Imperial College London

Undergraduate degree courses in Chemical Engineering

▶ H801 ▶ H802 ▶ H890

As far as we know, the course in Chemical Engineering which began in London in 1885 was the first to be established anywhere in the world. Today Imperial graduates in Chemical Engineering are represented and respected among the engineers and managers in a wide diversity of industries in the UK and in many overseas countries.

The breadth of the training provided is in the spirit of the Royal Charter to the Institution of Chemical Engineers in which the profession is defined “as a means of furthering the scientific and economic development and application of manufacturing processes in which chemical and physical changes of materials are involved”. It follows that those manufacturing enterprises which attract our graduates have always included not only those concerned with chemicals and oil, but also those in which materials are processed to make goods for retail markets, such as food, clothing and cars.

The foundations of Chemical Engineering were laid several millennia ago when mankind began to exploit mineral resources. In the twentieth century sophisticated mathematics and computing have been deployed to analyse, explain and predict our continuing interaction with the chemical environment. We live in a world of complicated manufacturing procedures, usually with social and economic dimensions as well as the quantifiable technical constraints.

In our course we hope to encourage students to learn in an atmosphere of debate and decision-making, believing that these will be the essence of professional life in the century to come. This is the one reason for our emphasis on project work which generally occupies students for half their study time.

Our MEng courses are always evolving in the actual content while the educational aims are retained. These are to show students how they can apply scientific and technological expertise to achieve material, commercial and environmental benefits. The course provides numbers of specialised and advanced options in the senior years to meet the way individual students’ needs and career preferences will develop; these may be focused in selected technologies and may provide, say, more opportunity for study of management science and economics, with business and communications skills. The experience which students gain in computing and information technologies is well-grounded in real problems.

The four-year, full time MEng courses have a firm foundation in science and mathematics, which is integrated from the first term onwards with practical applications in engineering subjects. Engineers from industry participate in some of the teaching, and studies in business management, economics and accounting are integral parts of the courses in all four years. Foreign language studies are open to all students, and for students of the course with a year's study abroad (H802) the appropriate language is studied in place of some of the courses in years one and two of the H801 curriculum.

It follows from the demanding nature of the courses that the students are highly qualified and motivated at entry, and that each year the graduating students have entered well-rewarded jobs.

The main categories of employers for our chemical engineering graduate are companies in the oil, petrochemical and other chemical and process industries, including manufacturers of pharmaceuticals, fine chemicals and specialty chemicals. Also substantial numbers enter the engineering industry more generally, particularly in design and manufacture of chemical plant. A great variety of other industries; for instance those supplying gases, food and drink, pharmaceuticals, nuclear energy, water – are significant employment areas for chemical engineering graduates, and they are also to be found in mining and minerals, wastewater treatment, electronics, computing, teaching, the armed forces, etc. In all these areas chemical engineers undertake a diversity of jobs: principally plant supervision, plant and process design and development but also computing and technical services, sales and marketing, supply and planning. Increasing numbers of chemical engineers are also finding their way into financial careers both within the industries mentioned above and in service industries such as computing, management consultancy, IT consultancy, banking and insurance.

A quarter of graduates go into the petrochemical industry

A fifth go into finance

A sixth take up further studies

An eighth go into engineering consultancy

others go mainly into energy, process engineering and manufacturing

Contents of the courses

Overall structure

The table on the right gives an impression of the allocation of students' time across the four years to the main subject areas of the courses, in lecture-based study and in project work.

Lecture-based courses in the first two years are supplemented by tutorials in small groups and by seminars, with some written assignments as appropriate. The principal assessment is by yearly examinations, however the quality of learning is assured by quite frequent 'open-book' assessments in which students demonstrate 'mastery' of key basic parts of the course and also demonstrate the ability to integrate material they have learnt in different lecture courses.

The projects are carried out mostly by pairs or larger groups of students in collaboration with academic teaching staff who will make the assessments of progress. The projects consist of design work, theoretical and computing studies, case studies, and practical work in the laboratories, for instance the computer-controlled operation of pilot plants, which every student experiences. In addition, many students carry out projects which involve work in industry during the summer vacations preceding the third or fourth years of the course, and which may continue in College in the first terms of the fourth year. The spring term of the final year contains a major process design study, working with comparatively large teams of students and staff.

Students on the H802 (Year Abroad) course study essentially the same syllabus as H801 during their three years at Imperial and take equivalent courses at the host university during their year overseas.

