
Academic Year of Degree: 2025/26

22134 - Control Theory and Self-Regulation

Teaching Guide Information

Academic Course: 2025/26

Academic Center: 337 - Engineering School

Study: 3378 - Bachelor's degree in Biomedical Engineering

Subject: 22134 - Control Theory and Self-Regulation

Credits: 5.0

Course: 3

Teaching languages:

Theory: Group 1: English

Practice: Group 101: English

Group 102: English

Seminar: Group 101: English

Teachers: Miguel Calvo Fullana

Teaching Period: Second term

Presentation

This course is an introduction to control theory. It deals with fundamental concepts and practical aspects regarding the analysis and the design of feedback control mechanisms for dynamic systems. The course aims three main objectives:

1. To overview the mathematical and physical foundations for modeling and analyzing the response of dynamic systems; both of continuous and of time discrete systems.
2. To introduce the principles of feedback control design based on well-established approaches (root-locus, frequency response and state-space), with a focus on PID controllers.
3. To put in practice the above acquired knowledge by modeling and analyzing physical systems, and designing, implementing and testing feedback controllers for them.

Associated skills | General learning outcomes

Basic competences

CB2. That the students can apply their knowledge to their work or vocation in a professional way and possess the competences which are usually proved by means of the elaboration and defense of arguments and solving of problems within their study area.

CB3. That the students have the ability of collecting and interpreting relevant data (normally within their study area) to pass judgements which include a reflection about relevant topics of social, scientific or ethical nature.

CB5. That the students have developed those learning abilities necessary to undertake later studies with a high degree of

autonomy.

Transversal competences

CT1. Working in group in international and interdisciplinary contexts.

CT3. Applying with flexibility and creativity the acquired knowledge

CT4. Communicating in academic and professional contexts in English, both orally and in writing and adapting it to new contexts and situations.

CT5. Generating new ideas and incorporating them in their daily work.

Specific competences

CE1. Solving the mathematical problems which arise in engineering and applying knowledge on: linear algebra; differential and integral calculus; numerical methods, numerical algorithms, statistics and optimization.

CE2. Mastering the basic concepts of fields and waves and electromagnetism, theory of electric circuits, electronic circuits, physical principles of semiconductors and logic families, electronic and photonic devices, and their application for solving typical problems in engineering.

CE4. Mastering the use and programming of computers, operating systems, databases and computer programs with application in engineering.

CE7. Master physical and chemical laws which regulate energy-matter interaction, mechanics and thermodynamic general laws and apply them in the context of typical problems in engineering.

CE9. Designing and implementing technological solutions related to the acquisition, processing, modeling, visualization and interpretation of biological, physiological and clinical variables and signals that contribute in the processes of prevention, diagnosis, treatment and rehabilitation.

Learning outcomes | Specific learning outcomes

On successful completion of the course, the students will be able to:

1. Model dynamic systems, both continuous and discrete, of different nature (e.g., mechanical, thermal, and electrical systems) using first and second order linear approaches, and analyze their response.
2. Design optimal PID feedback controllers using different well-established approaches.
3. Implement and test PID feedback controllers in actual systems using available hardware and software platforms.

Specific outcomes

RA.CE1.2 Show knowledge of differential and integral calculus to solve problems in engineering.

RA.CE1.6 Apply knowledge of optimization to solve problems which can arise in engineering.

RA.CE2.1 Apply basic knowledge of fields and waves and electromagnetism to solve problems in engineering.

RA.CE2.2 Manage basic concepts of linear systems, functions and their related transforms to solve typical problems of engineering.

RA.CE2.3 Master knowledge of electronic circuits, physical principles of semiconductors and logic families, electronic and photonic devices to solve problems in engineering.

RA.CE4.1 Master the basic and practical knowledge on the use and programming of computers with application in engineering.

RA.CE7.1 Apply knowledge of physical and chemical laws which regulate energy-matter interaction to solve problems in engineering.

RA.CE7.2 Manage mechanics and thermodynamic general laws to solve typical problems in engineering.

RA.CE9.1 Develop techniques of computational analysis of multimodal signals and images with applications in diagnosis and monitoring.

RA.CE9.2 Design technological solutions related to the acquisition, processing, modeling, visualization and interpretation of

biological, physiological and clinical variables and signals that contribute in the processes of prevention, diagnosis, treatment and rehabilitation.

Contents

1. Introduction to Feedback Control
Feedback systems, definitions, components and their analysis.
2. Mathematical modeling of dynamic systems
Modeling and study of different classes of dynamical systems.
3. Response analysis of dynamic systems
Linear system response, modeling diagrams, the Laplace transform, poles, zeros and stability.
4. Analysis of Feedback
Equations of control, steady-state error and the PID controller.
5. Control design using root-locus
Root-locus, guidelines for determining stability and dynamic compensation design using root-locus.
6. Control design using frequency response
Frequency response, stability criteria, Bode plots and compensation design using frequency response.
7. Digital Control
Digitization, response analysis of discrete systems, the z-transform and design using discrete equivalents.
8. Control design using state-space
System description in state-space, block diagrams, state equations and control-law design.
9. Introduction to non-linear systems
Non-linear systems and linearization.

Evaluation and grading system

The final course grade will be allocated as follows:

- **Lab Reports (40%):** Four reports based on laboratory work that apply the concepts learned in class.
- **Midterm Exam (20%):** An exam featuring both multiple-choice questions and problem-solving exercises.
- **Final exam (40%):** An exam featuring both multiple-choice questions and problem-solving exercises.