# COURSE DATA

| Data Subject | |
|---|---|
| **Code** | 44434 |
| **Name** | Advanced control of processes |
| **Cycle** | Master's degree |
| **ECTS Credits** | 6.0 |
| **Academic year** | 2023 - 2024 |

**Study (s)**

| Degree | Center | Acad. year | Period |
|---|---|---|---|
| 2209 - M.D. in Chemical Engineering | School of Engineering | 1 | Second term |

**Subject-matter**

| Degree | Subject-matter | Character |
|---|---|---|
| 2209 - M.D. in Chemical Engineering | 7 - Advanced control of processes | Obligatory |

**Coordination**

| Name | Department |
|---|---|
| ROBLES MARTINEZ, ANGEL | 245 - Chemical Engineering |

# SUMMARY

The Advanced Process Control course is a compulsory subject of 6 credits taught in the second semester of the Master of Chemical Engineering. The subject will be taught in Spanish. The aim of the course is therefore to provide an extension of the knowledge acquired in a basic control course that begins with the presentation of control techniques that go beyond classical feedback control techniques. It also aims to familiarize students with the problems that can be found in the control of complex processes as well as to present the basis for intelligent control systems. Given that more and more computers are used in control tasks, there is a chapter dedicated to digital control techniques where z transform is applied to the dynamic stability study. Finally, supervisory control and automation systems have an important consideration in the course.

The contents of the course to be developed on the program are:

Advanced control algorithms. Digital Control Systems. Multivariable Control Systems. Intelligent Control Systems: Fuzzy Control and Neural Networks. PLC's. SCADA Systems

# PREVIOUS KNOWLEDGE

## Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

## Other requirements

Previous knowledge of Unit Operations, Transport Phenomena and Basic Processes Control techniques is recommended.

# OUTCOMES

## 2209 - M.D. in Chemical Engineering

- Students should apply acquired knowledge to solve problems in unfamiliar contexts within their field of study, including multidisciplinary scenarios.
- Students should be able to integrate knowledge and address the complexity of making informed judgments based on incomplete or limited information, including reflections on the social and ethical responsibilities associated with the application of their knowledge and judgments.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Be able to apply the scientific method and the principles of engineering and economics to formulate and solve complex problems in processes, equipment, facilities and services in which matter changes its composition, state or energy content, these changes being characteristic of the chemical industry and of other related sectors such as pharmacology, biotechnology, materials science, energy, food or the environment.
- Conceive, plan, calculate and design processes, equipment, industrial facilities and services in the field of chemical engineering and other related industrial sectors in terms of quality, safety, economics, rational and efficient use of natural resources and environmental conservation.
- Know how to establish and develop mathematical models by using appropriate software in order to provide the scientific and technological basis for the design of new products, processes, systems and services and for the optimisation of others already developed.
- Integrate knowledge and handle the complexity of formulating judgments and decisions, based on incomplete or limited information, which take account of the social and ethical responsibilities of professional practice.
- Adapt to changes and be able to apply new and advanced technologies and other relevant developments with initiative and entrepreneurship.
- Have skills for independent learning in order to maintain and enhance the specific competences of chemical engineering which enable continuous professional development.

- Be able to access information tools in different areas of knowledge and use them properly.
- Be able to assess the need to complete their technical, scientific, language, computer, literary, ethical, social and human education, and to organise their own learning with a high degree of autonomy.
- Design products, processes, systems and services for the chemical industry and optimise others already developed, on the basis of the technologies of various areas of chemical engineering including transport processes and phenomena, separation operations and engineering of chemical, nuclear, electrochemical and biochemical reactions.
- Apply critical reasoning to their knowledge of mathematics, physics, chemistry, biology and other natural sciences, obtained through study, experience and practice, in order to establish economically viable solutions to technical problems.
- Conceptualize engineering models; apply innovative methods in problema solving and applications suitable for the design, simulation, optimization and control of processes and systems.

- Be able to solve unfamiliar and ill-defined problems that have specifications in competition by considering all possible methods of solution, including the most innovative ones, and selecting the most appropriate, and correct implementation by evaluating the different design solutions.
- Direct and supervise all types of facilities, processes, systems and services in different industrial areas related to chemical engineering.

