Universidad Zaragoza

Academic Year/course: 2021/22

28700 - Mathematics applied to engineering I

Syllabus Information

Academic Year: 2021/22
Subject: 28700 - Mathematics applied to engineering I
Faculty / School: 175 - Escuela Universitaria Politécnica de La Almunia
Degree: 423 - Bachelor's Degree in Civil Engineering
ECTS: 6.0
Year: 1
Semester: First semester
Subject Type: Basic Education
Module:

1. General information

1.1. Aims of the course

The foreseen outcomes of this signature are based on the following approaches and objectives:
The basic mathematical tools and their methods are part of the different tools that professional engineers need, to face and solve the different sort of problems they are going to find in the real life, therefore, among the learning outcomes, students are expected to get a good knowledge and capability for implementing numerical and analytical solutions using real calculus based on high quality softwares and computer programs. Taking this into account, this is the main reason why Engineering and Architectural students need to get the learning outcomes of this subject.
Successful students must be able to gather and implement the basic tools of this subject in any aspect related to the Engineering or Architectural area, making it into the basic tool for any other subject in their chosen degree and at the same time acquiring techniques that will improve and give them a successful professional development.

These approaches and objectives are in line with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of the course learning outcomes provides training and competence to contribute to their achievement to some degree.

Goal 4: Quality Education

1.2. Context and importance of this course in the degree

This subject is part of the basic structure of academic knowledges required for the students to overcome with success this academic degree. It is being taught in the first semester in the first course with the main purpose of providing students new mathematical tools and skills that are going to be essentials in the good learning and successful study of the different subjects they are going to face with in higher courses, such as Physics, Economy, Statistics, among others.
The main focus of this subject is to provide students high capability and skill in the comprehension, implementation and right use of the mathematical tools in any engineering problem, giving the best solution and being able to explain with it the different observed phenomena.

1.3. Recommendations to take this course

It is advisable for the students to have a good knowledge of basic integral and differential calculus along with a reasonable capability and skill using symbolic and numerical softwares.

2. Learning goals

2.1. Competences

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

- G01 - Ability to scheduling and organization
- G02 - Ability to problem solving
- G03 - Ability to decision making
- G04 - Ability for oral and written communication in the native language
- G05 - Ability for analysis and synthesis

- G06 - Ability to manage information
- G07 - Ability for teamwork
- G08 - Ability for critical reasoning
- G09 - Ability to work in an interdisciplinary team
- G10 - Ability to work in an international context
- G11 - Improvisation and adaptation capacity to face new situations
- G12 - Leadership aptitude
- G13 - Positive social attitude towards social and technological innovations
- G14 - Ability to reason, discuss and present your own ideas
- G15 - Ability to communicate through words and images
- G16 - Ability to search, analyze and select information
- G17 - Ability for independent learning
- G18 - Possess and understand knowledge in an area of study that starts at the base of general secondary education, and is usually found at a level that, although supported by advanced textbooks, also includes some aspects that involve cutting-edge knowledge from your field of study
- G19 - Apply their knowledge to their work or vocation in a professional way and possess the competencies that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of study
- G20 - Ability to collect and interpret relevant data (usually within their area of study) to make judgments that include reflection on relevant issues of a social, scientific or ethical nature
- G21 - Transmit information, ideas, problems and solutions to a specialized and non-specialized audience
- G22 - Develop those learning skills necessary to undertake further studies with a high degree of autonomy
- G23 - Know and understand respect for fundamental rights, equal opportunities for women and men, universal accessibility for people with disabilities, and respect for the values of the culture of peace and democratic values
- G24 - Promote entrepreneurship
- G25 - Knowledge in information and communication technologies
- B01 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge about: linear algebra; geometry; differential and integral calculus; numerical methods.

2.2. Learning goals

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

1. He/She is able to solve mathematical problems that may arise in Engineering.
2. He/She is able to use the acquired knowledge in Linear Algebra and Geometry.
3. He/She is able to use numerical methods in problem solving.
4. He/She knows how to use symbolic and numerical software tools.
5. He/She possesses scientific-mathematical thinking skills.
6. He/She is able to use methematical language, especially formal and symbolic language.

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, Economics. The ability to apply mathematical techniques to solve specific problems of different engineering-related fields is a core competence of an engineer, as well as how to use 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:

- **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.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards the achievement of the learning objectives. A wide range of teaching and learning tasks are implemented, such as theory sessions, practice sessions, and tutorials.

A strong interaction between the teacher and the student is promoted. 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 course "Matemática Aplicada a la Ingeniería I" is conceived as a stand-alone combination of contents, yet organized into two fundamental and complementary forms, which are: the theoretical concepts of each teaching unit and the solving of problems or resolution of questions, at the same time supported by other activities.

