Academic Year 2026/2027

Course Guide:

PROCESS SIMULATION AND CONTROL

FACULTY OF CHEMICAL SCIENCES

1. IDENTIFICATION

Degree Program	Bachelor's Degree in Chemical Engineering	Course Code	801548
Course	Process Simulation and Control	ECTS	9
Subject	Chemical Production Engineering		
Module	Chemical Technology		
Course Type	Compulsory	Year: Third Year	Semester: Second
Departamento responsable	Chemical Engineering and Materials		

Lecturers in Charge

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2. OBJETIVES

General Objective

The main objective of simulation is the description and utilization of a fundamental tool for the chemical engineer: process simulation. On the other hand, the objective of control is to provide the student with an extensive and deep knowledge of the fundamentals of automatic control systems and industrial instrumentation.

Specific Objectives

- To know the fundamentals of chemical process simulation software.
- To learn to use ASPEN PLUS.
- To design and optimize chemical industry processes in the presence of uncertainty.
- To understand and master the mathematical tools used in the description of open-loop and closed-loop process dynamics.
- To understand and master the mechanisms and basic operating principles of instrumentation and the basic characteristics of standard signals used in analog and digital control systems.
- To know how to design control circuits, actions, and loops with the most appropriate response and stability specifications.

3. PRIOR KNOWLEDGE AND RECOMENDATIONS

Prior knowledge

Basic concepts of computing (handling of Windows, Word, PowerPoint) and mathematics (differential equations, Laplace transforms).

Recomendations

It is recommended to have taken the courses Foundations of Chemical Engineering, Applied Thermodynamics, and Fluid Mechanics, as well as to be currently taking the third-year courses Separation Operations and Chemical Reaction Engineering.

It is recommended that the student be familiar with computer tools and software for solving complex problems.

It is recommended that the student have a basic level of English that allows them to handle English bibliography and conduct information searches.

4. CONTENTS

Brief Description

Time domain. Laplace domain. Frequency domain. Specifications and standards. Terminology. P&ID diagrams. Analog and digital instrumentation. Virtual instrumentation. MATLAB-SIMULINK environment. Temperature, pressure, flow, and level meters. Industrial analysis. Control. Automation levels. Open-loop and closed-loop. Control actions. Final element. Tuning and stability. Applications to pressure and temperature control with commercial computer software. Models. Process simulation through software. Optimization.

Course Syllabus

BLOCK 1. PROCESS SIMULATION

Unit 1. Introduction to Strategy and Process Simulation

Basic concepts. Applications of process simulation in the chemical industry. Models. Mathematical models. Systems. Construction of mathematical models. Commercial simulators. Simulator architecture. Steady-state and dynamic simulation.

Unit 2. Process Simulation in steady state.

Development of the process flow diagram for the simulation. Model-operation relationship. Unit systems. Components. Types of components. Thermodynamic systems. Methods for estimating LV and LL equilibrium. Degrees of freedom and design specifications. Types of problems related to process simulation. Sequential and parallel simulators.

Unit 3. The sequential modular strategy for simulating steady-state processes

Iterative methods in sequential simulations. Problem-solving with recycling and design specifications. Shear stresses. Termination criteria for iterative processes. Advantages and disadvantages of modular sequential solving. Methods for updating hypotheses (direct, over-relaxation, Wegstein, Newton and Broyden).

Unit 4. Process Simulation in steady state using ASPEN PLUS software

Key features of the ASPEN PLUS commercial software package. Use of the graphical interface. Requirements for carrying out a process simulation. Unit operation models. Estimation of physical properties. Types of variables. Sensitivity analysis of variables. Design specifications.

BLOCK 2: CONTROL PROCESS

Unit 5. Dynamics: Time Domain

System dynamics. First-order linear system. Second-order linear systems. Non-linear systems and linearization.

Unit 6. Laplace and Frequency Domains

Laplace transform. Transfer functions. Block diagrams. Block diagram algebra. Frequency response. Bode *diagrams*.

Unit 7. Control loops

Control actions. Final control element. Feedback and feedforward loops. Absolute and relative stability. Applications to operations and processes.

Unit 8. Instrumentation

Specifications, standards. Analog instrumentation. Digital instrumentation. Meters, transmitters, controllers, actuators, and industrial instrumentation.

