Course guide
820523 - EPQ - Chemical Process Engineering

Last modified: 02/03/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 713 - EQ - Department of Chemical Engineering.

Degree: BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: MOISES GRAELLS SOBRE

Others:
Primer quadrimestre:
GONZALO CAMBERO CHAVES - Grup: M11
HANNELIESE FREITES KONDRATOWITSCH - Grup: M11, Grup: M12
MOISES GRAELLS SOBRE - Grup: M12

Segon quadrimestre:
GONZALO CAMBERO CHAVES - Grup: T1
HANNELIESE FREITES KONDRATOWITSCH - Grup: T1

PRIOR SKILLS

Those of the subjects previously planned in the curriculum, with special emphasis on the subjects indicated as requirements.

REQUIREMENTS

OPERACIONS BÀSIQUES II - Prerequisit
SIMULACIÓ I OPTIMITZACIÓ DE PROCESSOS QUÍMICS - Prerequisit

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
2. Analyse, design, simulate and optimise processes and products.
CEQUI-22. Design, manage and run simulation, control and instrumentation procedures in chemical processes.
CEQUI-26. Study the feasibility of a proposed project.
CEQUI-27. Understand spatial vision and graphic representation techniques, whether using traditional metric and descriptive geometry methods or computer assisted design applications.
12. Understand mass and energy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, the design of reactors, and the recovery and processing of raw materials and energy resources.

Generical:
CG-04. (ENG) Capacidad de resolver problemas con iniciativa, toma de decisiones, creatividad, razonamiento crítico y de comunicar y transmitir conocimientos, habilidades y destrezas en el campo de la Ingeniería Industrial.
CG-07. (ENG) Capacidad de analizar y valorar el impacto social y medioambiental de las soluciones técnicas.

Transversal:
14. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
19. ENTREPRENEURSHIP AND INNOVATION - Level 3. Using knowledge and strategic skills to set up and manage projects. Applying systemic solutions to complex problems. Devising and managing innovation in organizations.
22. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 3. Taking social, economic and environmental factors into account in the application of solutions. Undertaking projects that tie in with human development and sustainability.
25. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

TEACHING METHODOLOGY

The course combines expository and practical sessions with an applied approach, focused on problem solving and case analysis. The common thread of teaching is decision-making in the design and operation of chemical processes, through a systematic vision guided by objective functions. The contents are organized into five large blocks, each with a linked task that allows the tools and concepts covered to be put into practice. These activities are solved in a guided way and with the help of technical software such as GAMS, Excel and HYSYS, promoting autonomy and critical thinking. The assessment is complemented by a final project that consolidates the knowledge acquired, and with two written tests that assess the students' understanding and analytical skills. Active participation, case-based learning and the reflective use of calculation and simulation tools are promoted in an industrial context.

LEARNING OBJECTIVES OF THE SUBJECT

General objective:
• Understand and apply in an integrated way the concepts and methods of chemical process engineering, with the capacity to analyze, design, optimize and control complex industrial processes, identifying priority objectives and indicators that measure their performance.
Specific objectives:
• Identify and formulate models of chemical processes and structure them in a hierarchical way.
• Define objective functions and select the most relevant variables according to the technical, economic or environmental context.
• Understand and apply performance indicators (KPIs/KOPs) to evaluate options for improvement.
• Apply basic techniques for process optimization and integration.
• Analyze options for operation and production planning.
• Dynamically simulate the behavior of processes.
• Understand the basic principles of process control and their practical application.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	30,0	20.00
Hours small group	30,0	20.00

Total learning time: 150 h

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CONTENTS

TEMA 0: Introduction

Description:
Introduction to the course and to Process Engineering. Problems of synthesis, design, operation, and control of processes. Practical examples. Need for systematic tools for the analysis and improvement of processes. This introductory session will focus on reflecting on decision-making and the formulation of the optimization problem (definition of the model, identification of the degrees of freedom and decision variables, identification of the constraints and selection of the objective function). We will discuss what is meant by optimization, how it can be achieved from different approaches (technical, economic, environmental...) and how this change of perspective structures the entire course. The organization of the course, the evaluation system and the learning methodology will also be presented.

Specific objectives:
• Understand the general methodology of the course and the assessment approach.
• Understand the need to analyze design, operation and control problems from a systematic and quantitative perspective.
• Understand the practical utility of the optimization-based approach to address technical decision-making problems.

Related activities:
Discussion session and conceptual introduction. There is no assignment associated with this topic.

Full-or-part-time: 5h
Theory classes: 1h
Laboratory classes: 1h
Self study : 3h

TEMA 1: Optimitzation of Continuos Processes

Description:
Definition of the optimization problem: model, variable, parameters, constraints and objective function. Types of problems: LP, MILP, NLP and MINLP. Quantification: economic evaluation, environmental evaluation, other indicators (KPIs).
Application of simulation and optimization techniques to flow planning in linear systems. Simplified models and model granularity. This part will be addressed mainly using tools such as MSExcel and GAMS. Separation systems. Reactor systems. Reaction-separation systems. Synthesis of distillation trains. Application of simulation and optimization techniques to the design of complex systems, such as distillation trains. Heuristics and decision strategies will be worked on to select efficient configurations, assessing options from a technical and economic point of view. The objective is to develop practical criteria for structural decision-making. This part will be addressed mainly using tools such as AspenHYSYS, AspenPlus and UniSim.

Specific objectives:
• Solve flow planning problems using simplified linear (LP) models.
• Simulate and analyze distillation trains in different configurations.
• Apply heuristics and strategic criteria to make design decisions.
• Evaluate the technical and economic effects of alternatives.

Related activities:
• Simulation and optimization exercises using tools such as AspenHYSYS, AspenPlus, UniSim, GAMS and Excel.
• Submission of an assignment related to the topic.