Here, the practical and theory sessions are combined with the continuous use of high quality free and open-source software, which allows a deeper comprehension and quick visualization of new mathematical tools and concepts.

Regarding the slides, proposed exercise photocopies, laboratory session guides and other materials used in class, all of them will be available on the Moodle platform of this course.

Material	Format
Topic theory notes Topic problems	Paper/repository
Topic theory notes Topic presentations Topic problems Related links	Digital/Moodle, E-mail
Educational software	Open source Maxima and Octave

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

4.2. Learning tasks

This course is organized as follows:

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

- **Theory sessions** (2 ECTS: 20 h): Theoretical activities carried out mainly through exposition by the teacher, where the theoretical concepts of the course are displayed, highlighting the fundamentals, structuring them in topics and/or sections, interrelating them.
- **Practice sessions** (1.77 ECTS: 17.7 h): The teacher solves practical problems or cases for demonstrative

purposes. This type of teaching complements the theory shown in the theory sessions with practical aspects. Here, students are expected to participate actively in the class throughout the term.

- **Tutorials**: Those carried out giving individual, personalized attention with a teacher from the department. These tutorials may be on-site or online.
- **Autonomous work and study**: (1.5 ECTS: 15 h)
    - 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 semester, in other words, 10 hours per week for 15 weeks of class.

A summary of a weekly timetable guide can be seen in the following table. These figures are obtained from the course file in the Accreditation Report of the degree, taking into account the level of experimentation considered for this course is moderate.

Activity	Weekly school hour
Lectures	6
Other activities	3

There is a tutorial calendar timetable set by the teacher that can be requested by those students who are interested in tutorials.

4.3. Syllabus

This course will address the following topics:

Introduction to the open-source software Maxima and revision of real functions of real variables

Limits and Continuity of functions

- Limits, indeterminate forms, equivalence functions
- Continuity and discontinuity of functions
- Classical theorems
- Bisection method

The derivative

- The derivative, the tangent (straight) line, properties, and rules
- The chain rule
- Implicit differentiation, inverse function, and parametric functions
- Newton's Method
- Classical theorems: Rolle, Mean value and L'Hôpital
- Taylor polynomials and approximations
- Interpolation and numerical differentiation
- Monotonic function, increasing and decreasing functions, concavity and convexity of functions

Integration

- Riemann Integral and its basic properties
- Antiderivatives and indefinite integration
- Fundamental theorems of Calculus
- Improper integrals
- Geometric applications
- Numerical integration

System of linear equations

- Groups, rings, and fields
- System of linear equations: elementary operations
- Gaussian elimination and rank of a matrix
- Theorems of characterization (Rouché-Frobenius)

- Determinants
- Numerical Gaussian elimination, condition number
- Decompositions: LU, QR, and Cholesky
- Iterative methods

Vector spaces with inner products

- Linearly independent sets, dimension, and basis
- Subspaces of vector spaces
- Inner product
- Length, angles, and orthogonality
- Orthogonal subspaces and sets
- Orthogonal projection and optimal approximation

Diagonalization

- Eigenvalues and eigenvectors
- Spectral decomposition and polynomials of matrices
- Normal matrices
- Numerical methods for approximating eigenvalues
- Compatible matrices
- Singular value decomposition (SVD)

4.4. Course planning and calendar

The written assessment tests will be related to the following topics:

- **Test 1**: Limits and continuity.
- **Test 2**: The derivative.
- **Test 3**: Infinitesimal calculus.
- **Test 4**: System of linear equations.
- **Test 5**: Vector spaces.
- **Test 6**: Linear Algebra.

Week	Topic	Contents	Test	Weight	Topics
1	1	Maxima - functions	First test	5%	Limits - Continuit
2	2	Limits - Continuity			
3	3	The derivative	Second test	5%	The derivative
4		Taylor			
5		Interpolation			
6	4	Integration	First written exam	40%	Infinitesimal calcu
7		Applications			
8		Numerical integration			
9	5	System of linear equations	Third test	5%	Linear systems
10		Determinants			
11		Numerical Linear Algebra			
12	6	Vector spaces	Fourth test	5%	Vector spaces
13		Optimal approximation			
14	7	Diagonalization	Second written exam	40%	Linear Algebra
15		Singular value decomposition			

Further information concerning the timetable, classroom, office hours, assessment dates (https://eupla.unizar.es/asuntos-academicos/examenes) and other details regarding this course will be provided on the first day of class or please refer to the Faculty of EUPLA website and Moodle.

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=28700&Identificador=12524