5. COMPETENCES

General

CG1-TQ1	Use concepts for the autonomous learning of new methods and theories.
CG5-TQ1	Analyse, design, simulate and optimise processes and products.

Specific

CE19-IP1	Perform macroscopic material and energy balances.
CE21-IP1	Analyse the components of a chemical process from the relevant thermodynamic, kinetic and operational perspectives and establish their optimal integration.
CE23-IP1	Know how to formulate and optimise models that enable process simulation.
CE23-IP2	Use commercial simulation programs in Chemical Engineering.
CE23-IP3	Use the mathematical tools employed in open-loop and closed-loop dynamic control.
CE23-IP4	Define, recognise and compare the accuracy and sensitivity of industrial measurement instruments.
CE23-IP5	Use commercial supervisory (SCADA) and instrumentation and control packages, and interpret and define specifications, block diagrams and P&ID diagrams

Transversal

CT1-TQ1	Develop capacity for analysis and synthesis.
CT2-TQ1	Solve problems in the area of Chemical Technology.
CT6-TQ1	Use computer tools and programs to calculate, simulate, and approximate.
CT8-TQ1	Demonstrate capacity for critical and self-critical reasoning.

6. WORKLOAD DISTRIBUTION BY ACTIVITY

Activity	In class (hours)	Self-study (hours)	Credits
Theory classes	42	63	4,2
Seminars	18	27	1,8
Laboratory	30	22,5	2,1
Tutorials	3	4,5	0,3
Preparation of Course work and Exams	6	9	0,6
Total	99	126	9

7. METHODOLOGY

The lecture time of the course is divided into theoretical classes, seminars, laboratories, and tutorials.

The theoretical classes held in the classroom will be taught to a single group, and those held in the computer room will be taught to two groups. They will mostly consist of lectures in which general theoretical knowledge on process simulation and control will be presented. Through this methodology, it is proposed to develop the following competencies in the student: CG1-TQ1, CE21-IP1, CE23-IP2, CE23-IP3, CE23-IP4, and CE23-IP5.

The seminar classes will be taught in two groups. In the process control block, these classes will address both the resolution of previously proposed problems and some complementary and eminently practical topics; Excel and Origin will be used to solve some of these problems. In the simulation block, they will be held in computer rooms. The necessary calculations will be carried out using scientific software (Excel, Origin, and Matlab). Furthermore, these classes will explain the use of the ASPEN PLUS program and mathematical tools used in control, focusing on the elements required to solve the practical cases assigned to the students. Through this methodology, it is proposed to develop the following competencies in the student: CG5-TQ1, CE19-IP1, CE23-IP2, CE23-IP5, CT1-TQ1, CT2-TQ1, CT6-TQ1, and CT8-TQ1.

In the laboratory of the process simulation part, students will solve different practical cases with ASPEN PLUS under the guidance of the professor. In the laboratory of the control part, students will also complete a control practical (pressure and temperature) equipped with SCADA and using LabVIEW. Excel and Origin will be used to write the report. Through this methodology, it is proposed to develop the following competencies in the student: CE23-IP2, CE23-IP4, CE23-IP5, CT1-TQ1, CT6-TQ1, CT8-TQ1.

In the tutorials, students' progress will be supervised, resolving their doubts about what has been learned in the theoretical classes and about the resolution of the proposed practical cases. Through this methodology, it is proposed to develop the competency CT8-TQ1 in the student. The Virtual Campus will be used as a tool to make the material to be used in the theoretical and practical classes available to the students, and as a means of communication between the professor and the students.

Part of the recommended bibliography and support material deposited on the virtual campus for the development of the teaching activities of this subject will be in English. The help system of the ASPEN PLUS program is entirely in English.

8. BIBLIOGRAPHY

Basic

- ASPEN PLUS, “*Manuales de usuario del programa*”.
- OLLERO DE CASTRO, P., “*Control e Instrumentación de los procesos químicos*”. Ed Síntesis, 2006.
- LUYBEN, W. L., “*Process Modelling, Simulation, and Control for Chemical Engineers*”, 2nd ed., McGraw-Hill, 1990.
- OGATA, K., “*Ingeniería de Control Moderna*”, 5° ed., Prentice Hall, 2010.

