UNIVERSITY OF CAMBRIDGE

Chemical Engineering and Biotechnology

Chemical Engineering: undergraduate course contents

2019-20

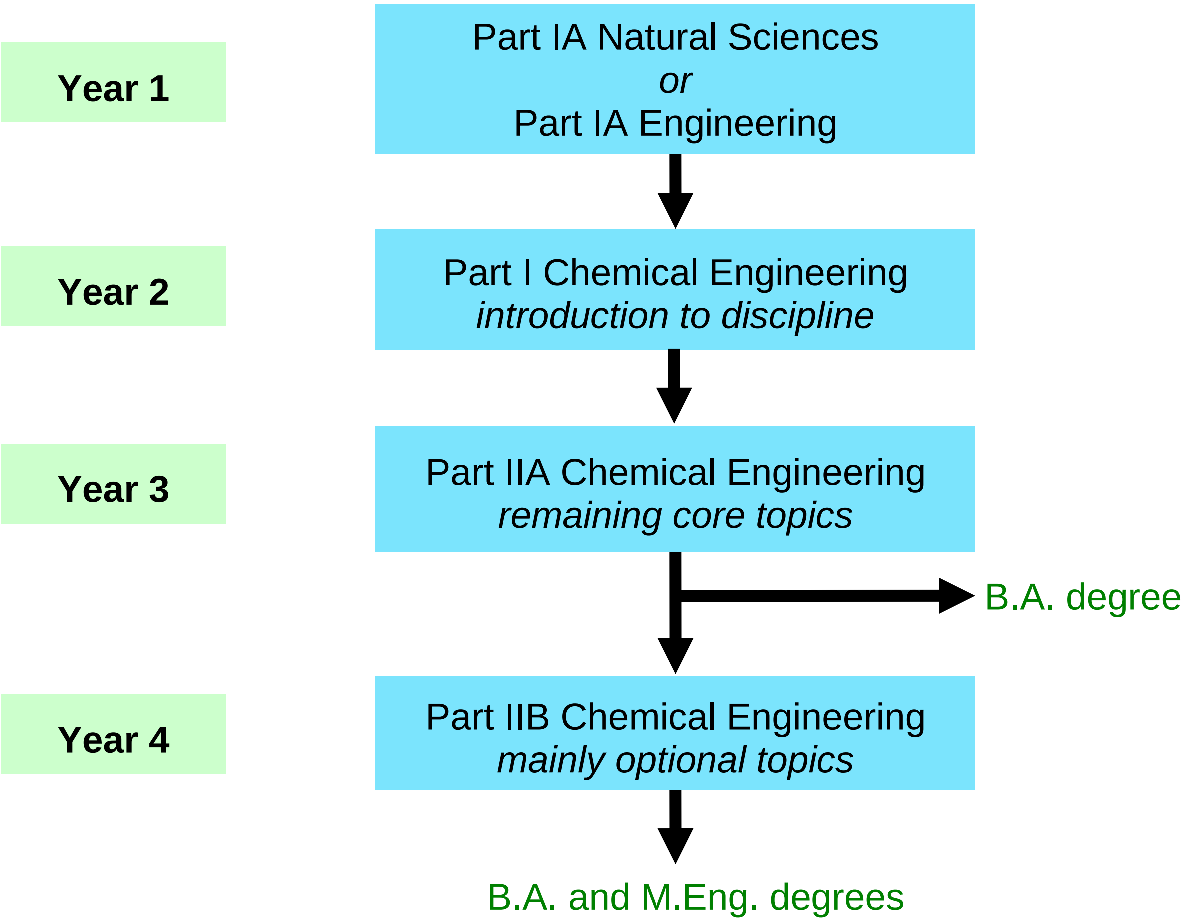
Chemical Engineering course contents

This document gives information on the course structure and contents to potential undergraduate applicants for the Chemical Engineering course at the University of Cambridge. It is designed to supplement the material in the official University prospectus which can be found online at http://www.undergraduate.study.cam.ac.uk/.

Disclaimer: the information in this document is correct at the time of publication. However, the Department reserves the right to change specific details of the syllabus as the course evolves.

Course structure

Chemical Engineering at Cambridge is a four-year undergraduate course leading to the B.A. and M.Eng. degrees. It is possible to graduate after three years with just a B.A. degree. The diagram below shows the course structure while the following pages give information on the topics that are studied.



It is necessary to obtain honours standard in the examinations each year in order to proceed to the following year. Furthermore, it is normally necessary to obtain at least class II.2 honours standard in year 3 in order to proceed to year 4 because this leads to a Masters-level qualification.

Course Contents

You should note that the syllabus can change from year to year as the course evolves.

Year 1 topics

In the first year at University, Chemical Engineers study Part IA Engineering or Part IA Natural Sciences. The material taught in the first year at University is determined by the choice of entry route. Assessment for both routes involves marked laboratory and project work, followed by a series of written examinations at the end of the year.