Students on either course are able to opt for a 'fine chemicals processing' stream which involves considerably more study of chemistry. This has been introduced as a result of perceived trends in industry towards lower-volume products, the manufacture of which requires complex chemistry (for instance pharmaceuticals, or advanced polymers).

TEACHING METHOD		YEAR ONE	YEAR TWO	YEAR THREE	YEAR FOUR
Lecture-based teaching	mathematics | chemistry | properties of matter | thermodynamics | transfer processes | process systems, reaction and environmental engineering | safety	67%	63%	70%*	49%*
Projects and coursework	labs | design | computing | including large design project in year four	20%	26%	18%	44%
Complementary subjects	mastery | business	13%	11%	12%	7%

*Includes elective courses

Lecture courses taken by all students

Chemical engineering topics extend throughout the course. For instance the first year contains process analysis (which means calculation of material and heat balances, recycling in reactors, etc.) and also fluid mechanics, transfer of heat and matter, and techniques for separation of materials. These fundamental themes presented in the first two years are later developed in the context of their application. For example, in the third year the emphasis in the subject of separation processes is on newer techniques such as those which use membranes, while the fluid mechanics is focussed on understanding the mixtures of fluid and particles which are often encountered in chemical processes.

There are substantial courses in Mathematics in the first and second years, covering a wide range of pure and applied topics, with emphasis on solving the large sets of non-linear equations which characteristically describe chemical engineering problems.

Distributed through the four years, there is approximately the same amount of physical chemistry as in pure science degree courses, while in the first year courses in chemistry and biochemistry are included for their own sake and also to support eventual elective courses in later years. Students may opt for a fine chemicals processing stream which

places more emphasis on organic chemistry and synthesis, thermodynamics of liquids and process development. The chemistry content of years two and three may thereby be augmented to about one fifth. Some courses and projects will be taken jointly with honours chemistry students.

Environmental effects of chemical operations are highlighted throughout, with an emphasis on successful control and mitigation. There are also major electives in which environmental technology themes can be taken further.

Attention to safety engineering is closely integrated with many of the courses and in most projects a safety audit is required. Chemical engineers have to face demands imposed, for instance, by the need for containment of reactants at increasingly higher temperatures or pressures, and for resistance to corrosion failure in high-stress conditions.

To cope with the needs of around 500 undergraduate students and over 200 postgraduates there is a teaching staff of some 40 Professors, Readers, and Lecturers, 11 technical support staff, and 20 administrative and clerical staff. These people are the major resource for running the undergraduate course.

Following a first-year course of familiarisation with the large networks of PCs and workstations, students have free access to these computers. Currently the Department has a policy of recommending students to equip themselves with a (simple specification) personal computer. Information technology in the form of design 'packages' and data-banks are continually used by students in projects and in lecture-based work; courses to support these activities are offered at intervals.

Industrial and business studies are designed by the College's Business School to develop awareness of the needs and opportunities faced by engineering managers in general, as well as to provide a background in the analysis of markets and the options for raising finance.

Practical projects

PILOT PLANT OPERATIONS

All students work with the computer-controlled pilot plants. They are required to analyse the process flowsheet of the plant and then to develop safe start-up and shut-down procedures. The students operate the plant and obtain measurements, to establish complete material and energy balances and subsequently to control and optimise separation of gases.

LABORATORY PROJECTS

Students work in pairs on laboratory projects normally for four weeks in each of the first three years, supervised by a lecturer. They typically begin with a discussion of the background to the experiments and the lecturer supplies a list of suitable reading. This is followed later by tutorials in order to check the students' understanding and progress.

As with all projects, the work is finally reported fully in writing for assessment of the technical merit and effective communication.

Design teaching

There is a continuous element of design running through all four years of the undergraduate course, where the open-ended nature of design problems is used as a key integrating part of the learning process. The term 'design' embraces all aspects of creating a process from a basic chemical proposal to the appropriate plant, and the implications of managing it commercially, safely and with regard to all environmental impacts.

In the first year, within their first month on the course, students undertake two mini-design projects:

- one is on the scheduling of maintenance and repair work on a pressurised-water reactor power station
- the other is on the synthesis of a heat exchanger network for a solvent manufacturing plant

Key aims in these projects are success in definition and solving of the problem and also experience of working in groups.

In the second year, students undertake three design projects:

- for a catalytic reactor students must write their own computer program to size the reactor in order to achieve a specified conversion
- for control of a furnace for heating a crude oil stream students use an existing real-time simulation package

Chemical engineers at Imperial are hard at work on carbon capture and storage to tackle the problem of fossil fuel emissions and global warming.

