Academic Year 2026/2027

Course Guide:

Process Engineering

FACULTY OF CHEMICAL SCIENCES

1. IDENTIFICATION

Degree Program	Bachelor's Degree in Chemical Engineering.			Course Code	801551
Course Name	Process Engineering			ECTS	12
Subject Area	Chemical Production Engineering				
Module	Chemical Technology				
Course Type	Compulsory	Year	Third Year	Semester	Full-year
Department	Chemical Engineering and Materials				

Lecturers in Charge

Activity	Lecturer	Email	Office
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Laboratory Instructors

Activity	Lecturer	Email	Office
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2. OBJECTIVES

General Objective

The aim of this course is for the student to acquire knowledge of the manufacturing processes of the most representative products of the Chemical Industry and their environmental, economic, safety, and health integration.

Specific Objectives

- Be able to analyze the components of a chemical process from thermodynamic, kinetic, and operational perspectives, and establish their optimal integration.
- Develop selection criteria for raw materials and auxiliary materials.
- Understand the utility and techno-economic characteristics of chemical products.

3. PRIOR KNOWLEDGE AND RECOMMENDATIONS

Satisfactory completion of this course requires the student to have previously acquired the knowledge and competences corresponding to the following courses: Physics, Fundamentals of Chemical Engineering, Basic Chemistry, Applied Computing, Mathematics I, Mathematics II, Fluid Mechanics, Organic Chemistry, and Applied Thermodynamics.

It is recommended that the student has a basic level of English that allows them to handle English-language references, conduct information searches, and communicate in writing and orally in that language. Furthermore, it is recommended that the student be familiar with computing tools and software for solving complex problems, as well as applications for drafting, editing, and presenting technical reports.

4. CONTENTS

Brief Description of the contents

- Introduction to the process industry: chemical, biotechnological, food processing, and related industrial processes.
- Thermodynamic cycles and cryogenic processes for the liquefaction and separation of industrial gases.
- Electrochemical processes, industrial electrolysis, fuel cells, electrodeposition, and membrane-based processes.
- Inorganic process industry.
- Processes and products derived from petroleum and natural gas. Petrochemistry and fine chemicals. Coal characterization and technological conversion processes.
- Synthesis gas-based processes and advanced combustion processes.
- Biomass-based processes. Biorefinery.

Course Syllabus

As a general guideline, the environmental and economic aspects of all processes will be considered throughout the course. Case studies related to safety in chemical plants, using good practice codes, will be addressed. The course integrates the principles of green chemistry to design safer, more efficient, and sustainable industrial processes.

Topic 1

The chemical industry. Classification, development, and key indicators. Industrial processes in different sectors. Auxiliary utilities and services in industrial processes.

Topic 2.

Industrial gas separation processes. Thermodynamic refrigeration cycles. Gas condensation. Cryogenic gas liquefaction processes. Gas separation by membrane technologies. Selective gas absorption. Pressure swing adsorption (PSA) processes.

Topic 3.

The inorganic process industry. Cement and hydraulic binders. Glass. Fertilizers. Acids. Alkalis. Mineral salts. Environmental aspects.

Topic 4.

Coal. Extraction, conditioning, and distribution of coal. Technological conversion processes: coking, gasification, and hydrogenation. Clean coal combustion. Environmental aspects.

Topic 5.

Processes and products derived from natural gas. Extraction, conditioning, and distribution of natural gas. Natural gas chemistry. Use of natural gas as a fuel. Hydrogen. Hydrogen production processes. Hydrogen as an energy carrier. Fuel cells. Hydrogen economy. Environmental aspects.

Topic 6.

Processes and products derived from petroleum. Extraction, conditioning, and distribution of crude oil. Petroleum refining. Separation, conversion, and finishing operations. Petroleum fractionation products as fuels. Environmental aspects.

Topic 7.

Petrochemistry. Production of olefins and BTEX compounds. Hydrocarbon cracking. Utilization of intermediate derivatives. Polymers and their chemistry. Environmental aspects.