Engineering route
Those who choose this route read Part IA Engineering, which consists of a series of lectures on the basics of engineering science: Mathematics; Mechanics, Vibrations and Thermodynamics; Structural Mechanics and Materials; Electrical Circuits and Electromagnetics. There are also supporting laboratories, and projects on topics such as design, computing and electronic instrumentation, management and drawing. There is no choice of papers in the Part IA Engineering route.

Natural Sciences route
Those who choose this route study three scientific topics from the following list of available Part IA Natural Sciences subjects: Chemistry, Physics, Materials Science, Biology of Cells, Earth Sciences, Evolution & Behaviour, Physiology of Organisms. To satisfy regulations, Chemical Engineering students need to choose at least one of Chemistry, Physics and Biology of Cells. However, apart from that restriction, the choice is open. Chemical Engineering students taking the Natural Sciences route must also study Mathematics or Mathematical Biology. The experimental science subjects feature supporting laboratories in addition to lectures. The amount of laboratory work is higher than the Engineering route, at up to three sessions each week, but there is less project activity.

Year 2 topics

In the second year, students study Part I Chemical Engineering. It introduces the discipline and covers many of the fundamental principles of chemical engineering. This course is taught full-time in the Department. Although the Part I class is made up of students drawn from Natural Sciences and Engineering, the vast majority of lectures (85%) are given jointly to the two groups. However, those students who did the sciences route receive some dedicated lectures on mechanical engineering, whereas those who did the engineering route receive some dedicated lectures on chemistry.

The topics that are taught in the Chemical Engineering course can be divided into five themes: Fundamentals, Process Operations, Process Systems, Mathematical Methods and Enabling Topics. The topics are examined in four 3 hour papers at the end of the year.

Fundamentals: Fluid Mechanics introduces the basic equations, and shows how to use them in practical applications. Heat & Mass Transfer Fundamentals covers the transfer of heat by conduction, convection and radiation, and the transport of molecules by diffusion and convection. Process Calculations covers the calculation of thermodynamic properties with the aim of answering questions such as 'Is this process possible?' and 'What energy does it require?' It includes mass and energy balances, power and refrigeration cycles, the thermodynamics of mixtures and reaction equilibrium. The course on Biotechnology describes the scientific and engineering background behind this increasingly important area. It covers some fundamental principles of the biology of cells, before going on to discuss microbial growth and the design of bioreactors.

Process Operations: Equilibrium Staged Processes considers the separation of binary mixtures using distillation, solvent extraction, leaching and gas absorption in plate columns. In contrast, the unit on Heat & Mass Transfer Operations looks at heat and mass transfer in co-current and counter-current devices, such as heat exchangers and packed columns. Homogeneous Reactors gives an introduction to chemical reaction engineering by considering the design of single-phase reactors.

Process Systems: The unit on Introductory Chemical Engineering gives some perspective on why the various unit operations are necessary and how they can be put together to form a plant flowsheet. The study of Safety, Health and Environment (SHE) and Economics is an essential part of a chemical engineer's training.

Mathematical Methods: The Engineering Mathematics course teaches the mathematical techniques that are often needed to solve Chemical Engineering problems. The course covers numerical methods for solving equations, and these principles are then tested by a set of practical computer exercises. The course also includes linear algebra, optimisation, differential equations and methods for solving process dynamics problems.

Enabling Topics: Those students entering from the Natural Sciences route are required to take lecture units on Structures, Dynamics, and the Mechanical Properties of Materials. Those students entering from the Engineering route are required to take lecture units on various topics in Chemistry: chemical thermodynamics and reaction kinetics, chemical bonding and inorganic chemistry, organic chemistry, and analytical chemistry. Both groups of students receive lectures on further aspects of mechanical engineering related to construction of process plant equipment.

Coursework: All students must complete a Teaching Laboratory course comprising 8 x 2 hour experiments on fluids mechanics and transport processes. Students also complete 6 classes in which they use computing packages to solve Chemical Engineering problems. Students entering from the Natural Sciences route attend an Engineering Drawing course (4 x 3 hour sessions) and undertake two Engineering Applications practicals, focussing on how particular items of process equipment are designed and constructed, within the Teaching Laboratory course. Students from the Engineering route complete 5 x 2 hour experiments on Physical Chemistry.

Every two or three weeks, students are issued with an engineering problem to tackle. These 'Exercises' or mini-projects require more time to solve than is possible in an examination or a taught class and many require the use of computer tools. Students submit their solutions as a report for assessment. The last exercise is a small design project in which students design an item of process equipment such as a heat exchanger.

A series of workshops is given in the Easter Term in which students are encouraged to develop their abilities in giving oral presentations, working in groups, project planning and team leadership.

Year 3 topics

In the third year, students study Part IIA Chemical Engineering. It completes the study of "core" chemical engineering and is a preparation for immediate professional practice. Students who pass this course are entitled to leave the University with the B.A. degree. (Cambridge offers Bachelor of Arts degrees, even to scientists and engineers, for historical reasons).

Many of the themes introduced in Part I are developed further. For instance, they may be extended to systems in which many chemical species are involved, and there may be time dependency effects. All Part IIA material is "core" chemical engineering, and so the topics in this year are compulsory. The year concludes with a major Design Project.