In the third year, students undertake four design projects:

- a combined flow-sheeting and process synthesis design
- the mechanical design of a pressure vessel: a detailed engineering drawing is required of each student, with instruction in drawing practice provided by an engineering graphics course
- a combined economic, social and technical analysis of proposed new technology
- five case studies on the safe design and operation of plant including sizing of relief systems and estimation of over-pressures arising from explosions

In the fourth year, students undertake a major project covering all aspects of the design of a chemical plant. These aspects are:

- the synthesis of a process; detailed design of key units; plant control (including start-up and shut-down procedures); plant safety and layout (including environmental impacts of the plant); development of a sound business plan

Students work in teams of eight to ten, after having completed a team building exercise. Example projects are:

– Production of PV grade silicon for solar cell manufacture
– Skid mounted methanol synthesis plants to treat associated and stranded natural gas
– Production of high grade polyaramid fibres
– Human insulin from plant extracts
– Enantioselective production of anti-inflammatory agent
– Reduced cost anti-cancer intermediate

Teams are supported by technical experts and facilitators. A number of projects are either associated with or directly involve industrial partners.

Elective subjects

In the third year of the course a student selects two elective subjects from the following (current) list. These options allow a degree of specialisation in developing technical fields of chemical engineering, or in management studies, humanities, transport processes in biological systems or languages.

TECHNICAL ELECTIVES

| advanced bioprocess engineering | advanced process synthesis and optimisation | clean fossil fuels | colloid and interface science | downstream separation in biotechnology | dynamic behaviour of process systems | dynamical systems and chaos | environmental biotechnology | formulation engineering and technology | fundamentals of biotechnology; introduction to nuclear energy | membrane science and membrane separation processes | modellng of biological systems | process heat transfer | nuclear chemical engineering | nuclear thermal hydraulics | nuclear materials | pharmaceutical process development | process heat transfer | product characterisation | polymers | separation processes | transport processes in biological systems |

BUSINESS ELECTIVES

| entrepreneurship | finance and financial management | innovation management | project management |

HUMANITIES

| philosophy | controversies and ethical dilemmas in science and technology | European history, 1870–1989 | history of medicine, science and technology in western civilisation | modern literature and drama; music and western civilisation | European languages | Japanese |

Other major projects

In addition to design and laboratory projects, the course contains a number of other projects in the third and fourth years of the course.

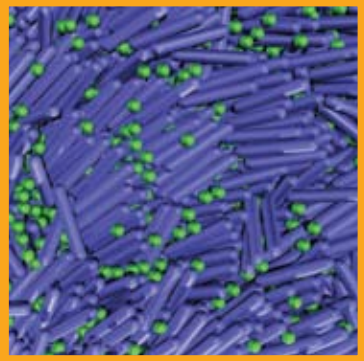
INDUSTRIAL PLACEMENTS

These projects (which are optional, but in high demand) represent the fusion of supervised vacation training with a coursework project conducted in the Department. The student spends six to eight weeks in industry during the long vacation at the end of third year and then most of the following term in College, working on a specific topic which will have been carefully selected by prior consultation between the academic and industrial project supervisors so as to be;

- of value to the firm
- academically satisfying
- capable of being developed usefully by further experimental or theoretical work during the autumn term in the Department

The work in industry may be an experimental study on an existing plant or participation in research, development or design. The part done in College often involves process evaluation, mathematical modelling or complementary experimental work. Examples of such projects are the design of a system to control emissions of organic vapours, a study of the use of superheated steam as a drying medium, the redesign of an energy recovery system on a crude oil distillation unit and a study of the performance of an oxidation train on a nitric acid plant. There are also projects in which the aim is to tackle problems with a socio-economic and/or a managerial flavour. Recent examples are a market analysis for a range of gases supplied to industrial and scientific customers, a study of a capital expenditure authorisation procedure and a study of product distribution by road.

Students prepare reports on their work, usually at the end of the period spent in industry and also on completion of the project. In addition, verbal reports are required and these are presented either at the participating company or at College. In most cases representatives of the company attend the presentations. Currently about thirty industrial organisations participate in the industrial placement scheme.



A leading effort in the Department is on using molecular dynamics computer simulations to 'design a molecule' for practical applications.

PhD students Vivian Ikem and Michael Bajomo working on microgels.

