Universidad Zaragoza

Year : 2020/21

30111 - Mathematics III

Syllabus Information

Academic Year: 2020/21
Subject: 30111 - Mathematics III
Faculty / School: 175 - Escuela Universitaria Politécnica de La Almunia
179 - Centro Universitario de la Defensa - Zaragoza
Degree: 457 - Bachelor's Degree in Industrial Organisational Engineering
563 - Bachelor's Degree in Industrial Organisational Engineering
425 - Bachelor's Degree in Industrial Organisational Engineering
ECTS: 6.0
Year: 2
Semester: First semester
Subject Type: Basic Education
Module: ---

1.General information

1.1.Aims of the course

Differential equations are a key element of modern mathematics. They constitute a solid ground for analysis, modeling and problem solving in diverse fields such as Engineering, Physical Sciences, Economics or Business.

An outstanding learning goal of the course is the mastery of practical and theoretical techniques which can be directly applied to realistic problem solving, using efficient and reliable computational software tools. It is therefore of utmost importance in the training of an engineer/officer to acquire this course's learning goals.

This course belongs to the basic education module. It addresses the ability to solve mathematical problems which can arise in Engineering. The basic education module provides working knowledge of linear algebra, geometry, differential geometry, differential and integral calculus, ordinary and partial differential equations, numerical methods and algorithms, statistics and optimization. All these subjects are covered by the courses Mathematics I, Mathematics II, Mathematics III and Statistics.

Mathematics III is a 6 ECTS credit compulsory course to be taken in the first semester, second year of the degree.

1.2.Context and importance of this course in the degree

The Mathematics III course is taken during the first semester of the second year of the Bachelor's Degree in Industrial Organisational Engineering.

This course aims to entitle students to pursue another scientific courses featuring mathematics, and prominently differential equations, as basic background. The topics covered in this course have applications in several fields of Engineering and Defense. The language, critical thinking and reasoning which are inherent to Mathematics will help the students to understand the aforementioned courses.

1.3.Recommendations to take this course

The recommended profile to take Mathematics III is to possess the knowledge and skills acquired in previous subjects of the degree as Mathematics I and II.

In order to follow this subject correctly, it is also necessary to have a willingness to carry out a continuous work and effort from the beginning of the course. It is also advisable for students to resolve its doubts as they arise using classroom, tutorials as well as resources that the teachers make available.

2.Learning goals

2.1.Competences

In passing this subject, the student will be competent in:

- **C04** - Ability to solve problems and take decisions with initiative, creativity and critical reasoning.
- **C05** - Ability to apply Information and Communication Technologies (ICTs) within the field of engineering.
- **C06** - Ability to communicate knowledge and skills in Spanish.
- **C11** - Ability to continue learning and develop self-learning strategies.
- **C12** - Ability to solve mathematical problems in engineering. Ability to apply knowledge about lineal algebra,

geometry, differential geometry, differential and integral calculus, differential equations, partial derivatives, numerical methods and algorithmics.

2.2.Learning goals

The student, in order to pass this subject, will have to achieve the following goals...

1. He/she knows how to apply the main results about ODEs and PDEs as well as the numerical methods solving problems from the aforementioned disciplines.
2. He/she develops and experiments problem solving strategies and is able to distinguish the most appropriate method in each case.
3. He/she is able to reason the difficulty of solving a problem in an exact way and the necessity to apply numerical approximation methods to solve it, determining the degree of precision and the error made.
4. He/she knows how to use a symbolic calculator applied to ODEs and PDEs.
5. He/she is able to pose and rigorously solve problems in the previous areas applied to Industrial Organizational Engineering, choosing the most appropriate methods and theoretical results and, in the view of the complexity of solving these real problems analytically, he/she is able to solve them using the software from point 4.
6. He/she is able to solve, working in team, the problems from point 5 widening the information and the methods presented during the classes. He/she is, in addition, able to perform oral presentations of the obtained results using the appropriate mathematical language and the more convenient software.
7. He/she is able to express, both in oral and written form, and using scientific language, the basic facts of the subject and the process of problem solving.

