Course guide
295105 - 295II021 - Control Systems

Last modified: 03/03/2026

Unit in charge: Barcelona East School of Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: ABEL TORRES CEBRIAN

Others: Segon quadrimestre:
JAVIER FRANCISCO GÁMIZ CARO - Grup: T11, Grup: T12
ANTONIO LÓPEZ FERNÁNDEZ - Grup: T11, Grup: T12
ARIEL MEDERO BORRELL - Grup: T11, Grup: T12
ABEL TORRES CEBRIAN - Grup: T11, Grup: T12

PRIOR SKILLS

This is an intermediate level subject in control systems. For a good understanding, a previous background is required: PID control, MATLAB-SIMULINK software, matrix algebra, ordinariy differential equations and process instrumentation.

REQUIREMENTS

It is recommended to have passed the subjects "Data acquisition Instrumentation" and "Systems Modeling".

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEMUEII-09. Design, implement and manage automated systems for the control and supervision of processes in engineering.

Generical:
CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.

Transversal:
05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

The methodologies used are:
- Master class
- Seminars
- Case study
- Project based learning

LEARNING OBJECTIVES OF THE SUBJECT

The purpose of this course is to integrate knowledge and skills in the design, development and performance of processes control in industrial domain. The course establishes the relationship between facilities and equipment, people and management systems. The main part of this subject is understand the automatic control using PID law and its application in industrial process control (motor control, level control, temperature control, industrial robot control, water treatment control). The course applies study cases in industrial context through examples of processes control and environmental management of wastewater plants.

STUDY LOAD

Type	Hours	Percentage
Self study	96,0	64.00
Hours small group	27,0	18.00
Hours large group	27,0	18.00

Total learning time: 150 h

CONTENTS

1. Introduction

Description:
1.1 Terminology. Definitions. PI-D Diagrams.
1.2 Control loop elements and basic examples.
1.3 Software resources (MATLAB/Simulink) - getting started.

Specific objectives:
Know how understand control systems and use of software resources.

Related activities:
Master Class. Use of software resources.
VIDEO: MATLAB. How to get started with Control Systems in MATLAB. At URL: https://youtu.be/MylJIqVVNr0, last visited 11 th December 2020.

Full-or-part-time: 2h
Theory classes: 1h
Self study : 1h

2. Foundations of Control Systems

Description:
2.1 Dynamical systems modelling (transfer functions, typical process models, FOPTD as an industrial baseline).
2.2 Time response: transient vs steady-state behaviour, performance indices (rise time, overshoot, settling time, steady-state error).
2.3 Stability and closed-loop interpretation (basic criteria and practical meaning).
2.4 Linking modelling assumptions to what is observed in laboratory identification.
2.5 Tuning of PID controllers.

Specific objectives:
Learn how link the dynamic model of a system with the control law. Learn how configure the PID control law for various applications.

Related activities:
Master class. Case study. Examples, Laboratory practices

Full-or-part-time: 20h
Theory classes: 9h
Self study : 11h

3. PID Control and Industrial Implementation

Description:
3.1 PID controllers - structure and actions (P, I, D).
3.2 Standard configurations and practical implementation aspects (filtering, 2DOF, saturation and anti-windup, etc.).
3.3 PID design and tuning (trial and error, empirical rules, industrial tuning and autotuning concepts).
3.4 Advanced strategies commonly used in industry (IMC overview, cascade, feedforward, time-delay compensation, multivariable overview).
3.5 Industrial context and integration constraints (instrumentation, actuators, sampling, robustness).
3.6 Industrial Control Technology Projects (ICT 1-3): applied sessions in a flexible format (lab, seminar, or mixed) to connect PID design with industrial technology.

Specific objectives:
Learn an integrated vision of industrial control.

Related activities:
Master class. Exam. Case study, SCADA/HMI examples. MATLAB examples.

Full-or-part-time: 18h
Theory classes: 10h
Self study : 8h

4. Water treatment control

Description:
4.1 Case study: Drinking Water treatment plant.
4.2 Case study: Wastewater Treatment plant (WWTP)
4.3 Aeration control system
4.4 Control strategies (PID fixed gain, PID-Fuzzy control)

Specific objectives:
General description of the water cycle concept, with special attention to the urban water cycle and its management. All the stages that make up this cycle will be explained and the different characteristics, both of the water and the infrastructures involved from a holistic vision and without forgetting the interrelations between each of stages and their involvement in sustainable resource management within their own cycle.