VACATION WORK EXPERIENCE

The distinctive (optional) industrial placements occupy the third long vacation of about half the students, and at least another quarter gain technical work experience or vacation training. The numbers who take up technical work in the third long vacation are similar. Those students who are sponsored by firms or government agencies normally work with them in several summers of the course.

RESEARCH PROJECTS

The Department has a wide range of research programmes at the forefront of their subjects, and fourth year students may choose a research investigation as part of their project work. In each case the student is integrated into a research team for the autumn term. The research may be experimental or theoretical in nature. The reporting arrangements are similar to those for industrial placements, with members of the research group attending the verbal presentations.

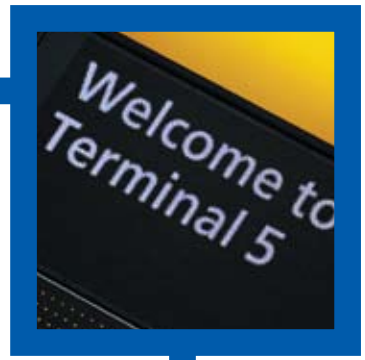
MEng Chemical Engineering with a year abroad

In this course the third or fourth year of study is spent at a leading school of chemical engineering in continental Europe, in Australia, or in the USA.

UCAS: H802

This degree course is entirely equivalent to the degree where all four years are spent at the College (Code H801), so the student addresses the same academic challenges in either. It follows that admission to the course with study in France, Switzerland, Germany or Spain demands either demonstrable skill in the foreign language or aptitude for learning it; a qualification at AS level or in the upper grades in GCSE would be appropriate. Language classes and tutorials are provided throughout the years at Imperial; skills are graded each year, and tested before proceeding to the year abroad, and transfers between the two courses are possible at several stages. It is normally the case that students are performing at least at upper second class Honours level before approval of the year abroad is given.

For UK students, it is normal for local authority awards to apply to the study abroad, including provision for tuition fees, and no extra financial burden should be anticipated. Supplementary grants from the EU are also normally awarded if the exchange destination is in the European Union. The list below gives an account of current opportunities for study at the schools with which we exchange students.



Ecole Nationale Supérieure d'Ingénieurs de Génie Chimique, (ENSIGC), a school of the Institut National Polytechnique de Toulouse

Ecole Nationale Supérieure des Industries Chimiques, (ENSIC) a school of the Institut Polytechnique de Lorraine, Nancy

Ecole Nationale Supérieure d'Ingénieurs en Génie des Technologies Industrielles (ENSGTI), at Université de Pau et des Pays de l'Adour