Topic 8.

Biomass utilization. The biorefinery concept. Thermochemical and biological valorization. Pulp and paper industry. Biofuels. Environmental aspects.

LABORATORY SESSIONS

- Electrochemical processes.
- Conversion processes of inorganic raw materials.
- Study of the properties of petroleum and its products and their relationship with conversion and refining processes.
- Characterization and properties of pulp suspensions and their relationship with pulp and paper manufacturing processes.
- Case studies of industries based on biomass valorization.

5. COMPETENCES

General

CG1-TQ1	Use concepts for the autonomous learning of new methods and theories.
CG4	Solve problems in the field of chemical engineering with initiative, decision-making ability, and critical thinking.
CG5	Perform calculations, measurements, assessments, expert evaluations, studies, and reports in the field of chemical engineering.
CG4-TQ1	Apply concepts of biotechnology, mass transfer, separation operations, and chemical reaction engineering. Evaluate the transformation of raw materials and energy resources.
CG5-TQ1	Analyze, design, simulate, and optimize processes and products.

Specific

CE20-IP1	Identify the fields of application of Chemical Engineering and its relationship with the Chemical Industry, raw materials, energy sources, and their environmental impacts.
CE20-IP3	Describe the operations and processes representative of the Chemical Industry.
CE21-IP2	Describe the Chemical Industry and the manufacturing processes of its most representative products, and their environmental, economic, safety, and health integration.
CE21-IP3	Develop criteria for selecting raw and auxiliary materials.
CE21-IP4	Recognize the practical and techno-economic characteristics of chemical products.

Cross-cutting

CT1-TQ1	Develop analytical and synthetic skills.
CT2-TQ1	Solve problems in the area of Chemical Technology.
CT4-TQ1	Communicate in Spanish using standard audiovisual media.
CT5-TQ1	Consult, use, and analyze bibliographic sources in the field of Chemical Technology.
CT5-TQ2	Consult, use, and analyze specialized databases and online resources.
CT6-TQ1	Use computer tools and programs to for calculate, simulate, and approximate.
CT8-TQ1	Demonstrate capacity for critical and self-critical reasoning.
CT11-TQ1	Learn autonomously.

6. WORKLOAD DISTRIBUTION BY ACTIVITY.

Activity	In-class (hours)	Self-study (hours)	Credits
Lectures	70	85	6,2
Seminars	20	35	2,2
Tutorials/guided work	4	6	0,4
Laboratory sessions	30	22.5	2.1
Preparation of Course work and Exams	8	19.5	1.1
Total	**132**	**168**	**12**

7. METHODOLOGY

The instructional practice will follow a mixed methodology based on cooperative learning, , and self-directed learning. This methodology will be implemented through:

1.- **Lectures**: will consist primarily of sessions in which the theoretical content of the course syllabus will be presented. Audiovisual material developed specifically for each topic will be used regularly.

2.- **Seminars**: will involve the comprehensive and detailed solution of a set of selected problems. Python and Excel will be used in the development of some problems. In addition, practical case studies of optimization operations in industrial plants will be examined, with a focus on maximizing the economic benefits of the process.

3.- **Laboratory sessions**: will consist of the experimental study of different processes and the determination of properties and characterization of various products. Upon completion of each laboratory session, the group will prepare a technical report on the experimental work carried out. Some of these activities will be conducted in English. The necessary calculations will be performed using scientific software (Matlab, Excel, Origin, Aspen Properties, and Solkane). Before attending the first laboratory session of the course, students must confirm in writing that they have read, understood, and accepted the laboratory safety regulations.

4.- **Guided tutorials**: will be conducted on an individual basis and will serve to support and monitor the progress of each student's personal work. Case studies related to cutting-edge topics, including safety in chemical plants, will be addressed. Part of this activity will be conducted in English.