Complementary

- RAMIREZ, W.F., "*Computational Methods for Process Simulation*", Butterworths, 1989.
- EIDER, WARREN D.; SEADER, J.D. y LEWIN, DANIEL R., "*Process Design Principles. Synthesis, Analysis and Evaluation*", John Wiley & Sons, Inc. New York, 1999.
- ALEXANDRE C. DIMIAN, "*Integrated Design and Simulation of Chemical Processes*", Elsevier, 2003.
- CREUS, A., "*Instrumentación Industrial*", Marcombo-Boixareu, 1993.
- OGATA, K., "*Sistemas de Control en Tiempo Discreto*", 2ª ed., Prentice Hall, 1996.
- ACEDO, J., "*Instrumentación y control avanzado de procesos*", Díaz de Santos, 2006.
- MIRANDA, R (Editor), "*Ingeniería de Procesos*". Dextra, 2020.
- SEBORG D.E., EDGAR T.F., MELLICHAMP D.A., DOYLE F.J., "*Process Dynamics and Control*", Wiley 2016.

9. EVALUATION

The evaluation of student performance and the competencies acquired in the subject will be carried out through a global evaluation, which will consider on one hand the exams taken and on the other hand the directed activities and personal work carried out by the student. In order to undergo the global evaluation of the subject, the student must have participated in at least 70% of the in-person classroom activities (theory, seminars, and tutorials). Attendance at all laboratory sessions is mandatory.

Academic performance and the final grade will be the result of the grades obtained in the Process Simulation Block (45%) and in the Process Control Block (55%), weighted as follows in each of the blocks:

Process Simulation		
	Exams:	30%
	Guided Activities:	35%
	Laboratory Sessions:	35%
Process Control		
	Exams:	70%
	Guided Activities:	15%
	Laboratory Sessions:	15%

The grades of the activities planned for the subject evaluation (midterm exams, laboratories, tutorials, problem assignments) will be communicated to the students with sufficient notice before the final exam, so they can properly plan their study for this or other subjects.

In particular, the grades of the midterm exams will be communicated within a maximum period of 20 days, except for the second midterm, where the period may be shorter to adapt to the final exam. In any case, the minimum period of seven days between the publication of the grades and the date of the final exam of the subject will be respected, although it could be altered depending on the annual planning of the third-year laboratories.

The final grade will result from the weighted average of the evaluable activities. However, to pass the subject, it will be necessary to achieve the minimum grade established in each of them. If this requirement is not met, the final grade will be the weighted average obtained, with a maximum of 4.5 out of 10..

❖ WRITTEN EXAMS: 52%

The evaluation of the competencies acquired in the subject (CG1-TQ1, CE21-IP1, CE23-IP2, CE23-IP3, CE23-IP4, and CE23-IP5) will be carried out through two written midterm exams, as well as a final exam, in the ordinary (June) and/or extraordinary (July) examination sessions. The exams for the Process Simulation Block will consist of a set of open-ended questions or direct applications of theory and numerical problems. The exams for the Process Control Block will consist of theoretical-practical questions.

The first midterm, which is mainly practical in nature, corresponds to the Process Simulation Block and will be taken halfway through the semester. The second midterm corresponds to the Process Control Block and will be taken once the semester has ended. In the midterm exam of the Process Control Block, it is necessary to obtain a minimum grade of 4 out of 10 to avoid having to take the final exam.

The final exam consists of two parts: Process Simulation (Part 1) and Process Control (Part 2). In Part 1, it will be necessary to obtain a minimum score of 4.0 points out of 10.0, and in Part 2, a minimum score of 5.0 points out of 10.0. This same criterion will be maintained for the extraordinary examination session.

or those students who have obtained a grade equal to or higher than five in the first midterm exam (Simulation), this grade will be saved for the Simulation part in both the ordinary and extraordinary exams, and they will not need to take that part in those exams. The grade obtained in the midterm exams or, where applicable, in the final exam, will represent 52% of the global evaluation. To pass the subject, students must obtain a minimum grade of four in each block (Process Simulation and Process Control), according to the percentages in the Table presented at the beginning of this section, and a block average grade equal to or higher than 5.

