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

Last modified: 04/05/2023

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 MECHANICAL ENGINEERING (Syllabus 2016). (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

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	30,0	20.00
Hours small group	30,0	20.00

Total learning time: 150 h

CONTENTS

Unit 1: Mathematical modelling of dynamical systems.

Description:
Mathematical models. First-order linear ODE models. General first-order ODE models. Higher-order ODE models.

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:
Mass-spring model. Mass-spring-damper model. Resonance. Multi-degree-of-freedom oscillators.

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

Activity A3: Chaos

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

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

GRADING SYSTEM

The course follows a continuous assessment system, which produces a course mark CM = 1/3 * (M1 + M2 + M3), where Mj, j = 1,2,3,4, represents the mark obtained in the activity Aj. 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:
- Klee, Harold. Simulation of dynamic systems with MATLAB and Simulink. Boca Raton, FL: CRC Press, cop. 2007. ISBN 9781420044188.
- Lynch, Stephen. Dynamical systems with applications using MATLAB [on line]. Boston [etc.]: Birkhäuser, cop. 2004 [Consultation: 29/01/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-319-06820-6. ISBN 0817643214.
- Bonet, Carles. Càlcul numèric [on line]. Barcelona: Edicions UPC, 1994 [Consultation: 27/07/2022]. Available on: https://upcommons.upc.edu/handle/2099.3/36356. ISBN 8476533764.
- Blanchard, Paul; Devaney, Robert L; Hall, Glen R; Persaud, Brian. Differential equations. 4th ed., International ed. Pacific Grove: Brooks/Cole, cop. 2011. ISBN 9781133110590.

RESOURCES

Other resources:
Notes and / or slides related to the theoretical and practical classes.

List of problems.