Last update: 04-07-2017

340602 - SIOP-R1O43 - Simulation and Optimization

Coordinating unit: 340 - EPSEVG - Vilanova i la Geltrú School of Engineering

Teaching unit: 749 - MAT - Department of Mathematics

Academic year: 2017

Degree: MASTER'S DEGREE IN AUTOMATIC SYSTEMS AND INDUSTRIAL ELECTRONICS (Syllabus 2012). (Teaching unit Compulsory)

ECTS credits: 5 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: IMMACULADA MASSANA HUGAS

Others: Carles Batlle Arnau

Prior skills

Ability to apply the basic tools of multivariable calculus
and differential equations.

Degree competences to which the subject contributes

Specific:

1. CG04- Ability to research, design, develop and implement simulation methods for the control of electronic systems, automatic and robotic
2. CB9 - Students can communicate their conclusions, knowledge and rationale underpinning these, to skilled and unskilled public in a clear and unambiguous way
3. CB7 - Students can apply their knowledge and their ability to solve problems in new or unfamiliar contexts within broader (or multidisciplinary) contexts related to their field of study

Teaching methodology

In the lectures the instructor presents some motivating ideas, the fundamental concepts and some relevant developments, intermingled with key examples and the resolution of representative problems.

In laboratory classes the students learn to use MATLAB to solve different kinds of problems that will be assigned in each session. Every week, the second session will be assessed.

Learning objectives of the subject

1. Calculate the curve (function) that maximizes or minimizes an integral (functional).
2. Know if a system described by ODE (state space) can be controlled by an external input (control function).
3. Compute the optimal control for systems controllable.
4. Know and use MATLAB to solve ODE numerically.
5. Use MATLAB to solve different kind of exercises.

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Study load

Total learning time: 125h	Hours large group:	22h 30m	18.00%
	Hours medium group:	0h	0.00%
	Hours small group:	22h 30m	18.00%
	Guided activities:	0h	0.00%
	Self study:	80h	64.00%

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Content

1. Introduction

Learning time: 2h
Theory classes: 1h
Self study : 1h

Description:
We introduce with historic examples the several problems that we explain in this subject: optimal function, calculus of variations and optimal control problems.

2. Calculus of variations

Learning time: 16h
Theory classes: 5h
Self study : 11h

Description:
2.1 Probelm Statement.
2.2 Basic theory: necessary condition, Euler-Lagrange equation.
2.3 Particular cases.
2.4 Generalizations of the Euler-Lagrange equation.
2.5 Variable endpoints.

3. Lagrange Multipliers

Learning time: 6h
Theory classes: 2h
Self study : 4h

Description:
3.1 Constrained maximization or minimization of a function: Lagrange multipliers theory.
3.2 Constrained calculus of variations.

4. Controllability

Learning time: 6h
Theory classes: 2h
Self study : 4h

Description:
4.1 Controllability of control linear systems.
4.2 Examples.

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5. Optimal Control	Learning time: 8h Theory classes: 3h Self study : 5h

Description:
5.1 Problem statement.
5.2 Hamiltonian.
5.3 Pontryagin's minimum principle (PMP).
5.4 Property of the Hamiltonian.

6. Linear quadratic problem (LQP)	Learning time: 6h Theory classes: 2h Self study : 4h

Description:
6.1 Linear quadratic problems.
6.2 Riccati equations.
6.3 Examples.

7. Pontryagin's Minimum Principle. Piecewise continuous control	Learning time: 8h Theory classes: 3h Self study : 5h

Description:
The time-optimal control.

8. MATLAB Simulation (first part)	Learning time: 24h Laboratory classes: 16h Self study : 8h

Description:
8.1 Introduction.
8.2 MATLAB as advanced calculator.
8.3 Scripts and functions.
8.4 Vectors and matrixs.
8.5 The ode45 MATLAB function.
8.6 Optimatization.

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9. MATLAB Simulation (second part)	Learning time: 9h Laboratory classes: 6h Self study : 3h

Description:
9.1 The SIMULINK.
9.2 Simulation of systems and processes.

Planning of activities

A1: FIRST LABORATORY EXAM WITH MATLAB (SUBJECT 8 and 9)	Hours: 4h Guided activities: 2h Self study: 2h
A2: FIRST PARTIAL EXAM (SUBJECTS 2,3 AND 4)	Hours: 6h Guided activities: 2h Self study: 4h
A3: SECOND PARTIAL EXAM (SUBJECTS 5,6 i 7)	Hours: 6h Guided activities: 2h Self study: 4h
A4: FINAL EXAM (SUBJECTS 2,3,4,5,6 AND 7)	Hours: 8h Guided activities: 2h Self study: 6h

Qualification system

Final grade will be obtained from one of the following formulas:
1. 30% A1, 35% A2 and 35% A3.
2. 30% A1 and 70% A4.

A4 is the only re-gradable activity.

Regulations for carrying out activities

The conditions for carrying out the written exams will be announced in each case in due time.
Activities A3 and A4 will be the same day and, therefore, only one of them can be carry out.

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Bibliography

Basic:

Pinch, Enid R. Optimal control and the calculus of variations. Oxford: Oxford Science Publications, 1993. ISBN 0198532172.

Kirk, Donald E. Optimal control theory: an introduction. Mineola, N.Y.: Dover Publication, 2004. ISBN 0486434842.

Cerdá Tena, Emilio. Optimización dinámica. Madrid [etc.]: Prentice Hall, 2001. ISBN 8420529370.