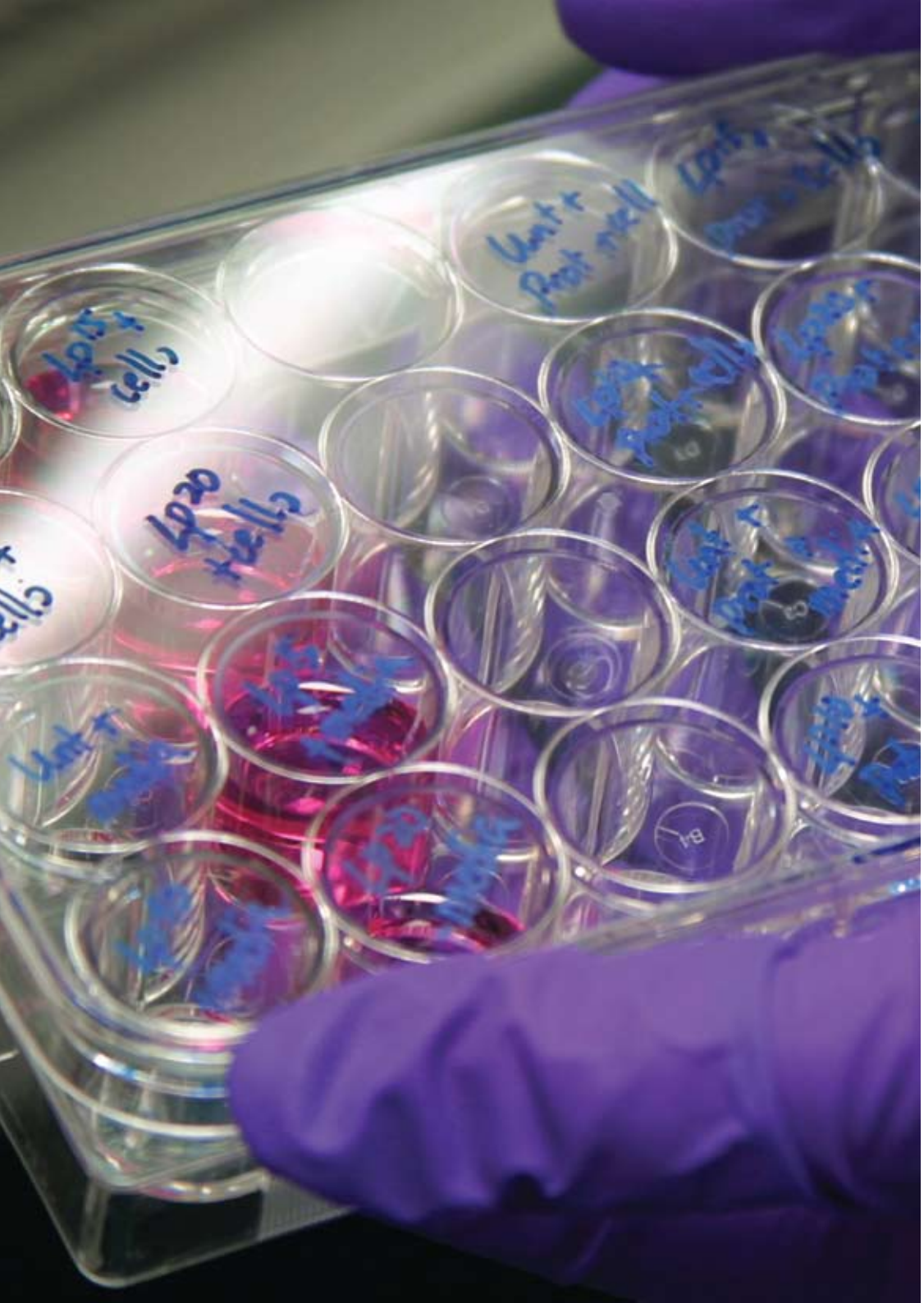
These schools resemble the Department at Imperial in the size of classes and numbers of the staff, and offer final year studies having much in common with those in Imperial, including a major design project. Several of the final year students in the Diplome d'Ingénieur course at each school attend Imperial in an exchange arrangement.

Ecole Polytechnique Fédérale de Lausanne (EPFL)

As an alternative to the fourth year exchange in France, students can spend their third year at EPFL. Courses are given in French. The study program is somewhat different from our four-year integrated masters, thus emphasis has to be put on a good complement of elective courses while in Lausanne.

Rheinisch Westfälische Technische Hochschule, Aachen (RWTH)

The German tradition in engineering education has more flexibility for the individual student in choosing courses and their timing. In collaboration with staff there, curricula have been developed which maintain this principle while providing academic content equivalent to the course in London. The third year is the one normally spent in Aachen.



Centro Politécnico Superior, Universidad de Zaragoza
Departamento de Ingenieria Quimica y Tecnologia del Medio Ambiente, Universidad de Valladolid

Institut Químic de Sarrià, Universitat Ramón LLull, Barcelona

There are possibilities to spend the third or fourth year at these partner institutions in Spain.

Apart from the destinations above, where instruction occurs in the local language, we entertain a flourishing exchange program with universities where no knowledge of a foreign language is required. In Australia, students can enroll for a year at the *University of Melbourne*, the *University of Sydney* or *Queensland University in Brisbane*. Students spend their third year at those institutions. The study program is closely matched to the one at Imperial but provides opportunities to take advantage of elective courses offered by these universities that reflect the specific research strengths of these departments.

Exchange destinations in the USA comprise of *Carnegie Mellon University, Pittsburgh, Pennsylvania, Columbia University, New York* and several campuses of the *University of California*. The third year is the appropriate year for the exchange. Students benefit from the higher degree of flexibility in course choices at the US destinations where universities have a traditionally broader spectrum of courses on offer.

A similar exchange program has been in place for several years with the *National University of Singapore* where our students spend their third year.

We also offer full-year exchanges in the fourth year with the *University of Delft, Netherlands* and *KTH Stockholm, Sweden*. Instruction at these schools is in English but students are advised to have a basic command of the local language. Intensive language courses are offered at both destinations in the summer preceding the academic year.

All these schools enjoy high prestige in education and research. They have of course substantial links with national and international firms in the project work they provide for students.

VACATION PROJECTS ABROAD

Frequently students take up ‘link’ projects with firms in France, Belgium, Germany, Italy, Netherlands, Switzerland, the USA or the Middle East. These may usefully be combined with the elective foreign language courses which are available to all chemical engineering students.

