The aim of this course is to train students in methods for the design and analysis of digital controllers by means of the computer. The course includes a brief introduction to control theory for the students not familiar with this field and it is mainly developed on the basis of several application examples and two case studies (Magnetic Levitator and SegwayTM). The students will work with the Matlab/Simulink software in class and at home they will perform remote virtual experiments via Moodle. Finally, several laboratory experiments with a physical magnetic levitator will be performed.

Learning results of the subject:
- Ability to formulate the control problem specifications taking into account theoretical and practical constraints.
- Ability to describe and analyze the dynamical behavior of any system by means of transfer functions and state space descriptions.
- Ability to design digital controllers by several software-based techniques: root locus, direct synthesis, loop-shaping, and optimization.
- Ability to select, analyze and implement digital controllers.

Application examples solved in class via Matlab/Simulink: Flexible arm, active suspension system, heading control of a ship, helicopter stabilization

Individual work:
- Remote control of the two case studies (magnetic levitator and segway) via Moodle.

Short answer test (Test):
- Partial evaluation test with theoretical questions and short exercises.

Final examination:
- Final work in pairs regarding the case studies or any other applications of interest for the students.
## Study load

<table>
<thead>
<tr>
<th>Total learning time: 62h 30m</th>
<th>Hours large group:</th>
<th>10h</th>
<th>16.00%</th>
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<tbody>
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<td></td>
<td>Hours small group:</td>
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<tr>
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<td>Self study:</td>
<td>42h 30m</td>
<td>68.00%</td>
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</tbody>
</table>
## Content

### Unit 1. Digital controllers

**Description:**
1.1 Fundamentals of Control Theory. Feedback. Specifications
1.2 Signal processing for digital control systems. Z Transform
1.3 Discretization of analog controllers
1.4 Deadbeat and Dahlin controllers
1.5 Matlab/Simulink tools for digital control design and implementation

**Learning time:** 12h 30m  
Theory classes: 4h  
Self study: 8h 30m

### Unit 2. Software-based controller design in the complex plane

**Description:**
2.1 Laplace modeling of dynamic systems. Linearization
2.2 Design of pole-zero and PID controllers by means of the root locus
2.3 Design of optimal ITAE controllers by direct synthesis
2.4 Design of two degrees of freedom robust controllers by loop-shaping
Applications: Flexible arm and active suspension system
Case study: Magnetic Levitator

**Learning time:** 10h 50m  
Theory classes: 2h 20m  
Self study: 8h 30m

### Unit 3. Software-based controller design in the state space

**Description:**
3.1 State space descriptions of dynamic systems. Controllability and observability  
3.2 State feedback. Design of state observers
3.3 LQG (Linear Quadratic Gaussian) regulator. Integral action.
Applications: Heading control of a ship and helicopter stabilization
Case study: Segway

**Learning time:** 12h 30m  
Theory classes: 4h  
Self study: 8h 30m
Unit 4. PRACTICE on MATLAB programed ARDUINO for Control Applications

Learning time: 25h
- Theory classes: 17h
- Self study: 8h

Description:
4.1 Basics on ARDUINO

4.2 Programming ARDUINO with MATLAB/Simulink

4.3 Actuating and Monitoring Hardware using ARDUINO & MATLAB

4.4 Developing a Controller in ARDUINO with MATLAB

Case study: Controlling a Tunable Laser or Electronic Circuit with ARDUINO & MATLAB.

Qualification system

Final examination: from 20% to 50%
Partial examinations and controls: from 0% to 50%
Exercises: from 0% to 20%
Laboratory assessments: from 0% to 50%

Bibliography

Basic: