Department of Earth Science and Engineering, Imperial College London

Course Syllabus, 2015-2016

The degree course is structured but flexible; core modules are covered in year 1 and 2, where students may select the mix of geology and geophysics modules that suits their interests. Significant choice is introduced in year 3 and 4. In all years, students additionally have the option of taking a humanities, language or business studies module to broaden their horizons. Typically students take these optional courses ‘not for credit’ in year 1 and year 2. Some business modules are for credit in year 2, and all languages/business/humanities are normally for credit in year 3. For example, finance courses and higher level language courses are currently offered. The list below does not include all modules currently offered and is intended to give an outline of the current syllabus only.

First Year

Dynamic Earth A
The course provides an introduction to Earth’s dynamic systems, including plate tectonics, the climate system, life and the Solar System.

Stratigraphy
The aim of this course is to provide an introduction the key principles of stratigraphy and palaeontology, providing a grounding and foundation for the second level course Earth and Life.

Earth Materials
The aim of this course is to provide an understanding of the properties and attributes of the key rock forming minerals (silicates and non-silicates), and the significant rock groups (igneous, sedimentary and metamorphic), as a basis for further study in geology and geophysics.

Solid Earth geochemistry
This course will provide an understanding of the principles that govern the behaviour and distribution of elements in the Earth, introduce equations that can be used to predict the behaviour of elements during partial melting and crystallisation and familiarize the students with various radiogenic and stable isotope systems and introduce their application in solid Earth geochemistry. Students who have taken an A level or equivalent in chemistry, will study an introductory chemistry class as an alternative.

Programming for geoscientists
This course will develop students algorithmic and problem solving skills, helping to prepare students for future careers in the geophysical sector. Here you will get a series of lectures focused on learning to program using a language called Python.

Maths 0
Designed for those students without Maths A level. The aim of the course is to provide sufficient background knowledge for these students to tackle the mathematical aspects of the geoscience course.

Maths Methods 1
Teaches a variety of important and fundamental university-level mathematical tools to tackle mathematical problems that commonly arise in Earth Science.

Numerical methods 1
The basic techniques that underlie the computational mathematical techniques commonly used in Earth sciences. It will provide an overview of the capabilities and limitations of scientific computation including the concepts of error and conditioning. The course will cover techniques applicable to both observational data and simulation and will have an emphasis on the practical implementation of the methods studied in the Python programming language. Normally taken by geophysics students.

Surface processes
An introduction to the processes that shape Earth’s surface, and how these lead to the formation of landscapes and sedimentary deposits. This course will provide you a background in the main processes that move material across Earth’s dynamic surface, and how to read these from modern landscapes and the ancient sedimentary rock record.

Physical processes
A course covering some of the physics that governs how various processes which are important for the Earth "work". Estimating & approximating, isostasy, gravity & circular motion, dimensional analysis & non-dimensional numbers,
modelling the real world with simple equations, fluid flow, Reynolds number, Bernoulli’s equation, heat & heat transport, sediment transport, diffusion, thermal convection.

**Structural geology**
Tectonics plus time creates the amazing array of geological structures we see on Earth. Structural geology is all about understanding how present-day rock geometries evolve and how they can be decoded to reveal the geological past. This course covers structural geology at every scale and the module introduces many of the key ideas in this field, from the basics of how rocks break, to the way in which mountain belts grow.

**Optical mineralogy and Petrology**
This course will enable students to observe, recognise and interpret the optical properties of the principal rock-forming minerals in thin section using a standard petrological (polarised light) microscope. Students will learn how to differentiate between igneous, sedimentary and metamorphic rocks in thin section.

**Graphics and statistics for Geoscientists**
Students will be versed in Inkscape (vector drawing), G.I.M.P. (raster graphics), and will also be taught enough computer-graphics theory to inform their use of these packages. In the second half of the course they will be taught basic statistics, and chart-generation through Python.

**Introduction to field geology and Dorset fieldtrip**
To give students a grounding in the practical and theoretical skills required to perform geological analysis in the field, students receive at least two days of classroom-based teaching followed by a three day field trip to the Dorset coast.

**Field course to southeast Spain**
Introduction to the principles of geological fieldwork, including rock and mineral identification, measurement and interpretation of geological features, and geological mapping. A wide range of rock types and geological features are seen; these tie in with the other first year modules and allow students to put their existing knowledge into context and to gain greater confidence in independent work.

**Tutorials**
Tuition in groups of around four students, focussing on a range of geological topics outside the main syllabus. Essay-writing and research skills are developed in a series of essay assignments that receive extensive feedback, including oral and other presentational skills.

**Workshops and clinics**
Workshops and clinics are held throughout the year on topics such as field safety, first aid, field notebook preparation, use of compass clinometer and rock description to support classes and fieldwork.

**Igneous and metamorphic processes**
This module teaches understanding of the origin of igneous and metamorphic rocks and how to classify rock types in hand specimen.

**Palaeontology 1**
This course will provide you with the basic skills needed to identify the main groups of marine invertebrates, appreciate how biodiversity has changed through geological time and be able to interpret how the morphology of fossil organisms can be used to infer their mode of life and depositional environment.

**Igneous 1**
This course aims to provide the intellectual tools to allow you to interpret the mineralogies and textures of igneous rocks to their mode of formation within the framework of processes on scales ranging from atomic to global.

**Maths methods 2**
Understanding complex numbers, double integrals, second-order differential equations, and the concept of a general solution of an ordinary differential equation.

**Chemistry for geoscientists**
This course is for students who do not have A-level Chemistry or equivalent. It teaches students to master the fundamentals of physical, inorganic, and organic chemistry relevant to geology and geochemistry to a level directly applicable at university.

**Physics for geoscientists**
Designed for those students without Physics A level. The aim of the course is to provide sufficient background knowledge of the A-level physics syllabus for these students to understand the physical aspects of the geoscience course.
Second Year

**Applied geophysics 1**
To introduce the use of geophysical techniques and their applications. Students will learn to explain the physical principles behind each geophysical method studied, describe how to acquire these geophysical data in the field, recall how to process these raw geophysical data and recognise and sketch the processed data.

**Igneous 2**
The objective of this course is to enable students to relate the petrology, mineralogy and chemistry of igneous rocks to their tectonic setting and interpret the mineralogy, textures and geochemistry of igneous rocks in terms of processes operating during magma genesis and evolution.

**Structural 2**
The interpretation of geological maps and sub-surface structure, preceded by an additional four-hour prep-class prior to the start of the formal course to focus on map work.

**Vibrations and waves**
To understand the physics of vibrations and waves with particular emphasis on the properties and behaviours encountered in geophysics (reflection, refraction, transmission, interference, diffraction, polarisation, attenuation and dispersion). This course provides the basic physical understanding underpinning the seismology course.

**Sedimentary geology**
This course studies the sedimentary processes that operate in different depositional environments, and the evidence contained within sedimentary rocks that allows us to interpret these environments in the geological record. It is a core course for second years who wish to continue studying in the field of geology.

**Maths methods 3**
To extend students’ mathematical skills in the areas of vector calculus and Fourier analysis.

**Maths methods 4**
This course provides students with a continued development of their mathematical skills, with a particular focus on partial differential equations (PDEs). The course will prepare students for higher level modules and further their appreciation of mathematical methods in the Earth Sciences.

**Numerical Methods 2**
The aim of this course is to learn how to solve differential equations numerically. Most differential equations do not have analytical solutions and therefore need to be solved numerically. In this course methods for solving both ordinary and partial differential equations will be presented. Students will learn the mathematical tools required to approximate the differential equations in forms that can then be implemented and solved as a computer program. The programming language that will be used in Python. In this course you will be expected to make use of the programming skills that you have developed in previous courses.

**Mechanics**
In this course we will learn the classical laws of motion of a particle and a rigid body, and the concept of stress in a solid or fluid body, and apply these laws and concepts to some simple problems in Earth and planetary science.

**Low-temperature geochemistry**
The aim is to introduce the fundamental inorganic chemical processes and principles that determine the distribution of elements in earth materials and environments. The focus is on solutions and low temperature geochemistry.

**Metamorphic 1**
To provide an in-depth understanding of metamorphic rocks by helping students develop skills in interpreting mineralogical, textural and compositional information and linking this with the theory behind metamorphism in order to determine the petrogenesis and tectonic context of metamorphic rocks.

**Remote sensing and GIS**
An introductory course on remote sensing and GIS for 2nd year students. The course is aiming to provide basic knowledge of remote sensing principles and skills on essential image processing and GIS for computerised interactive image interpretation and field use for geological mapping. The aims are to become familiar with Earth Observation (remote sensing) and GIS, their use in geo-scientific applications and to gain hands-on experience with industry standard software (ArcGIS). The topics covered will include the physical principles, basic processing and examples from various fields of application.
Structural 3
Upon completion of this course students should be able to constrain strain rate histories of the lithosphere. They should understand how rheology of crust and mantle influences histories of deformation. Techniques to determine lithospheric stress and strain using large-scale geodetic measurements will be reviewed. We will discuss methods to deduce histories of deformation from structural measurements in the field. These observations will be used to constrain mechanics of fold and fault development. In summary, measurements of strain will be used to constrain processes responsible for deformation at lithospheric and sub-lithospheric scales.

Earth resources
The course will provide an introduction to energy and mineral deposits; their origin, extraction and use. It will describe the formation of ore deposits as well as oil and gas reservoirs. The techniques of surface and underground mining and processing to metals will be covered. Sustainability and the morality of mining will also be discussed. Case studies will be presented for offshore oil and gas exploration and mining project development.

Rocks master class
The goal of the Rocks Master Class is to hone skills in rock and mineral identification and cement and link knowledge gained from courses in igneous, metamorphic and sedimentary petrology. The Rocks Master Class is intended to provide practical experience in rock and mineral identification not possible in practical sessions in other courses.

Palaeontology 2
To review the evolution of life on earth, and provide practical experience with identification and interpretation of fossils (including vertebrate and trace fossils).