2.3.Importance of learning goals

The obtained learning outcomes are important because they provide the students mathematical and procedural knowledge. These are in the basis of other scientific and technological subjects of the degree like, for instance, Physics, Mechanics, Operations research, Economics, Electronics, and Materials resistance. The ability to apply mathematical techniques to solve specific problems of different engineering-related fields is a core competence of an engineer or an officer, as well as how to use of available resources and how to interpret the solutions.

3.Assessment (1st and 2nd call)

3.1.Assessment tasks (description of tasks, marking system and assessment criteria)

Students must show that they have achieved the expected learning outcomes through the following assessment activities:

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- **Continuous assessment system:**
  - **Written tests:** Throughout the semester there will be two written tests on theoretical and practical aspects on the subject. Its weight in the final grade will be 80%.
    These tests will assess:
    - The understanding of mathematical and statistical topics used in problem solving.
    - The correct use of strategies and appropriate procedures towards its resolution.
    - Clear and detailed explanations.
    - The correct use of terminology and notation.
    - Orderly, clear and organized exhibition.

    In order to opt for the continuous assessment modality, it is necessary to attend at least 80% of the classroom activities of the subject.
  - **Participatory tests:** Throughout the course, the student will carry out 4 participatory tests valued at 5% of the final grade. They will consist of carrying out practical exercises.
    These tests will assess:
    - The understanding of mathematical and statistical topics used in problem solving.
    - The correct use of strategies and appropriate procedures towards its resolution.
    - Clear and detailed explanations.
    - The correct use of terminology and notation.
    - Orderly, clear and organized exhibition.
- **Global assessment**
  Students who have not passed the subject with the continuous assessment system must take a compulsory written test in official calls equivalent to the written tests described in point 1, whose weight in the final grade will be 100%. The evaluation criteria will be those described in the previous sections.

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CONTINUOUS ASSESSMENT

There will be 3 tests (whose combined weight will be the 50% of the final grade) and a written exam (weighing the remaining 50%) during the semester. In order to pass the subject under this type of evaluation, students must obtain a grade equal to or higher than 5 in the addition of the 4 examinations.

GLOBAL ASSESSMENT

According to the schedule of the Centre there are two official calls, one in January and one in August. Each of these calls will consist of an exam with two parts (a test and written exercises). To pass the course, students must obtain a grade equal to or higher than 5 in the exam. Those students having passed the subject in the continuous assessment mode can decide to carry out the global assessment examination without losing their earned grade. No grades will be preserved for the August call.

ASSESSMENT CRITERIA

The tests will assess:

- The understanding of the mathematical concepts used to solve problems.
- The use of efficient strategies and procedures in their resolution.
- The absence of mathematical errors in the development and solutions.
- Correct use of terminology and notation.
- Orderly, clear and organized exposition.
- The correct resolution of the problems and the mathematical methods and strategies used.
- The correct interpretation of the obtained results.
- The ability to choose the most appropriate method.
- Explanations and/or clear and detailed reasoning to the asked questions.
- The mastery and correct use of the mathematical software commands necessary to solve practical tests.

4.Methodology, learning tasks, syllabus and resources

4.1.Methodological overview

The learning process designed for this subject is based on the following:

Strong interaction between the teacher/student. This interaction is brought into being through a division of work and responsibilities between the students and the teacher. Nevertheless, it must be taken into account that, to a certain degree, students can set their learning pace based on their own needs and availability, following the guidelines set by the teacher.

The current subject, Matemáticas III, is conceived as a stand-alone combination of contents, yet organized into three fundamental and complementary forms, which are: the theoretical concepts of each teaching unit, the solving of problems or resolution of questions, at the same time supported by other activities.

The organization of teaching will be carried out using the following steps:

Lectures:

Theoretical activities carried out mainly through exposition by the teacher, where the theoretical supports of the subject are displayed, highlighting the fundamental, structuring them in topics and or sections, interrelating them.

Practice sessions:

The teacher resolves practical problems or cases for demonstrative purposes. This type of teaching complements the theory shown in the lectures with practical aspects.

Individual Tutorials:

Those carried out giving individual, personalized attention with a teacher from the department. Said tutorials may be in person or online.

If classroom teaching were not possible due to health reasons, it would be carried out on-line.

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If this teaching could not be done in person for health reasons, it would be done telematically

The methodology of the course encourages students' continuous assessment focusing on the practical aspects of differential equations. In order to achieve this goal, the theoretical concepts of the subject are presented with examples and case studies. Additionally, the notions discussed in class are reinforced weekly with tutorials and seminars. Also, the use of a mathematical software tool is promoted.

