Course guide
200212 - TCL - Control Theory

Last modified: 01/06/2023

Unit in charge: School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN MATHEMATICS (Syllabus 2009). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: JOSEP MARIA OLM MIRAS

Others: Segon quadrimestre:
JAIME FRANCH BULLICH - M-A
JOSEP MARIA OLM MIRAS - M-A

PRIOR SKILLS

Linear algebra, elementary calculus in one and multiple variables, differential equations.
It is adviceable but not compulsory to have some knowledge on differential geometry.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
3. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.
4. CE-4. Have the ability to use computational tools as an aid to mathematical processes.
5. Ability to solve problems from academic, technical, financial and social fields through mathematical methods.
13. CE-1. Propose, analyze, validate and interpret simple models of real situations, using the mathematical tools most appropriate to the goals to be achieved.
14. CE-3. Have the knowledge of specific programming languages and software.

Generical:
1. CB-4. Have the ability to communicate their conclusions, and the knowledge and rationale underpinning these to specialist and non-specialist audiences clearly and unambiguously.
2. To have developed those learning skills necessary to undertake further interdisciplinary studies with a high degree of autonomy in scientific disciplines in which Mathematics have a significant role.
6. CG-1. Show knowledge and proficiency in the use of mathematical language.
7. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.
8. CG-3. Have the ability to define new mathematical objects in terms of others already know and ability to use these objects in different contexts.
9. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
10. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.

Transversal:
11. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
12. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

TEACHING METHODOLOGY

We distinguish between lectures and problem solving sessions.

- In lectures, using a minimum number of basic concepts, the theory of linear systems will be presented. Of course, we will resort to examples both to motivate and to illustrate the theoretical results.
- At problem solving sessions, students will apply theoretical results to solve problems, eventually having to resort to their knowledge.

LEARNING OBJECTIVES OF THE SUBJECT

1. To identify a control system and to distinguish among state variables, inputs and outputs.
2. To apply to control systems the existence and uniqueness theorems of differential equations.
3. To compute controllability and observability matrices, and to decide the controllability and observability of a system.
4. To compute different canonical forms and to use them in controllers design.
5. To compute transfer functions and matrices, and to use them in controllers design.
6. To understand and to use frequency methods in order to find the responses to different inputs.
7. To design PID controllers.
8. To decide on the controllability and observability of nonlinear systems.
9. To linearize nonlinear systems and use it for controller design.
10. To know the basic concepts of sliding mode control and adaptive control.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	20.00
Hours small group	30,0	20.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

Introduction to control theory

Full-or-part-time: 4h
Theory classes: 4h

Linear systems: state space representation

Full-or-part-time: 6h
Theory classes: 6h

Linear systems: input-output representation

Full-or-part-time: 6h
Theory classes: 6h

Stability

Full-or-part-time: 4h
Theory classes: 4h

Time-domain analysis

Full-or-part-time: 6h
Theory classes: 6h

Controller design

Full-or-part-time: 4h
Theory classes: 4h

Nonlinear systems: controllability and observability

Full-or-part-time: 6h
Theory classes: 6h

Linearization. Flatness. Controller design

Full-or-part-time: 6h
Theory classes: 6h

Sliding mode control

Full-or-part-time: 6h
Theory classes: 6h

Adaptive control

Full-or-part-time: 5h
Theory classes: 5h

Presentation and defense of student projects

Full-or-part-time: 7h
Theory classes: 7h

GRADING SYSTEM

- Students must deliver exercises on a periodic basis.
- Project presentation of a work chosen from a list proposed by the initiative of the student or faculty, and accepted by the instructor.

BIBLIOGRAPHY

Basic:
- Isidori, Alberto. Nonlinear control systems. 3rd ed. Springer-Verlag, 1995. ISBN 3540199160.
- Slotine, Jean-Jacques; Li, Weiping. Applied nonlinear control. Prentice-Hall, 1991. ISBN 0130408905.
- Khalil, Hassan. Nonlinear systems. 3rd. Prentice-Hall, 2002. ISBN 0130673897.
- Lewis, Andrew. A Mathematical approach to classical control [on line]. Preprint. [Consultation: 23/11/2012]. Available on: https://mast.queensu.ca/~andrew/teaching/pdf/332-notes.pdf.

Complementary:
- Kailath, Thomas. Linear systems. Englewood Cliffs, NJ: Prentice-Hall, 1980. ISBN 0135369614.