Seismology
During this course you will develop an understanding of various aspects of global seismology with a strong emphasis on its use in the study of Earth’s deep interior. By the end of the course, you will have a strong grounding in the fundamentals of global seismology, including theory and practice. We will review the theory of wave propagation (including stress, strain, and the derivation of the seismic wave equation), and discuss various body and surface wave methods that can be used to image Earth’s internal structure. You will see how seismic recording equipment works, and how seismometers can be used in networks and arrays. During practicals, you will learn to use a piece of software called SAC (the Seismic Analysis Code) - a widely used research tool in passive seismology. This will allow you to make measurements of the kind commonly found in the seismology research literature. We will also explore the extent to which seismology can be used to discriminate between earthquakes and nuclear explosions.

Global geophysics
This course provides an introduction to the internal structure of the Earth and plate tectonics. Objectives are to study the structure of the interior of the Earth, understand the observations that led to plate tectonic theory, understand how the plates have moved over time.

Field geophysics
You will learn how to apply near-surface geophysical techniques to try to understand the geology of a particular area, in this case Cyprus. You will learn how to collect the data in the field using a suite of geophysical techniques. This data will be processed and analysed on your return.

Geophysics course to Cyprus and data analysis project.
A twelve day trip to Cyprus in March that introduces students to measurement techniques such as seismic, ground penetrating radar, resistivity, electrical and gravity. Students start to process data while in the field and complete the data processing in workshops on return to the Department.

Field geology 1 to Almeria, Southern Spain
Introduction to the principles of geological fieldwork, including rock and mineral identification, measurement and interpretation of geological features, and geological mapping. This course takes place in the Province of Almeria, Andalucia in southern Spain in May.

Field Geology 2 to the Spanish Pyrenees
A 10-day fieldtrip to introduce students to mapping techniques in structurally simple terrain incorporating sedimentary interpretive techniques in a small-scale fold and thrust belt.

Field Geology 3: Mapping field course to the Scottish Highlands
A two-week field trip to Kinlochleven and Assynt in the Scottish Highlands to introduce the students to aspects of igneous and metamorphic geology not yet covered in the field and to train students to analyse complexly deformed regions by the detailed field mapping and structural analysis in preparation for their independent mapping exercise.
Tutorials
In second year students have a series of academic tutorials focussing on the specialist areas of a range of lecturers; they prepare a second year research essay building on work completed in year 1; additionally, second year students meet regularly with their personal tutor to discuss their progress and welfare.

Imperial Horizons
Students also have the opportunity to sign up for the Imperial Horizons programme offers a wide range of courses for all Imperial College undergraduates. It is designed to broaden your education, inspire your creativity and enhance your professional impact. Over 80 different short course options are available from four fields of study throughout your undergraduate degree. Students in year 1 and 2 take Horizons courses not for credit.

Second year summer term, independent project
All students work on their independent project, currently structured as follows:

- Geology: students undertake a 6-week independent mapping project (in pairs) in an agreed location.
- Geophysics: students continue with a data-analysis project following on from the 12-day field course in Cyprus.
- Environmental or desk-based project: for those students unable to undertake the geology or geophysics project, a lab-based or desk based project may be offered.

All students submit their main report at the end of autumn term of year 3.

Third and Fourth Years
A range of modules or electives are available for third and fourth year undergraduates in the spring term; some are listed below. For some students, it is possible to take second-year modules that they have not previously studied, timetable permitting.

- Physics of planet Earth; Flow and reactive transport; Impact cratering; Marine geology and geophysics; Mining waste and water management; Palaeoceanography; Basin analysis; Subduction geochemistry; Applied sedimentology; Marine stratigraphy; Palaeobiology; Planetary science; Basins and Tectonics; Environmental geochemistry; Thermodynamics; Dynamic stratigraphy; Seismic techniques; Advanced programming; Climate; Solar system geoscience; Ore deposits; Geodesy and geomagnetism; Environmental impact assessment; Hydrogeology and fluid flow; Environmental seminars; Ice and Fire; Minerals processing; EPEX business simulation; Science communication; Coastal engineering; Impact cratering; Imperial horizons, Business for professional Engineers and Scientists; Humanities options etc...

Geologists go on field trips to Sardinia (third year) and the Italian Apennines (fourth year); geophysicists may attend the Apennines or a relevant conference in year 4.

All fourth year students carry out an independent research project into an unsolved geological or geophysical or environmental problem, developing a deep understanding of the topic; many students go on to publish their results in internationally acclaimed scientific journals. The project spans 24 weeks and is an excellent showcase for students applying for jobs or wishing to continue on to study for a PhD.

Full details of each module, including the learning outcomes and assessment are available on the departmental website: [http://www.imperial.ac.uk/earth-science/current-student-staff-info/ug/](http://www.imperial.ac.uk/earth-science/current-student-staff-info/ug/)

Students are also encouraged to view the programme specifications for each of the UG degrees available through the link: [http://www.imperial.ac.uk/earth-science/current-student-staff-info/ug/](http://www.imperial.ac.uk/earth-science/current-student-staff-info/ug/)

This document is current for 2015-2016 only and will be subject to change annually.

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