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: 2018
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

Teaching staff
Coordinator: ROSA M. FERNANDEZ CANTI
Others: Primer quadrimestre:
   ROSA M. FERNANDEZ CANTI - 1

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:
CB10. Students must possess the learning skills that enable them continue studying in a way that will be largely self-directed or autonomous.
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

Specific:
CE24MEM. Apply analytical and experimental research techniques.

Generical:
CG8MEM. Acquire a critical independence. Defender of oral and written form their own ideas.

CG3MEM. Apply the acquired knowledge and problem solving environments new or unfamiliar environments within broader contexts and multidisciplinary being able to integrate this knowledge

Transversal:
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.
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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

This course will evaluate the following STCW competences:
A-III/2 - 3. Operation, surveillance, performance, assessment and maintaining safety of propulsion plant and auxiliary machinery,
including the KUPs: A-III/2 - 3.4 Functions and mechanism of automatic control for main engine, and A-III/2 - 3.5 Functions and mechanism of automatic control for auxiliary machinery.
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.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 45h</th>
<th>Hours large group:</th>
<th>45h</th>
<th>100.00%</th>
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# Content

## Unit 1. Introduction to the marine systems control

| Learning time: 4h |
|-------------------|---------------------|
| Theory classes: 2h |
| Self study: 2h    |

**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.

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

| Learning time: 14h |
|-------------------|---------------------|
| Theory classes: 6h |
| Practical classes: 4h |
| Guided activities: 2h |
| Self study: 2h      |

**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).
Unit 3. Analysis of feedback systems (A-III/2 - 5.5)

**Learning time:** 16h
- Theory classes: 8h
- Practical classes: 4h
- Guided activities: 2h
- Self study: 2h

**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.

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

**Learning time:** 26h
- Theory classes: 12h
- Practical classes: 6h
- Guided activities: 4h
- Self study: 4h

**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.
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**Qualification system**

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

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

- **Nfinal**: Final grade
- **Npf**: Qualification final test
- **Npp**: Rating partial test
- **Nac**: Continuous assessment (delivery problems)
- **Nel**: 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