Course guide
240743 - 240743 - System Dynamics

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

Degree: BACHELOR’S DEGREE IN INDUSTRIAL TECHNOLOGIES AND ECONOMIC ANALYSIS (Syllabus 2018). (Compulsory subject).

Academic year: 2022  ECTS Credits: 4.5  Languages: English

LECTURER

Coordinating lecturer: Serra Prat, Maria
Others: Giralt Ludevid, Xavier  Serra Prat, Maria

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
04 COE. 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.
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.
07 AAT. 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.
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

THEORY CLASSES:
The theory classes consist in the presentation of the theory concepts and the resolution of related problems. The problems of the document "System Dynamic. Problems" by P. Caminal et al. are solved in the classroom.
Apart from the problems solved in the classroom, students are encouraged to do the problems of the following books:
- Caminal et al. Problemes d'Examen de Dinàmica de Sistemes. Atenea, 2009

PRACTICE CLASSES
The practical classes are focused on the design and implementation of controllers for the position and velocity control of a DC motor. These sessions, which are compulsory, are done in the laboratory.

LEARNING OBJECTIVES OF THE SUBJECT

General objective
- To provide the students with the concept of dynamic system, applicable to all the fields of engineering, and the concept of signal as the variable of this system evolving over time.

Specific Objectives
- To provide tools for the dynamic systems analysis in the time and frequency domains
- To present different methodologies for the study of the dynamic systems stability
- To present the basic concepts of continuous-time control systems
- To design controllers that improve the operation specifications of the dynamic systems
### STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Hours small group</td>
<td>7,5</td>
<td>6.67</td>
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<tr>
<td>Hours large group</td>
<td>37,5</td>
<td>33.33</td>
</tr>
<tr>
<td>Self study</td>
<td>67,5</td>
<td>60.00</td>
</tr>
</tbody>
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**Total learning time:** 112.5 h
CONTENTS

System Dynamics

Description:
1. INTRODUCTION
   1.1. Object and scope of the course
   1.2. Basic definitions and examples of dynamic systems

2. SYSTEMS MODELING AND TRANSFER FUNCTION
   2.1. Elementary signals
   2.2. External representation
   2.3. Transfer function of linear systems
   2.4. Characteristic equation
   2.5. Poles and zeros, canonical gain and canonical form
   2.6. Delays
   2.7. Block schemes and block algebra
   2.8. Systems with multiple inputs and outputs
   2.9. Examples of models of physical systems.

3. TIME RESPONSE
   3.1. Impulse response of first and second order systems
   3.2. Step response of first and second order systems
   3.3. Stability
   3.4. Necessary and sufficient condition of stability
   3.5. Routh's theorem
   3.6. Stationary error

4. DESIGN OF CONTROLLERS IN THE TIME DOMAIN
   4.1. Basic control actions: proportional, integral and derivative control
   4.2. Design of PID controllers

5. FREQUENCY RESPONSE
   5.1. Isochronous transfer function
   5.2. Bode diagram
   5.3. Frequency response of the basic elements
   5.4. Asymptotic Bode diagram of a generic transfer function
   5.5. Polar diagram

6. STABILITY IN THE FREQUENCY DOMAIN
   6.1. Nyquist stability criterion
   6.2. Gain margin and phase margin.

7. DESIGN OF CONTROLLERS IN THE FREQUENCY DOMAIN
   7.1. Design of lead compensators
   7.2. Design of lag compensators

Specific objectives:
- To provide tools for the dynamic systems analysis in the time and frequency domains
- To present different methodologies for the study of the dynamic systems stability
- To present the basic concepts of continuous-time control systems
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Related activities:
There are four 2-hour sessions (L1, L2, L3, EXAM) and one 2-hour session of autonomous learning in the Informatic Classroom (IC). The laboratory is in 2nd plant of the H building of the ETSEIB School.
The content of practical work is as follows:

IC. Introduction to Matlab and its Control Toolbox. It must be carried out in one of the Informatic Classrooms of the school as autonomous work.
L1. Identification and modeling of an experimental DC electric motor. Analysis of open loop and closed loop behaviour.
L2. Experimental study of the behavior of the controlled DC electric motor, both for speed and position control.
L3. Design and implementation of a PID controller.

EXAM. In this session the students will be evaluated of their practical work during sessions IC, L1, L2 and L3.

**Full-or-part-time:** 112h 30m
Theory classes: 37h 30m
Laboratory classes: 8h
Self study : 67h

**GRADING SYSTEM**

**ORDINARY EVALUATION:**
There are four evaluations during the course:

- Partial Exam. It is an exam done approximately at the middle of the course, consisting of conceptual questions and one problem. The exam subject includes chapters 1 to 4. For the problem resolution, students can have a personal double sided DIN A4 with formulas, the table of Laplace Transforms and one calculator. The mark of this exam is Npe.
- Two deliverables. They are exercises done at home. The mark of this test is Nt.
- Practical mark. It is the mark of the reports corresponding to the three practical sessions. The mark of this part is Npre.
- Final Exam. It is an exam of all the course matter, consisting of conceptual questions and some problems. For the problems resolution, a personal double sided DIN A4 with formulas, the table of Laplace Transforms and one calculator are permitted. Students are asked to provide semi-logarithmic paper. The mark of this test is Nf.

The final mark, Nf, is calculated as follows:

Nf = 0,5Nfe + 0,275Npe + 0,1Nt + 0,125Npre

**EXTRAORDINARY EVALUATION:**
The students that have failed the subject (Nf<5) can do an extraordinary exam.

The extraordinary exam consists of conceptual questions and some problems. For the problems resolution, a personal double sided DIN A4 with formulas, the table of Laplace Transforms and one calculator are permitted. Students are asked to provide semi-logarithmic paper. The mark of this test is Nee.

For the students presented to the extraordinary exam, the final mark, Nf, is calculated as follows:

Nf = 0,875Nee + 0,125Npre

**EXAMINATION RULES.**
In all the written exams, for the problems resolution part, a personal double sided DIN A4 with formulas, the table of Laplace Transforms and one calculator are permitted.
In the practical exam, students are asked to bring all the notes they have taken during the realisation of the practical sessions.

**BIBLIOGRAPHY**

**Basic:**

**Complementary:**