## 280725 - Advanced Control of Marine Systems

**Coordinating unit:** 280 - FNB - Barcelona School of Nautical Studies  
**Teaching unit:** 707 - ESAII - Department of Automatic Control  
**Academic year:** 2020  
**Degree:** MASTER'S DEGREE IN THE MANAGEMENT AND OPERATION OF MARINE ENERGY FACILITIES (Syllabus 2016). (Teaching unit Compulsory)  
**ECTS credits:** 5  
**Teaching languages:** Catalan, Spanish

### Prior skills

It is desirable to have knowledge of physics (Newton's second law, analogies, linear circuits), mathematics (Laplace transform, complex variable theory, Taylor series) and computers (matlab).

### Requirements

Basic course on automatic regulation

### Degree competences to which the subject contributes

**Basic:**
- CB7. That the students can apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their study area.
- CB9. That students can communicate their conclusions and the knowledge and latest rationale underpinning to specialists and non-specialty clearly and unambiguously.
- CB10. Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous.

**Specific:**
- CE7-MGOIEM. Capacitat per conèixer, entendre i utilitzar els principis de control avançat de processos d'operació, manteniment i reparació

**Generical:**
- CG1-MGOIEM. Conocimientos suficientes en materias básicas y tecnológicas, que le capaciten para el desarrollo de nuevos métodos y procedimientos.
- CG2-MGOIEM. (ENG) Capacidad para resolver problemas complejos y tomar decisiones con responsabilidad sobre bases científicas y tecnológicas en el ámbito de su especialidad.
- CG5-MGOIEM. (ENG) Capacidad de integración de sistemas marítimos complejos y de traducción en soluciones viables.
- CG11MGOIEM. Capacitat per realitzar tasques d’investigació, desenvolupament i innovació en l’àmbit de la seva especialitat

**Transversal:**
- CT2. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
- CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
- CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
- CT1. ENTREPRENEURSHIP AND INNOVATION: Knowing and understanding the organization of a company and the
This course will evaluate the following STCW competences:


A-III/2 - 5. Manage operation of electrical and electronic control equipment, including the KUPs: A-III/2 - 5.2 Design features and system configurations of automatic control equipment and safety devices, A-III/2 - 5.3 Design features and system configurations of operational control equipment for electrical motors, and A-III/2 - 5.5 Features of hydraulic and pneumatic control equipment.

Given different systems of the ship and/or marine facilities,
1. Know how to get models of their dynamic behavior that allow the subsequent design of control systems.
2. Know how to pose realistic specifications (stability, bandwidth, precision, implementability, cost).
3. Given the model and specifications, design and instrument a one-loop feedback control system, and know how to choose the control law.
4. Know how to design the controller by different methods (polynomial, empirical and graphical) in hand and with the help of the computer.
5. Understand the concept of optimal control, being able to choose reasonable behavior indexes and know to design the corresponding controllers.
6. Know how to design state space controllers for both pole placement and optimization.
7. Know how to analyze the behavior of the control system with the help of the computer.

Teaching methodology

Receive, understand and synthesize knowledge.
Define and solve problems by hand and with the help of the computer.
During the course each student will develop an individual work ("control system draft project"), in which he or she will apply the concepts presented in the lectures. This work consists in the design of a control system for a marine application chosen by each student and it will be delivered in four phases. At the end of the course, the students will have to defend their project orally.

Learning objectives of the subject

Total learning time:

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total learning time:</strong> 45h</td>
<td>45h</td>
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</tbody>
</table>
280725 - Avanced Control of Marine Systems

## Content

### Unit 1. Introduction to the marine systems control

**Description:**
As motivation several examples of control systems in marine applications are presented. The concept of feedback is introduced as well as the main transfer functions in a feedback control system.

**Related activities:**
- Phase I of the control project

**Specific objectives:**
- Know how to pose a control problem in the marine applications.

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>4h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theory classes:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Self study:</strong></td>
<td>2h</td>
</tr>
</tbody>
</table>

### Unit 2. Modeling and dynamic behavior (A-III/2 - 3.4, A-III/2 - 3.5)

**Description:**
The main mathematical and graphical methods that allow us to describe the behavior (time and frequency) of dynamic systems are presented. It is described how to identify the experimental model of a system.

**Related activities:**
- Phase II of the control project
- Practice 1
- Practice 2
- Problems

**Specific objectives:**
- To obtain models of dynamic systems in the marine applications (either by hand and simulation).

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
<th>14h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theory classes:</strong></td>
<td>6h</td>
</tr>
<tr>
<td><strong>Practical classes:</strong></td>
<td>4h</td>
</tr>
<tr>
<td><strong>Guided activities:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Self study:</strong></td>
<td>2h</td>
</tr>
</tbody>
</table>
### Unit 3. Analysis of feedback systems (A-III/2 - 5.5)

**Description:**
It is presented the root locus of Evans and the main tools for analyzing the stability and performance of feedback control systems.

**Related activities:**
- Phase III of the control project
- Practice 3
- Practice 4
- Problems

**Specific objectives:**
To know how to analyze the position of the poles, stability and behavior of a feedback control system.

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>16h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>8h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>4h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>2h</td>
</tr>
<tr>
<td>Self study:</td>
<td>2h</td>
</tr>
</tbody>
</table>

### Unit 4. Controller design (A-III/2 - 5.2, A-III/2 - 5.3)

**Description:**
It is described the main specifications that must satisfy a control system. We present different types of controllers and methods for their design.

**Related activities:**
- Phase IV of the control project l'ASC
- Practice 5
- Practice 6
- Practice 7
- Problems

**Specific objectives:**
To know how to choose the specifications and type of controller adequate for each situation and know how to design it.

<table>
<thead>
<tr>
<th>Learning time:</th>
<th>26h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes:</td>
<td>12h</td>
</tr>
<tr>
<td>Practical classes:</td>
<td>6h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>4h</td>
</tr>
<tr>
<td>Self study:</td>
<td>4h</td>
</tr>
</tbody>
</table>
Qualification system

The final mark is the sum of the partial grades as follows:

\[ N_{final} = 0.4 \times N_{pf} + 0.4 \times N_{pp} + 0.1 \times N_{ac} + 0.1 \times N_{el} \]

\( N_{final} \): Final grade
\( N_{pf} \): Qualification final test
\( N_{pp} \): Rating partial test
\( N_{ac} \): Continuous assessment (delivery problems)
\( N_{el} \): Qualification of laboratory sessions

Regulations for carrying out activities

If not done any of the continuous assessment activities or laboratory practices, this will be considered as non-rated (and its value is 0).
The delay in the deliveries (practice memòries, proposed problems, and phases of the control project will be penalized (each day of delay will take a point to the activity mark).
Students who do not make the final test will be graded as "not presented" in the subject.

Bibliography

Basic:

Complementary:

Others resources:
- Course notes, practices and problems collections in Atenea