Related activities:
Laboratory Practices

Full-or-part-time: 3h
Theory classes: 1h
Self study : 2h

5. Laboratory practices.

Description:
PART P1 Foundations and PID implementation (Labs 1-5)
Description:
L1. Introduction to MATLAB/Simulink for control systems.
L2-L3. Experimental identification of a FOPTD (First-Order Plus Time Delay) model, data acquisition and model fitting (part 1 and part 2).
L4. Empirical PID tuning and practical PID modifications.
L5. Industrial PID tuning methods and introduction to autotuning.
Specific objectives:
Gain autonomy in MATLAB/Simulink, identify a simple process model, and apply PID tuning with performance and robustness criteria.
Related activities:
Guided MATLAB/Simulink labs and results analysis.

PART P2 - ICT projects + Water treatment control
Description:

ICT1-ICT3. Industrial Control Technology Projects (ICT): applied sessions in a flexible format (lab, seminar, or mixed) to connect PID design with implementation and the industrial context.
L6-L9. WWTP/EDAR processes and control: variable analysis, control loops and strategies (part 1 to part 4).
WWTP/EDAR visit. Integrative activity to observe a real process and discuss control objectives, constraints, and performance indicators.
Specific objectives:
Apply control concepts in an industrial setting and consolidate them through a real case study (WWTP/EDAR), integrating modelling, tuning and control assessment.
Related activities:
Applied ICT sessions, WWTP-focused labs, and a technical visit.

Specific objectives:
The practical part of the subject contributes to the integration between various software, the acquisition of technical ability in PID control and industrial process control with advanced algorithms.

Related activities:
In the Laboratory A5.6 Automatic Control is available:
- academic plants for level and flow process control
- MATLAB V. R2018b (or last version)

In the Laboratory A5.4 Automation and Industrial Robotics, is available:
- MATLAB/SIMULINK v. R2018b

At the end of each part of practices, the student's group delivers a report

Full-or-part-time: 104h
Laboratory classes: 28h
Self study : 76h

GRADING SYSTEM

The qualification system includes activities (written exam) and laboratory practices-
Exam1*(0,3)+Exam2*(0,3) +Practices_1*(0,20)+Practices_2*(0,20)
Exam1: Module 2
Exam2: Module 3
Practices_1: Practices 1,2,3,4,5
Practices_2: Practices 6,7,8,9,10

EXAMINATION RULES.

The Exams are test, exercises.
Laboratory activities are mandatory. Laboratory activities are carried out in groups of 2 people in Laboratory A5.6 , in Laboratory A5.4 or in a Computer Room.

The evaluation method of this course meets the current academic regulations to be qualified: NO RE-EVALUABLE.

BIBLIOGRAPHY

Basic:
- Seborg, Dale E.; Mellichamp, Duncan A.; Doyle III, Francis J.; Edgar, Thomas F. Process Dynamics and Control. Fourth edition. Hoboken, NJ: Wiley, [2017]. ISBN 9781119285915.
- Love, Jonathan. Process automation handbook : a guide to theory and practice. London: Springer, 2007. ISBN 9781846282812.
- Ivergård, Toni; Hunts, Brian. Handbook of control room design and ergonomics : a perspective for the future. London ; New York: Taylor & Francis, cop. 2009. ISBN 9781420064292.

Complementary:
- Alfaro, Victor M.; Vilanova i Arbós, Ramon. Model-reference robust tuning of PID controllers [on line]. Cham: Springer International, 2016 [Consultation: 24/04/2020]. Available on: https://dx.doi.org/10.1007/978-3-319-28213-8. ISBN 9783319282138.
- Macaulay, T.; Singer, B. Cybersecurity for industrial control systems : SCADA, DCS, PLC, HMI, and SIS. Boca Raton, FL: CRC Press, [2012]. ISBN 9781439801963.
- Dorf, Richard C.; Bishop, Robert H. Modern control systems. 12th ed., international ed. Boston [etc.]: Pearson, cop. 2011. ISBN 9780131383104.

RESOURCES

Other resources:
Magazine Control Engineering: https://www.controleng.com/magazine

International Water Association IWA: https://www.iwapublishing.com/ />
MATLAB Control Systems Toolbox: https://es.mathworks.com/help/control/index