculty experts in subsurface geoscience and engineering, as well as data science, computational methods and machine learning. Where appropriate the teaching will be supplemented by input from external experts in these areas. The faculty are also actively engaged in research in the Department of

Earth Science and Engineering and will incorporate the latest research ideas and industry applications into the programme.

Based on previous cohorts of students, approximately one third go on to further study either another MSc programme or a PhD. The other two-thirds work mainly in industry. The principal employers of graduates from this programme will be the large data and computer companies, consultancies offering services to the energy industry and working on natural geo-hazards, and the energy industry itself, including oil and gas, as well as renewables. In particular there will also be opportunity to engage with potential employers in the energy industry outside the current oil and gas industry.

Learning Outcomes

On successful completion of the MSc in Geo-Energy with Machine Learning and Data Science you will be able to:

1. Program in Python to solve numerical problems related to subsurface processes.
2. Apply modern data science and machine learning methods to analyse geological data.
3. Solve porous media flow and geomechanics problems numerically and analytically to calculate average permeability, flow speeds and wavespeeds.
4. Apply concepts in thermodynamics, geoscience and engineering to interpret and design subsurface flow processes relevant to the energy transition.
5. Design numerical models and apply geoscience and engineering relevant to energy technologies: carbon capture and storage, geothermal energy, hydrogen storage, hydrocarbon production, renewable energy.
6. Work independently to solve problems associated with subsurface processes, applying modern computational methods, machine learning and data science.
7. Work in interdisciplinary teams to tackle problems associated with subsurface energy and storage.
8. Conduct a piece of independent research, setting out a project brief and research plan within a defined timeframe and available resources, that demonstrates a contribution to knowledge in a research area of interest.
9. Interpret state-of-the-art technical and scientific publications related to a research topic and critically evaluate the results of others.
10. Produce, as a written output, a research paper which presents in a coherent manner the aims/research content, a literature review, research methodology, research results, discussion and conclusions concisely written in the style of a scientific publication.

On successful completion of the PG Diploma[1] in Geo-Energy with Machine Learning and Data Science you will be able to:

1. Program in Python to solve numerical problems related to subsurface processes.
2. Apply modern data science and machine learning methods to analyse geological data.
3. Solve porous media flow and geomechanics problems numerically and analytically to calculate average permeability, flow speeds and wavespeeds.
4. Apply concepts in thermodynamics, geoscience and engineering to interpret and design subsurface flow processes relevant to the energy transition.
5. Design numerical models and apply geoscience and engineering relevant to energy technologies: carbon capture and storage, geothermal energy, hydrogen storage, hydrocarbon production, renewable energy.
6. Work independently to solve problems associated with subsurface processes, applying modern computational methods, machine learning and data science.
7. Work in interdisciplinary teams to tackle problems associated with subsurface energy and storage.

[1] Corresponding to the Autumn, Spring and Summer Term taught modules

On successful completion of the PG Certificate[2] in Geo-Energy with Machine Learning and Data Science you will be able to:

1. Program in Python to solve numerical problems related to subsurface processes.
2. Apply modern data science and machine learning methods to analyse geological data.
3. Solve porous media flow and geomechanics problems numerically and analytically to calculate average permeability, flow speeds and wavespeeds.
4. Apply concepts in thermodynamics, geoscience and engineering to interpret and design subsurface flow processes relevant to the energy transition.
5. Design numerical models and apply geoscience and engineering relevant to energy technologies: carbon capture and storage, geothermal energy, hydrogen storage, hydrocarbon production, renewable energy.

The Imperial Graduate Attributes are a set of core competencies which we expect students to achieve through completion of any Imperial College degree programme. The Graduate Attributes are available at: www.imperial.ac.uk/students/academic-support/graduate-attributes

In accordance with these core competencies, set out below, our aim is for our graduates to:

- Demonstrate deep conceptual understanding of their chosen discipline
- Work effectively in multi-cultural, international teams and across disciplinary boundaries
- Approach challenges with curiosity, critical-thinking and creativity
- Innovatively apply their skills to tackling complex real-world problems
- Understand and value different cultures and perspectives
- Have developed into independent learners with high self-efficacy
- Display a strong sense of personal and professional identity

Entry Requirements	
Academic Requirement	UG degree in any geological or physical science or engineering subject. The minimum requirement is a 2:1 with evidence of a good quantitative background (Evidence of mathematics programmes at undergraduate level - especially calculus, linear algebra and statistics). Prior coding experience is not required, but is desirable. You need to have a desire to develop computational skills. For further information on entry requirements, please go to PG: www.imperial.ac.uk/study/pg/apply/requirements/pgacademic
Non-academic Requirements	Relevant industrial/professional experience may also be considered. Special cases, based on relevant experience, may be considered in some circumstances.
English Language Requirement	Standard requirement (PG) Please check for other Accepted English Qualifications
Admissions Test/Interview	Applicants may be invited for a face-to-face or remote interview with the Programme Directors. No additional entry assessments are required.