MEng Chemical with Nuclear Engineering

The need to continue and expand the generation of nuclear power is now widely recognised as part of the solution to the world's problem of meeting rapidly growing energy demand whilst at the same time protecting the environment.

UCAS: H890

To achieve the rapid growth necessary, there is an urgent requirement for new technical staff. In order to meet this requirement, we have set up a new degree, Chemical with Nuclear Engineering. Students on this degree course will be fully qualified in Chemical Engineering but will take a series of courses which will give them a basis for employment in the nuclear and related industries. In addition, students pursuing this new combined degree will be encouraged to carry out project work relevant to nuclear power and every effort will be made to find them placements in relevant industry in the summer vacation between their third and fourth years.

The Department leads Centres in Process Systems (CPSE) and in Carbon Capture and Storage (QCCSRC).

www.imperial.ac.uk/chemicalengineering/research

Research in the Department includes a large range of activities, including natural resource, biological, fluids, materials, process systems, reaction and separation engineering.

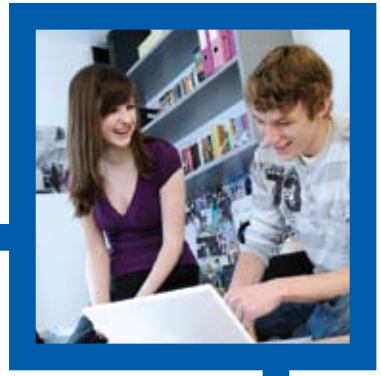
Accommodation

Imperial's Student Accommodation Centre team is here to support students in finding the right place to live and settling in. All first year students are guaranteed a place in Imperial accommodation provided you are eligible and complete your application in the required timescales – see the website for details of eligibility and how to apply.

About 3,000 of around 14,000 Imperial students live in accommodation owned or leased by Imperial. These include fully furnished single and shared study bedrooms with communal kitchens, common rooms, bathroom facilities and laundries. There are also a number of single and shared rooms with en suite facilities. All our accommodation is self-catered and non-smoking and are located for easy access to the South Kensington campus. All accommodation has regular security patrols and secure swipe card access. Each hall has its own wardening team who are responsible for student welfare and safety in addition to its own committee so those all-important social events are taken care of.

The Student Accommodation Centre also provides advice and practical support for finding accommodation in the private sector as well as up-to-date listings for available accommodation for rent.

To learn more about accommodation at Imperial visit
www.imperial.ac.uk/accommodation



Extra-curricular activites

As well as being a fantastic place to study, Imperial has a huge number of clubs and societies to help you relax. From football to knitting, rowing to cheese eating, Imperial College Union has it all.

A full list of over 350 clubs can be found at:
www.imperialcollegeunion.org/clubs-and-societies

Within the department, there is a very active Student Chemical Engineering Society who will try their best to provide as many distractions as possible from academic life! The society boasts a calendar of formal dinners, parties, sporting events and many company presentations throughout the year.

Off campus, London is a great place to live as a student with a huge number of things to see and do, many of which are either free or cheap. There is also a good social scene surrounding almost all of the halls of residence with everything from pizza nights to European jaunts being organised on a weekly basis. Overall life at Imperial is busy, fun and rewarding and is a welcome break from lectures whenever you get the chance!

Contribution from the Chemical Engineering Society

Course entry requirements

The courses are intended for able students who are selected on the basis of academic ability and motivation. The first will normally be judged by performance in examinations, and the second will be assessed at an interview, which all applicants attend if they live within reasonable travelling distance, or if they can meet one of our staff at another place.

In terms of A-levels, typical offer requirements include

- A* in Mathematics
- A in Chemistry
- A in one further relevant subject such as Physics or Biology

Applicants with Baccalaureates or the leaving certificates of various national systems are very much welcomed and the eligibility of the latter can be checked with the Admissions Tutor before making a formal UCAS application.

GCSE achievements are also considered, as are also the references provided. Sponsorship is encouraged, and the option of a pre-university year if the applicant wishes, but neither is a pre-requisite of the courses.

For more information, see Imperial's Undergraduate Prospectus:
www.imperial.ac.uk/ugprospectus

You can order a hard copy from:
www.imperial.ac.uk/prospectus

For more information about the courses, requests to visit, etc, please write to

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THE ENVIRONMENT

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www.imperial.ac.uk/chemicalengineering