❖ ACTIVITIES GUIDED AND SEMINAR PARTICIPATION: 24%

The evaluation of the assigned tasks will show the degree of attainment of the competencies CG5-TQ1, CE19-IP1, CE23-IP2, CE23-IP5, CT1-TQ1, CT2-TQ1, CT6-TQ1, and CT8-TQ1. For the extraordinary examination session, the grade from the assigned tasks will be maintained.

Students must submit, according to deadlines set at the beginning of the course, the resolution of some of the problems from the collection and will also complete two short written tests in the Process Control Block to measure the degree of attainment of competencies and skills in performing the exercise—from the problem specifications to the obtained results—in both the Simulation block and the Process Control block.

Once this grade is obtained, it will be maintained across all examination sessions for both parts.

❖ LABORATORY: from an assigned task 24%

With the aim of promoting cooperative learning, small groups will be organized.

Attendance at all laboratory sessions is mandatory. Evaluation in the ordinary examination session will take into account the student's aptitude and attitude during the practical sessions, their responses to specific questions posed by the professor, and the quality of the written report submitted by the working group regarding the resolution of the practical case and the laboratory practical.

This report must be submitted to the course professors for evaluation. Students must also turn in the scientific calculation files and programs they developed to generate their results. Furthermore, students will complete a group project on a practical control case within a more general chemical industry context; the conditions and schedule for this project will be published on the Virtual Campus.

This evaluation will determine the degree of attainment of the competencies CE23-IP2, CE23-IP4, CE23-IP5, CT1-TQ1, CT6-TQ1, and CT8-TQ1. In the extraordinary examination session, those students who have a grade below 4 must repeat the written report. Laboratory practicals represent 24% of the global evaluation.

In Block 2 (Process Control), students who have completed the practicals in previous academic years will have the option to request an exemption from repeating them, provided that no more than 1 year has elapsed since they carried out those practicals and they were graded with more than a five.

In the section corresponding to the simulation block, in order to receive a grade for the practical case, the student must obtain a minimum grade of four on the written exam.

Activities carried out in English will be evaluated.

ACTIVITY SCHEDULE

UNIT	ACTIVITY	HOURS	GROUPS	START	END
1. PROCESS SIMULATION	Theory classes	19	2	2nd week	15th week
	Seminars	8	2		
2. CONTROL PROCESS	Theory classes	23	1	1st week	15th week
	Seminars	10	2		
BLOCKS 1 and 2.	Tutorials*	3	4	6th, 13th, 15th weeks	
1. PROCESS SIMULATION	Laboratory	15	4	12th week	14th week
2. CONTROL PROCESS	Laboratory	15	10	8th week	13th week

* Scheduled tutorials are subject to possible modifications depending on the overall planning of the course.

SUMMARY OF ACTIVITIES

ACTIVITY	ASSOCIATED COMPETENCES	TEACHING ACTIVITY	STUDENT ACTIVITY	EVALUATION	P	NP	TOTAL	C
Theory classes	CG1-TQ1 CE21-IP1 CE23-IP1 CE23-IP2 CE23-IP3 CE23-IP4 CE23-IP5	Presentation of the theoretical knowledge required to solve the case studies	Note-taking		42	63	105	
Seminars	CG5-TQ1, CE19-IP1, CE23-IP2, CE23-IP5, CT1-TQ1, CT2-TQ1, CT6-TQ1, CT8-TQ1	Explanation of how to use ASPEN PLUS	Note-taking Computer skills	Evaluación del programa entregado para resolver el caso asignado	18	27	45	**24%**
Laboratory	CE23-IP2, CE23-IP4, CE23-IP5, CT1-TQ1, CT6-TQ1, CT8-TQ1.	Providing guidance to students on their assigned case studies. Conducting laboratory practicals	Application of the knowledge acquired in lectures and seminars. Management of sales teams	Assessment of the report on the assigned case and of practical skills in the laboratory	30	22,5	52,5	**24%**
Tutorials	CT8-TQ1	Monitoring pupils' progress	Preparing questions for the teacher, taking in and applying the explanations given		3	4,5	7,5	
Exams	CG1-TQ1, CE21-IP1, CE23-IP3	Setting, invigilation and marking of the examination. Student assessment	Study and take the exam	Exam on the material covered in the lectures	6	9	15	**52%**

P: Presential activities

NP: No presential activities (self-work)

C: Calification