The UCM Virtual Learning Environment (Campus Virtual) will be used to ensure smooth communication between instructors and students, and as a tool to make available to students the materials to be used in lectures, seminars, and laboratory sessions. Part of the recommended bibliography and support materials deposited on the virtual campus for the development of the teaching activities of this course will be in English.

8. BIBLIOGRAPHY

Basic

- Vian Ortuño, A.: "*Introducción a la Química Industrial*"; 2ª Edición, Ed. Reverté S.A., Barcelona, 1998.
- Refino de petróleo, gas natural y petroquímica; Fundación Fomento Innovación Industrial. Madrid, 1997.
- Perrin, R. y Scharff: "*Chimie Industrielle 1*"; Masson. Madrid, 1993.
- Turton, R. et al.: "*Analysis, synthesis and design of chemical processes*"; 4ª Edición. Pearson Education International. NJ 2013.
- Fahim, M. et al.: "*Fundamental of petroleum refining*". Elsevier. Amsterdam, 2010.
- Miranda, R (Editor), "*Ingeniería de Procesos*". Dextra, 2020.
- Kuila, A.; Mukhopadhyay, M. "*Biorefinery Production Technologies for Chemicals and Energy*"; John Wiley & Sons, Incorporated: Newark, 2020.
- Alfares, H.K. *Applied Optimization in the Petroleum Industry*. Springer, 2023.

Complementary

- Elvers, Barbara; Hawkins, Stephen y Russey, William: "*Ullmann's Encyclopedia of Industrial Chemistry*"; 5ª ed., Ed. Weinheim, 1996.
- Kirk-Othmer: "*Encyclopedia of Chemical Technology*"; 5ª ed., John Wiley & Son; 2006.

9. EVALUATION

The final course grade will be calculated as the weighted average of the different assessable activities. However, to pass the course, students must obtain the minimum grade established for each activity. If this requirement is not met, the final grade will be the weighted average, capped at 4.5 out of 10. This criterion shall apply to both the ordinary and extraordinary assessment periods.

❖ WRITTEN EXAMS: 70%

The knowledge and competences acquired will be assessed through two written partial examinations covering both theoretical questions and practical case studies and numerical problems. Likewise, a final examination will be held in the June and July examination sessions covering the complete course syllabus. In each examination, the theoretical part will account for 60% of the grade, while the practical part will account for the remaining 40%. The latter will include the assessment of problems requiring the use of computing tools. In order to pass each examination, a minimum grade of 4.0 out of 10 must be achieved in each part (theoretical and practical) of all examinations taken.

Students who pass or compensate both partial examinations, with a minimum grade of 4.0 out of 10 in each and an average equal to or greater than 5.0 out of 10, will not be required to sit the final examination. Otherwise, they must sit the final examination covering the complete course syllabus.

❖ SELF-WORK AND GUIDED ACTIVITIES: 10%

The assessment of the individual learning work carried out by the student during the scheduled tutorials will account for 10% of the final grade. Activities conducted in English will also be assessed.

❖ LABORATORY SESSIONS: 20%

The assessment of the laboratory sessions will be based on the technical reports, prepared in groups, derived from the experimental results and their interpretation, as well as from responses to the questions posed during the laboratory sessions. In addition to the corresponding report, the scientific calculation programs/files developed by the student in the preparation of results must be submitted. In order to pass the laboratory component, attendance at all experimental sessions, laboratory seminars, and submission of the laboratory notebooks is mandatory. A minimum average grade of 5 out of 10 is required between the grades for the technical reports (10%) and the laboratory examination (10%), with a minimum of 3 in each of them, which together represent 20% of the final grade. Activities conducted in English will also be assessed.

Students who have completed the laboratory sessions in previous academic years may request exemption from repeating them, provided that no more than 3 years have elapsed since they completed those sessions and that they received a grade above five.

❖ ATTENDANCE AND ACTIVE PARTICIPATION:

In order to pass the course, students must have participated in at least 70% of the contact teaching activities. Attendance at guided tutorials and laboratory sessions is 100% mandatory.

