

# Course guide 220072 - 220072 - Advanced Control Systems

Last modified: 02/04/2024

Teaching unit:	707 - ESAII - Department of Automatic Control.
Degree:	<ul> <li>BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).</li> <li>BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).</li> <li>BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).</li> <li>BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Optional subject).</li> <li>BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).</li> </ul>
Academic year: 2024	ECTS Credits: 3.0 Languages: English

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Coordinating lecturer:	Masip Alvarez, Albert	
Others:	Cayero Becerra, Julián Francisco	

## **PRIOR SKILLS**

**LECTURER** 

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This course requires the student to have basic skills in: Modelling of dynamic systems and transfer function Control techniques (PID tuning)

# **TEACHING METHODOLOGY**

The course is divided into parts: Theory classes Laboratory sessions Self-study for doing exercises and activities. In the theory classes, teachers will introduce the theoretical basis of the concepts, methods and results and illustrate them with

examples appropriate to facilitate their understanding. In the lab sessions, teachers guide students in applying theoretical concepts to solve problems, always using critical reasoning. We propose that students solve two autonomous robot control projects in and outside the classroom, to promote contact and use the basic tools needed to solve problems.

Students, independently, need to work on the materials provided by teachers in order to fix and assimilate the concepts. The teachers provide the syllabus and monitoring of activities (by ATENEA).

# LEARNING OBJECTIVES OF THE SUBJECT

This course is about autonomous mobile robots as seen from the control point of view. The main types of mobile robots (ground, aerial and underwater) are reviewed and their common control architecture is presented. This architecture introduces four control problem categories which are examined (planning, navigation, perception and control). The course is about the control problems and the control tools to solve some of them.

One of the main objectives of the course is to acquire a hands-on experience, which will be obtained through the robotic control projects.

The principal tools of advanced control system design are introduced in the theory lectures and applied in the lab. These tools are the operational aspects of discrete control theory and the state space representation and analysis framework, which allows the natural introduction of advanced control techniques, such as optimal control, model predictive control, etc.



# **STUDY LOAD**

Туре	Hours	Percentage
Self study	45,0	60.00
Hours large group	30,0	40.00

# Total learning time: 75 h

# CONTENTS

# Module 1: Basics for Drone manoeuvring

#### **Description:**

Drone flight principles AR-Drone architecture (soft+hard) Matlab,coms,física ROS basics/fundamentals AR-Drone simulation model

Specific objectives:

Related activities: 1, 2, 3

Full-or-part-time: 25h Theory classes: 10h Self study : 15h

# Module 2: Identification and controller design

## **Description:**

Models for control: transfer functions Identification of transfer functions from experimental data Controller design based on pole placement using transfer functions Cascade control structure

Related activities: 1, 2, 3

**Full-or-part-time:** 25h Theory classes: 10h Self study : 15h

#### **Mission control**

**Description:** Image processing Path tracking algorithm State machines

Related activities: 1, 2, 3

**Full-or-part-time:** 25h Theory classes: 10h Self study : 15h



# **ACTIVITIES**

## **1. Theory lectures**

**Description:** 

Exposition of the subject theory contents.

#### **Specific objectives:**

Knowledge transfer, creation of a conceptual reference frame, solving questions and generating interest about the subject.

#### Material:

Slide compilations and handouts at Atenea General bibliography of the subject

## Full-or-part-time: 10h

Theory classes: 10h

## 2. Laboratory projects

## **Description:**

Students, in groups, follow the instructions to resolve a practical control problem. These sessions take place at the lab and there are two problems to solve. Terrestrial and aerial mobile robots are the platforms used in the projects developed in the lab sessions.

## Specific objectives:

Proper application of control design methodology.

#### Material:

Project instructions at Atenea Simulation software (Matlab) Lab plants (aerial and mobile robots) Course handouts and notes

#### **Delivery:**

Each group has to deliver a report describing the results of the projects, the methodology and techniques applied to obtain the final results. A practical demonstrations is also required.

#### Full-or-part-time: 53h

Theory classes: 18h Self study: 35h



# 3. Final examination

#### **Description:**

Written individual examination about the concepts of theory modules. The examination includes conceptual questions, test questions, and problems to be solved by hand.

#### Specific objectives:

Assess the knowledge acquisition of activities 1, 2. Distinguish from the group evaluation in activity 2.

# Material:

Examination instructions.

## **Delivery:**

Answers to the questions and solutions to the problems posed in the instructions.

**Full-or-part-time:** 12h Self study: 10h Theory classes: 2h

## **GRADING SYSTEM**

Individual exam: 40%

Lab deliverings: 60%

The students who do not pass the subject can take an additional global written exam that will take place the date stated in the calendar of final exams. The grade obtained in this exam will replace the one of the final exam in case it is higher. The maximum final mark in this case will be 5.0

## **BIBLIOGRAPHY**

#### **Basic:**

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- Ogata, Katsuhiko. Discrete-time control systems. Englewood Cliffs, NJ: Prentice-Hall, cop. 1987. ISBN 0132161028.

- Aström, K. J.; Wittenmark, B. Computer controlled systems: theory and design [on line]. 3rd ed. Mineola, NY: Dover Publications, 2011 [Consultation: 09/05/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=1893 090. ISBN 9780486486130.

- Siegwart, Roland; Nourbakhsh, Illah Reza; Scaramuzza, Davide. Introduction to autonomous mobile robots [on line]. 2nd ed. Cambridge: MIT Press, cop. 2011 [Consultation: 09/05/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3339 191. ISBN 9780262015356.