Full-or-part-time: 25h
Theory classes: 4h
Laboratory classes: 4h
Guided activities: 2h
Self study : 15h

TEMA 2: Integration of Continuous Processes

Description:
Introduction to the concepts and methods of process integration, especially energy integration and the integration of utilities in industrial processes. Presentation of the fundamentals of Pinch analysis, determination of thermodynamic limits and identification of minimum heating and cooling requirements (targeting). Principles of heat exchanger network design, as well as the evaluation of the costs associated with different integration strategies. Discussion of the optimization problem, advantages and limitations of rigorous procedures with respect to heuristic methods.

Specific objectives:
• Analyze energy integration opportunities using Pinch analysis.
• Evaluate different integration options economically.

Related activities:
• Exercises to determine the minimum heating and cooling requirements.
• Exercises to design heat networks with Excel support.
• Submission of an assignment related to the topic.

Full-or-part-time: 25h
Theory classes: 4h
Laboratory classes: 4h
Guided activities: 2h
Self study : 15h

TEMA 3: Optimization of Batch and Semi-continuos Processes

Description:
Introduction to semi-continuous processes. Production lines. Simplified allocation and timing models (LP). Non-productive operations (set-up, cleaning, etc.) and MILP models. Introduction to discontinuous processes (batch). Concepts of batch process operations: cycle time, batch size, parallel operation (in-phase and out-of-phase), storage needs. Operations scheduling in multi-product plants (MILP).

Specific objectives:
• Formulate and solve simplified production planning problems in semi-continuous lines.
• Formulate and solve simplified production planning problems in multi-product plants.

Related activities:
• Formulation of LP and MILP optimization problems.
• Solving LP and MILP optimization problems using Excel and GAMS.
• Submission of an assignment related to the topic.

Full-or-part-time: 25h
Theory classes: 4h
Laboratory classes: 4h
Guided activities: 2h
Self study : 15h

TEMA 4: Dynamic Process Simulation

Description:
Review and extension of steady-state process simulation concepts. Logical operations such as Adjust, Set and Recycle. Introduction to dynamic simulation. Time and capacity (holdup). Valves. Flow-driven and Pressure-driven modes. Integration and simulation time. Disturbances. Valve design.

Specific objectives:
• Transform stationary simulations in AspenHYSYS into dynamic simulations.
• Run dynamic simulations and analyze and compare transient behaviors.

Related activities:
• Dynamic simulation exercises in AspenHYSYS.
• Assignment submission linked to the topic.

Full-or-part-time: 35h
Theory classes: 6h
Laboratory classes: 6h
Guided activities: 2h
Self study : 21h

TEMA 5: Process Control

Description:
Fundamentals of process control: controllers, open and closed loops, types of action, capacitance and dead time. Controller tuning. Control applied to distillation columns. Safety systems: protection of equipment and operations.

Specific objectives:
• Introduce controllers in dynamic simulations in AspenHYSYS.
• Adjust controllers and compare and analyze different control actions and strategies.

Related activities:
• Process control exercises using AspenHYSYS.
• Assignment submission linked to the topic.

Full-or-part-time: 35h
Theory classes: 6h
Laboratory classes: 2h
Guided activities: 21h
Self study : 6h

GRADING SYSTEM

• Individual exercises: 17%
• Team project: 25%
• Midterm exam: 29% (during class time)
• Final exam: 29% (on the date scheduled by Academic Management)
• There is no re-evaluation exam.

EXAMINATION RULES.

Exams will be carried out individually in the computer room. They will consist of the elaboration of solutions to a proposal for simulation and/or optimization, total or partial, of a process and must be presented in digital format and delivered through ATENEA within the time period predetermined by the teaching staff.

BIBLIOGRAPHY

Basic:

- Seider, Warren D. Product and process design principles : synthesis, analysis, and evaluation. 4rd ed. Hoboken: John Wiley & Sons, cop. 2017. ISBN 9781119588009.
- Smith, Robin. Chemical process design and integration. Chichester, UK: John Wiley & Sons, cop. 2005. ISBN 0471486817.
- Biegler, Lorenz T.; Grossmann, Ignacio E.; Westerberg, Arthur W. Systematic methods of chemical process design. Upper Saddle River (New Jersey): Prentice Hall PTR, cop. 1997. ISBN 0134924223.
- Altmann, Wolfgang. Practical process control for engineers and technicians [on line]. Amsterdam: Elsevier, 2005 [Consultation: 14/07/2025]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780750664004/practical-process-control-for-engineers-and-technicians. ISBN 9786611009458.
- Svrcek, William Y.; Mahoney, Donald P.; Young, Brent R. A Real-time approach to process control [on line]. Third edition. Chichester [etc.]: John Wiley & sons, 2014 [Consultation: 14/07/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4037756. ISBN 9781119993872.
- Peters, Max Stone; Timmerhaus, Klaus D; West, Ronald E. Plant design and economics for chemical engineers. 5th ed. New York [etc.]: McGraw-Hill International Book, cop. 2003. ISBN 9780071240444.
- Edgar, Thomas F.; Himmelblau, David Mautner; Lasdon, Leon S. Optimization of chemical processes. 2nd ed. Boston [etc.]: McGraw-Hill, cop. 2001. ISBN 0070393591.

Complementary:

- Douglas, James M. Conceptual design of chemical processes. New York [etc.]: McGraw-Hill, cop. 1988. ISBN 0070177627.
- CAPE : computer aided process and product engineering. Weinheim: Wiley-VCH, cop. 2006. ISBN 9783527308040.

RESOURCES

Other resources:

Copies of the slides used in the lectures and other materials distributed through the course intranet. Calculation and process simulation software available in the computer rooms of the EEBE.