Course guide
330137 - MSSD - Modelling and Simulation of Dynamical Systems

Unit in charge: Manresa School of Engineering
Teaching unit: 749 - MAT - Department of Mathematics.
Degree: BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN AUTOMOTIVE ENGINEERING (Syllabus 2017). (Optional subject).
Academic year: 2023
ECTS Credits: 6.0
Languages: Catalan, English

LECTURER

Coordinating lecturer: Cors Iglesias, Josep M.

Others:

PRIOR SKILLS

For a successful completion of the course, it is convenient to have previously taken the subjects Mathematics I, Mathematics II and Mathematics III.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to solve mathematical problems that may arise in engineering. Ability to apply the knowledge of: linear algebra, differential and integral calculus, differential equations, numerical methods, numerical algorithms and optimization

Transversal:
2. 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.
3. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

TEACHING METHODOLOGY

The large-group sessions (2 hours per week) will be held in the ordinary classroom. In these sessions the main methods and theoretical content will be presented. The small-group sessions (2 hours per week) will be held in the computer room, and will be mainly focused on the usage of Matlab as a simulation tool.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, students have to be able to:
- Formulate suitable mathematical models for different types of dynamical systems.
- Use of Matlab as a tool to simulate dynamical systems.
- Compute numerically the main objects of a dynamical system: periodic orbits, invariant manifolds,...
## STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self study</td>
<td>90,0</td>
<td>60.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>30,0</td>
<td>20.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>30,0</td>
<td>20.00</td>
</tr>
</tbody>
</table>

**Total learning time: 150 h**

## CONTENTS

### Unit 1: Mathematical modelling of dynamical systems.

**Description:**

**Specific objectives:**
Review of the main elements of mathematical modelling for dynamical systems with lumped parameters.

**Related activities:**
Activity A1.

**Full-or-part-time: 20h**
- Theory classes: 4h
- Laboratory classes: 4h
- Self study: 12h

### Unit 2: Numerical tools

**Description:**
Introduction to numerical methods.

**Specific objectives:**
Presentation of the main concepts and methods for numerical ODE solving.

**Related activities:**
Activity A1.

**Full-or-part-time: 40h**
- Theory classes: 8h
- Laboratory classes: 8h
- Self study: 24h
Unit 3: Mechanical vibrations.

Description:

Specific objectives:
Study and discussion of various dynamical models of mechanical oscillators and their numerical simulation.

Related activities:
Activity A2.

Full-or-part-time: 40h
Theory classes: 8h
Laboratory classes: 8h
Self study: 24h

Unit 4: Introduction to Chaos

Description:
Periodic forcing of nonlinear system and chaos.

Related activities:
Activity A3.

Full-or-part-time: 30h
Theory classes: 6h
Laboratory classes: 6h
Self study: 18h

Unit 5: Introduction to Simulink

Description:
To model, simulate, and analyze dynamical systems using Simulink

Related activities:
Activity A2.

Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 4h
Self study: 12h

ACTIVITIES

Activity A1: Computing periodic orbits in first-order equations

Description:
To compute periodic orbits using numerical tools.

Full-or-part-time: 8h
Self study: 8h
**Activity A2: Numerical simulation of mechanical vibrations.**

**Description:**
Application of the basic concepts of mechanical vibrations. Numerical modelling and simulation of mechanical oscillators with Matlab and Simulink.

**Full-or-part-time:** 8h  
Self study: 8h

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**Activity A3: Chaos**

**Description:**
Poincaré sections for a mechanical systems with a periodic forcing.

**Full-or-part-time:** 8h  
Self study: 8h

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**GRADING SYSTEM**

The course follows a continuous assessment system, which produces a course mark \( CM = \frac{1}{3} \times (M_1 + M_2 + M_3) \), where \( M_j, j = 1,2,3,4 \), represents the mark obtained in the activity \( A_j \). The course objectives will be considered achieved if \( CM \) is at least 5. Students who have completed the evaluation activities and obtain a course mark \( CM \) less than 5 can take a global exam. Students who pass that global exam will obtain a final grade of Pass 5; otherwise, they will keep their course mark (CM) as final grade.

Reevaluation: In this course there is a reevaluation procedure. Students who have obtained a failing grade in the ordinary assessment period can access the reevaluation process (students with a not-attended grade cannot access the reevaluation process). The reevaluation scheme consists in a new examination that takes place in the reevaluation period (at the end of June or the beginning of July). The reevaluation exam includes all the course material and produces a pass /fail outcome. Students who achieve a pass grade in the reevaluation exam will be awarded a final course mark of 5; otherwise, they will keep the grade obtained in the ordinary assessment process.

**EXAMINATION RULES.**

All evaluation activities are compulsory. A zero mark will be obtained in not-attended activities. Whenever possible, evaluation activities will be carried out in person. In online and homemade evaluation activities, when deemed appropriate, the authorship of the presented exams/reports will be validated by means of an additional questionnaire and / or a personal interview (online or in person).

**BIBLIOGRAPHY**

**Basic:**

**RESOURCES**

**Other resources:**
Notes and / or slides related to the theoretical and practical classes.  
List of problems.