The programme's competency standards documents can be found at: https://www.imperial.ac.uk/media/imperial-college/faculty-of-engineering/civil/public/msc/Competency-Standards-MSc-Civil-2019-2020.pdf

[2] Corresponding to the Autumn term taught modules.

Learning & Teaching Approach

Learning and Teaching Delivery Methods

- Lectures
- Seminars and practical coding activities
- One geological field trip
- Case studies
- Group work exercises
- Individual research
- Formal presentations

All the module content will be available online. The lectures themselves will have a strong emphasis on skills development, where short lectures will be punctuated by individual or paired exercises with the support of teaching staff.

Individual and group projects will run throughout the year. These will be both analytical and problem-solving based, combined with computational and data analysis based projects with application to subsurface geoscience and engineering. These smaller projects also help prepare the student for the independent project at the end of the year.

You will undertake a research project within a research group or as a placement in industry.

Overall Workload
Your overall workload consists of face-to-face sessions and independent learning. While your actual contact hours may vary according to the optional modules you choose to study, the following gives an indication of how much time you will need to allocate to different activities at each level of the programme. At Imperial, each ECTS credit taken equates to an expected total study time of 25 hours. Therefore, the expected total study time is 2,250 (90 ECTS) hours per year.

The programme is structured with lectures and practical sessions in the morning, with the afternoons free for private study. This structure spans 9 months punctuated with three week-long project sessions where you will have the opportunity to work in teams or individually. One project session will be a geological field trip where you will reinforce your knowledge of basic geoscience and see how to acquire and analyse geological data.

Three months will be devoted exclusively to the summer individual research project.

Assessment Strategy

Assessment Methods

All assessment will be based on coursework with no formal written examinations.

Formative assessment to provide feedback and aid learning will be provided through the practical sessions that will run throughout each module. During project work, this will be provided through ongoing supervision from the faculty. The feedback will be provided in written form and orally by members of the faculty and graduate teaching assistants working on each module.

Summative assessment will be provided by at least two items of assessed coursework for each module which can be completed in class and at home. Dependent on the module, this may be a combination of written homework, solving problems, as well as numerical and coding exercises. For project work assessment will also be based on oral presentation of the work and from project reports.

A final thesis and presentation will also be required for the summative assessment of the final summer research project. 80% of the total mark will be based on written material and 20% on a presentation and demonstration of the software developed.

In group project work, all team members will receive the same mark. Support for project work will be provided by graduate teaching assistants and faculty with tutorial staff available to guide you through difficulties in team working.

Academic Feedback Policy

Feedback on coursework will be provided in line with the College's Policy on Academic Feedback. The good practice guidelines of feedback being provided within two weeks of the submission date will be employed. Since all the assessment is coursework-based, students will receive provisional marks combined with written and oral feedback at the end of each module. In some cases, feedback will be provided on exercises throughout the module.

The final numerical marks will be provided by the Registry after the Board of Examiner's meeting at the end of the academic year.

The College's Policy on Academic Feedback and guidance on issuing provisional marks to students is available at:
www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/

Re-sit Policy

Students will be allowed to re-submit any coursework that has been failed once within the same academic year.

The College's Policy on Re-sits is available at: www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/

Mitigating Circumstances Policy

The College's Policy on Mitigating Circumstances is available at: www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/

Additional Programme Costs

There are no additional costs. The field trip will be provided free of charge.

Important notice: The Programme Specifications are the result of a large curriculum and pedagogy reform implemented by the Department and supported by the Learning and Teaching Strategy of Imperial College London. The modules, structure and assessments presented in this Programme Specification are correct at time of publication but might change as a result of student and staff feedback and the introduction of new or innovative approaches to teaching and learning. You will be consulted and notified in a timely manner of any changes to this document.

Programme Structure[3]

FHEQ Level 7
For the MSc you will need to complete all core and compulsory modules. For the PG Diploma you need to complete all modules except the last – Applied Computational/Data Science Project relevant to subsurface geoscience and engineering. For the PG Cert you need to complete all modules in Term 1. There are no electives.