## LEARNING OUTCOMES

- Apply the fundamentals of artificial intelligence in the design of controllers for processes subject to uncertainty and unpredictable changes.
- Model, analyze and design multivariable control systems.
- Implement advanced control systems via computers.
- Apply hierarchical structures in the control of complex chemical processes.
- Describe the advantages achieved with process control with the operation of an industrial installation.
- Know different types of SCADA system for the monitoring and control of industrial processes.
- Describe the operation of a PLC and its programming to control processing units.
- Develop dynamic models of process units for using them in control algorithms.

## DESCRIPTION OF CONTENTS

### 1. Advanced Control Systems

Control systems with multiple cycles: Cascade Control; Split Range Control. Feedforward Control: Features; Feedforward Control v.s. Feedback control

## 2. Multivariable Control Systems

Space-state Model: Examples. Solving the differential equation state vector. Multivariable control systems. The problem of interaction. Noninteractive Control

## 3. Digital Control system Design

Digital Control. Sampling of continuous systems: Ideal Sampling. The z transform. The pulse transfer function. Digital Control Systems. Stability in the z domain

## 4. Intelligent Control System Design

Intelligent Control Systems. Fuzzy logic control systems. Neural network control systems. Genetic algorithms and their application to control system design.

## 5. Process Sequential Control

Introduction. Logic equations. Combinational and sequential systems. PLCs: Programming

## 6. SCADA Control Systems

Introduction. Core Scheme. Main functions. HMI interface examples. Features of a SCADA package. A process module. Hardware Components. SCADA software examples.

## 7. Advanced Control Laboratory

Control system simulation by software

# WORKLOAD

| ACTIVITY | Hours | % To be attended |
|---|---|---|
| Theory classes | 35,00 | 100 |
| Classroom practices | 15,00 | 100 |
| Laboratory practices | 5,00 | 100 |
| Tutorials | 5,00 | 100 |
| Development of group work | 5,00 | 0 |
| Study and independent work | 20,00 | 0 |
| Preparation of evaluation activities | 15,00 | 0 |
| Preparing lectures | 18,00 | 0 |
| Preparation of practical classes and problem | 18,00 | 0 |
| Resolution of case studies | 14,00 | 0 |

| | |
|---|---|
| TOTAL | 150,00 |

# TEACHING METHODOLOGY

The training activities are developed in accordance with the following distribution:

**Theoretical activities**

In the theoretical classes chapters will be developed to provide a comprehensive and integrated vision, analyzing in detail the key aspects and more complex issues, encouraging, at the same time, student participation.

**Practical activities**

Complement the theoretical activities in order to apply the basic concepts and expand the knowledge and experience they acquire during the performance of the proposed work. They can include any of the following types of classroom activities:

- Classes of problems and questions in classroom
- Discussion sessions and problem solving exercises previously developed by students
- Conducting group projects
- Lab and / or computers sessions.

**Transverse activities**

Visit to industrial facilities, attending courses, conferences, round tables and other types of organized and/or proposed activities.

**Evaluation**

Completion of questionnaires/individual written assessment tests in the classroom with the teacher's presence.

**Tutorials**

Mentoring activities by the responsible faculty.

The practical activities carried out during the course are not recoverable for the 2nd Call and the mark obtained for the 1st Call is maintained.

# EVALUATION

To assess student learning, one or more tests including both theoretical questions as the resolution of a case will be taken and have a weight in the final mark of 50%. The rest of the mark will be obtained from the evaluation of practical activities such as preparation of papers, reports and / or presentations and laboratory report (40%) and the continuous evolution of each student, based on the regular attendance at classes, participation and degree of involvement of students in the teaching-learning process (10%).

The weighted average grade of examinations must be greater than 40 out of 100 to pass the course.

The assessment system is independent of the call (1st or 2nd).

# REFERENCES

## Basic

- Roland S. Burns; Advanced Control Engineering.Butterworth-Heinemann, Oxford 2001
- Pedro Ollero, Eduardo Fernández; Control e instrumentación de processos químicos. Editorial Síntesis, Madrid 1997
- Richard C. Dort, Robert H. Bishop; Sistemas de Control Moderno Pearson-Prentice Halll, Madrid 2005
- G. Stephanopoulos; Chemical process control. An introduction to theory and practice. Prentice Hall 1984

## Additional

- W. Bolton; Programmable Logic Controllers 2nd Ed.; Newnes, Oxford 2000
- Leonid Reznik; Fuzzy Controllers; Newnes, Oxford 1997
- Stuart G. McCrady; Designing SCADA Application Software. A Practical Approach Elsevier, Amsterdam 2013 (ebook)