The grades for the activities planned for the assessment of the course (partial examinations, laboratory sessions, tutorials, submission of problems...) will be communicated to students with sufficient notice before the final examination, so that they can adequately plan their study of this and other courses. In particular, the grades for the partial examinations will be communicated within a maximum period of 20 days, except in the case of the second partial examination, where the period may be shorter in order to adapt to the final examination. In any case, a minimum period of seven days between the publication of grades and the date of the final examination of the course will be observed.

ACTIVITY SCHEDULE

UNIT	ACTIVITY	HOURS	GROUPS	START	END
Topic 1. The chemical industry	Lectures	2	1	Week 1	Week 1
Topic 2. Industrial gas separation processes	Lectures	6	1	Week 1	Week 4
	Seminars	5	2		
Topic 3. Inorganic process industry	Lectures	12	1	Week 5	Week 10
	Seminars	5	2		
Topic 4. Coal	Lectures	6	1	Week 10	Week 13
	Seminars	2	1		
Topic 5. Processes and products derived from natural gas	Lectures	10	1	Week 13	Week 17
	Seminars	3	2		
Topic 6. Processes and products derived from petroleum	Lectures	14	1	Week 18	Week 22
	Seminars	5	2		
Topic 7. Petrochemistry	Lectures	12	1	Week 23	Week 26
Topic 8. Biomass utilization. Biorefinery.	Lectures	8	1	Week 27	Week 30
	Seminars	1	2		
Laboratory sessions	Data collection	15	2	Week 2	Week 28
	Calculation	15	2		
Scheduled tutorials	Tutorial 1*	1	4	Week 4	Week 7
	Tutorial 2*	1	4	Week 9	Week 12
	Tutorial 3*	1	4	Week 19	Week 22
	Tutorial 4*	1	4	Week 26	Week 28

* The scheduled tutorials are subject to possible modifications according to the joint course planning.

SUMMARY OF ACTIVITIES

ACTIVITY	ASSOCIATED COMPETENCES	TEACHING ACTIVITY	STUDENT ACTIVITY	EVALUATION	P	NP	TOTAL	C
Lectures	CG1-TQ1, CG4-TQ1, CG5-TQ1 CE20-IP1, CE20-IP3, CE21-IP2, CE21-IP3, CE21-IP4	Presentation of theoretical concepts	Note-taking and active participation	Mandatory attendance at 70% of contact hours	70	85	155	
Seminars	CG4 CT2-TQ1	Application of theory to the solution of exercises and problems	Note-taking. Problem-solving. Use of computing tools (Excel, Python). Formulation of questions and doubts.	Assessment of written responses (approach and result) to practical exercises and numerical problems will be assessed in the course examination.	20	35	55	
Laboratory	CG5 CT5-TQ1, CT5-TQ2, CT11-TQ1	Presentation of theoretical concepts and the methods required to carry out the experiments. Supervision of the student during experimental work. Grading of technical reports. Assessment of the student	Completion of experimental work and preparation of technical reports. Use of scientific software (Matlab, Excel, Origin, Aspen Properties, and Solkane).	Assessment of technical reports prepared in groups based on the experimental work carried out in the laboratory	30	22.5	52.5	**20%**
Tutorials	CT1-TQ1, CT8-TQ1, CT4-TQ1, CT5-TQ1, CT5-TQ2	Guiding the student in directing their study and group work, providing explanations and bibliographic recommendations. Grading and evaluating the work completed by the student.	Consultation with the instructor regarding conceptual and methodological difficulties encountered while studying the subject matter. Completion of the group work assigned by the instructor.	Assessment of work	4	6	10	**10%**
Examinations	CT1-TQ1, CT8-TQ1	Design, supervision, and grading of examinations for both the theoretical and practical components. Assessment of the student.	Preparation and completion of examinations covering the theoretical content and seminars.		8	19.5	27.5	**70%**

P: On-site activities **NP:** Independent activities (independent study) **C:** Grade