4.2.Learning tasks

The course includes the following learning tasks:

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Involves the active participation of the student, in a way that the results achieved in the learning process are developed, not taking away from those already set out, the activities are the following:

- Face-to-face generic activities:

    - Lectures: The theoretical concepts of the subject are explained and illustrative examples are developed as a support to the theory when necessary.
    - Practice sessions: Problems and practical cases are carried out, complementary to the theoretical concepts studied.
- Generic non-class activities:
    - Study and understanding of the theory taught in the lectures.
    - Understanding and assimilation of the problems and practical cases solved in the practical classes.
    - Preparation of seminars, solutions to proposed problems, etc.
    - Preparation of the written tests for continuous assessment and final exams.

The subject has 6 ECTS credits, which represents 150 hours of student work in the subject during the trimester, in other words, 10 hours per week for 15 weeks of class.

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Theoretical lectures for the understanding of the basic knowledge, fostering a participatory approach.

Exercise and problem lectures, combining the standard resolution of exercises on the blackboard with group work and discussion.

Computer lab sessions using specific mathematical software. Classes are designed to allow students to practice and develop a wide range of practical and manipulative skills.

Personal attention both in small groups and individually.

Individual continuous work from the beginning of the academic year. Basic theoretical contents, worksheets, guides of computer lab sessions as well as any other complementary material are available on the Moodle platform.

4.3.Syllabus

The course will address the following topics:

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1. Ordinary Differential Equations: basic concepts, existence, and uniqueness.
2. Analytic solvability.
3. Qualitative aspects: fixed points and linear stability.
4. Numerical methods: Euler, Runge-Kutta.
5. Higher-order ODE: Oscillators; resonance. Beam stability.
6. Higher-order numerical methods (FDM y FEM).
7. Introduction to Partial Differential Equations: separation of variables; vibrations.
8. Laplace Transform.
9. Laplace Transform Applications.
10. Discrete-time systems.
11. The Z Transform.
12. Z Transform Applications.
13. Fourier Series and Fourier Transform.
14. Applications of Fourier Series and Transforms.
15. Discrete-Time Fourier Transform: FFT and Applications.

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The contents of this subject are organized as follows:

- Chapter 1: Introduction to differential equations
- Chapter 2: Existence and uniqueness of solution or ordinary differential equations and initial value problems
- Chapter 3: Qualitative study of the solutions of ordinary differential equations and autonomous systems
- Chapter 4: Solution of ordinary differential equations and initial value problems of the first order
- Chapter 5: Mathematical tools: Laplace transforms and Fourier series
- Chapter 6: Solution of ordinary differential equations and initial value problems of higher order and of first-order linear systems
- Chapter 7: Partial differential equations

4.4.Course planning and calendar

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The dates of the final exams will be those that are officially published at https://eupla.unizar.es/asuntos-academicos/examenes.

Week	Theme	Topic	Tests	Weight	Content
1	1	ODE: Introduction, 1st order			
2		Linear equation, Systems	1st test	5	ODE 1st order
3		Linear stability			
4		Numerical Methods			
5	2	2nd order ODE			
6		Oscillators, resonance	2nd test	5	Oscillators
7		Beam Stability			
8			1st Exam	40	ODE, Oscillators
9	3	Signals and systems			
10		Laplace Transform			
11		Applications	3rd test	5	Laplace Transf.
12		Z Transform			
13	4	Fourier Series and Transform	4th test	5	Z/Fourier Transf.
14	5	PDE: Introduction			
15		Separation of variables	2nd Exam	40	Systems, PDE

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The course is organized in 15 weeks of two-hour lectures twice a week approximately. The academic calendar, computer lab sessions, and the formal examination dates are published on the Moodle platform and the website of the Institution (http://cud.unizar.es) at the beginning of the academic year.

4.5.Bibliography and recommended resources

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Main resources

- Subject presentations (available in the subject's Moodle webpage)
- Problem sheets (available in the subject's Moodle webpage)
- Symbolic calculus tool `Maxima` http://andrejv.github.io/wxmaxima/.

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Bibliography can be found at:

http://biblos.unizar.es/br/br_citas.php?codigo=30111&year=2020