Code	Module Title	Core/ Elective/ Compulsory	*Group*	Term	Credits
EART70159	Numerical programming in Python	Compulsory		1	5
EART70160	Data science and machine learning	Compulsory		1	5
EART70161	Computational mathematics	Compulsory		1	5
EART70162	Applying computational/data science	Compulsory		1,2,3	7.5
EART70163	Introduction to resource geology and geophysics	Compulsory		1	7.5
EART70164	Fluids and fluid flow in porous media	Compulsory		2	7.5
EART70165	Geomechanics and pressure analysis	Compulsory		2	7.5
EART70166	Energy geoscience and engineering	Compulsory		2	7.5
EART70167	Deep learning	Compulsory		3	7.5
EART70168	Applied Computational/Data Science Project relevant to subsurface geoscience and engineering	Core		3 and 4	30
				Credit Total	90

[3] **Core** modules are those which serve a fundamental role within the curriculum, and for which achievement of the credits for that module is essential for the achievement of the target award. Core modules must therefore be taken and passed in order to achieve that named award. **Compulsory** modules are those which are designated as necessary to be taken as part of the programme syllabus. Compulsory modules can be compensated. **Elective** modules are those which are in the same subject area as the field of study and are offered to students in order to offer an element of choice in the curriculum and from which students are able to select. Elective modules can be compensated.

Progression and Classification

Award and Classification for Postgraduate Students

Award of a Postgraduate Certificate (PG Cert)
To qualify for the award of a postgraduate certificate a student must have a minimum of 30 credits at Level 7 from the taught modules starting in Autumn term.

Award of a Postgraduate Diploma (PG Dip)
To qualify for the award of a postgraduate diploma a student must have passed modules to the value of no fewer than 60 credits at Level 7 from the taught modules in the Autumn, Spring and Summer terms

1. and no more than 10 credits as a Compensated Pass;

Award of a Postgraduate Degree (including MRes)
To qualify for the award of a postgraduate degree a student must have:

1. accumulated credit to the value of no fewer than 90 credits at level 7;
2. and no more than 15 credits as a Compensated Pass;
3. met any specific requirements for an award as outlined in the approved programme specification for that award.

Compensation allows a marginal failure (i.e. between 40.00-49.99 inclusive for Level 7) of modules up to a maximum of 15 ECTS per academic level and awarding credit for them on the basis of good overall academic performance.

Classification of Postgraduate Taught Awards

The College sets the class of Degree that may be awarded as follows:

1. Distinction: The student has achieved an overall weighted average of 70.00% or above across the programme.
2. Merit: The student has achieved an overall weighted average of above 60.00% but less than 70.00%.
3. Pass: The student has achieved an overall weighted average of 50.00% but less than 60.00%.

a. Students must normally achieve a distinction (70.00%) mark in the dissertation or designated final major project (as designated in the programme specification) in order to be awarded a distinction.
b. Students must normally achieve a minimum of a merit (60.00%) mark in the dissertation or designated final major project (as designated in the programme specification) in order to be awarded a merit

Programme Specific Regulations

None

Supporting Information
The Programme Handbook is available at: TBA
The Module Handbook is available at: TBA
The College's entry requirements for postgraduate programmes can be found at: www.imperial.ac.uk/study/pg/apply/requirements
The College's Quality & Enhancement Framework is available at: www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance
The College's Academic and Examination Regulations can be found at: www.imperial.ac.uk/about/governance/academic-governance/regulations
Imperial College is an independent corporation whose legal status derives from a Royal Charter granted under Letters Patent in 1907. In 2007 a Supplemental Charter and Statutes was granted by HM Queen Elizabeth II. This Supplemental Charter, which came into force on the date of the College's Centenary, 8th July 2007, established the College as a University with the name and style of "The Imperial College of Science, Technology and Medicine". www.imperial.ac.uk/admin-services/secretariat/college-governance/charters/
Imperial College London is regulated by the Office for Students (OfS) www.officeforstudents.org.uk/advice-and-guidance/the-register/
This document provides a definitive record of the main features of the programme and the learning outcomes that a typical student may reasonably be expected to achieve and demonstrate if s/he takes full advantage of the learning opportunities provided. This programme specification is primarily intended as a reference point for prospective and current students, academic and support staff involved in delivering the programme and enabling student development and achievement, for its assessment by internal and external examiners, and in subsequent monitoring and review.

Modifications			
Description	**Approved**	**Date**	**Paper Reference**
Approval of the programme	Programmes committee	29/04/2021	