> **Fundamentals:** The Fluid Mechanics course covers more complicated systems than those described in the Part I course. It includes modelling of turbulent flows, compressible flow, and two-phase flow. The course on Equilibrium Thermodynamics describes phase equilibrium behaviour for mixtures. Radiative Heat Transfer is considered in more detail.
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> **Process Operations:** The Separations course discusses multicomponent mixtures and more advanced forms of continuous separations such as (de-)humidification, membrane separations and adsorption processes are considered. The Heterogeneous Reactors course covers heterogeneous reactors and catalysts, and considers further the effects of non-ideal flows. The unit on Bioprocessing contains coverage of upstream and downstream processing, including the purification of bioproducts. The unit on Particle Processing describes aspects of particle characterisation, separation and flow.
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> **Process Systems:** The unsteady-state behaviour of process systems (and their safe operation) is taught in Process Dynamics and Control. The course on Process Synthesis discusses how a flowsheet is constructed and considers heat integration, namely how to use pinch technology so that available energy on a process plant is used as efficiently as possible.
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> **Enabling Topics:** These include a unit on Corrosion and Materials and some lectures on Process Design to prepare students for the design project. Further mathematical techniques are also taught including Statistics and Partial Differential Equations.
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> **Coursework and Examinations:** There are fortnightly continually assessed exercises in the first two terms. These include 'mini-projects' such as literature surveys and problems that involve significant computational calculations. The examinations take place at the start of the Easter Term.
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> **Design Project:** A full-time Design Project lasting five weeks is undertaken after the examinations. The project involves the conceptual and process design of a modern industrial process, such as a liquefied natural gas storage facility, a sugar refinery or a hydrotreater to meet the sulphur specification of diesel fuel. The project is performed in groups of about five students, and includes all the important aspects of Chemical Engineering design: process flowsheet development, equipment sizing, control, economics, safety and environmental considerations. A major feature of the project is the use of modern IT tools such as process simulators, mathematical tools, drawing packages, and materials databases. Students write reports and give a presentation on their design.

Year 4 topics

Almost all students stay on to study the course in the fourth year at University, termed Part IIB Chemical Engineering. This is an advanced course in chemical engineering that is intended as preparation for a long-term career in the discipline. Students who pass this course are entitled to both the B.A. and M.Eng. degrees. The M.Eng. degree satisfies the academic requirements for full membership of the IChemE leading to Chartered Engineer status.

The Part IIB course gives a deeper understanding of some fundamental subjects, introduces a range of specialist areas of knowledge, and provides an opportunity for studying some broadening material. There are a few compulsory subjects taken by all students, and a wide range of options.

Compulsory Subjects: The Sustainability in Chemical Engineering lectures cover environmental impact, life cycle analysis and consider how sustainability issues can be quantified. The unit entitled Energy Technology shows how chemical engineering principles are important in understanding how energy can be converted efficiently into another useful form. The course covers combustion processes (e.g. power stations and internal combustion engines), renewable energy processes (e.g. wind turbines, hydroelectric systems and solar power), and nuclear energy.

Chemical Product Design: This course considers how new products can be identified and developed. Students undertake projects in teams to propose products that have specific attributes, and then comment on the process route and technology that would be needed to make them.

Research Project: Each Part IIB student undertakes a Research Project, often in collaboration with another student, during the fourth year. The project is an original piece of research that is closely supervised by a member of staff. The projects available reflect the various research activities in the Department. They might involve experimental, theoretical and/or computational work. Some projects support ongoing research activities while others are 'blue sky' investigations leading to new research programmes. Several projects are sponsored by interested companies, or are spin-offs of ongoing investigations. Successful projects sometimes lead to students becoming authors of publications in the scientific literature.

Optional Modules: students are required to be examined on six optional modules. The courses are taught by lecturers who specialise in that particular field of research. The topics taught vary from year to year.
Some of the options are classed as chemical engineering (depth) topics. In recent years, these have included:

- Advanced Transport Processes
- Computational Fluid Dynamics
- Interface Engineering
- Fluid Mechanics and the Environment
- Pharmaceutical Engineering
- Rheology and Processing

Some of the options are classed as chemical engineering (breadth) topics. In recent years, these have included:

- Bionanotechnology
- Biophysics
- Biosensors
- Entrepreneurship
- Foreign Language
- Healthcare Biotechnology
- Optical Microscopy
- Optimisation

Vacation Work

Relevant vacation work is not compulsory in the Chemical Engineering course at Cambridge. However, it is actively encouraged and the Department facilitates placements in the summer vacation between year 3 and year 4. This is when there are the most opportunities for work experience in the process industries. The vast majority of undergraduates who want to get a vacation placement in a relevant industry are able to get one in the summer between year 3 and year 4. A smaller, but still significant, number of Chemical Engineering students are successful in getting vacation placements in industry in earlier years.

Further information

More information on the Chemical Engineering course at Cambridge can be found at:
University prospectus – http://www.undergraduate.study.cam.ac.uk/
Department website – http://www.ceb.cam.ac.uk/

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