Linear Algebra

Academic Year: (2023 / 2024) **Review date: 12-02-2024**

Department assigned to the subject: Mathematics Department

Coordinating teacher: RASCON DIAZ, CARLOS

Type: Basic Core ECTS Credits : 6.0

Year : 1 Semester : 1

Branch of knowledge: Engineering and Architecture

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Mathematics in scientific-technological "bachillerato" (high school)

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CE1. Solve mathematical problems that may arise in engineering and apply knowledge of linear algebra, differential and integral calculus, numerical methods, numerical algorithms, statistics, differential equations and in partial derivatives, complex and transformed variables.
CE22. Design, plan and estimate the costs of an engineering project.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.

RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require creating and innovative thinking.
RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study.
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be

able to plan and organize their own training with a high degree of independence.

OBJECTIVES

The student will become familiar with the concepts of:

1- Linear systems.
2- The algebra of matrices and vectors.
3- Vector subspaces in Rn.
4- Complex numbers.

The student will acquire the skills to be able:

1- Calculate the solution of a system of linear equations
2- Discuss the existence and uniqueness of solutions of a system of linear equations
3- Operate with vectors and matrices
4- Calculate the inverse of a matrix
5- Calculate bases of vector subspaces
6- Calculate eigenvalues and eigenvectors of a matrix
7- Calculate an orthonormal base from any basis
8- Solve least-squares problems
9- Calculate a unitary diagonalization of a normal matrix

DESCRIPTION OF CONTENTS: PROGRAMME

1. Complex numbers
   · Numbers sets
   · Necessity of complex numbers
   · Binomial form of a complex number
   · Graphical representation
   · Operations
   · Complex conjugate, modulus, argument
   · Polar form of a complex number
   · Roots of complex numbers
   · Exponential of a complex number
   · Solving equations
2. Systems of linear equations
   · Introduction to Linear Equations
   · Geometrical Interpretation
   · Existence and Uniqueness
   · Matrix Notation
   · Gaussian Elimination
   · Row Equivalence and Echelon Forms
   · Solving Linear Systems
   · Homogeneous Systems
   · Simultaneous Solving
   · Systems with parameters
3. The vector space Cn
   · Vectors
   · Linear Subspace
   · Linear Combinations
   · Subspace Spanned by Vectors
   · Column and Row Spaces
   · The Matrix Equation Ax=b
   · Null Space
   · Revisiting Linear Systems
   · Linear Independence
   · Basis for a Linear Subspace
   · Dimension of a Linear Subspace
   · Basis for Col A, Row A and Nul A
   · Rank of a Matrix
   · Coordinate Systems
   · Introduction to Linear Transformations

4. Matrix algebra
   · Matrix Operations
   · Transpose of a Matrix
   · Conjugate Transpose of a Matrix
   · Inverse of a Matrix
   · Partitioned Matrices
   · Determinants
5. Eigenvalues and eigenvectors
   · Eigenvalues & Eigenvectors
   · The Characteristic Equation
   · Diagonalization
   · Change of Basis
   · Transformations between Linear Subspaces
   · Abstract Vector Spaces
6. Orthogonality
   · Dot Product and Modulus
   · Orthogonal Sets
   · Unitary Matrices
   · Orthogonal Complement
   · Orthogonal Projection
   · The Gram-Schmidt Process
   · The QR decomposition
   · Least-Squares Problems
7. Normal matrices
   · Schur Decomposition
   · Normal Matrices & Unitary Diagonalization
   · Particular Cases of Normal Matrices

LEARNING ACTIVITIES AND METHODOLOGY

The teaching methodology will include
- Theory classes, where the knowledge that students must acquire will be presented. A textbook (Linear Algebra and its Applications, by David C. Lay) will be followed to facilitate its development. Students will receive the course syllabus and are expected to prepare classes in advance.
- Resolution of exercises by the student that will serve as self-evaluation and to acquire the necessary skills.
- Problem classes, in which the problems proposed to the students are developed and discussed.
- The teacher may pose problems and work to solve individually or in group.
- The teacher will set his schedule of individual tutorials.

ASSESSMENT SYSTEM

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

- Continuous evaluation: It corresponds to 40% of the final mark. At the beginning of the course, the theory teacher will choose one of these:
1) Mid-term exams held along the course to assess the student's progression.
2) Students must hand in the proposed problems, in the problem class.

- Final exam: It corresponds to 60% of the final mark. It helps assess the student's general understanding of the subject.

ATTENTION: To pass the subject, the student MUST pass the final exam.

BASIC BIBLIOGRAPHY

- D.C. Lay, S.R. Lay and J.J MacDonald Linear algebra and its applications, Pearson, 2016

- G. Strang Introduction to Linear Algebra, Cambridge, 2016

- S.A. García and R.A. Horn A second course in linear algebra, Cambridge, 2017

- Sergei Treil Linear Algebra Done Wrong, Edited by the author, available from https://www.math.brown.edu/~treil/papers/LADW/LADW.html, 2017 (last update)

ADDITIONAL BIBLIOGRAPHY

- B. Noble and J. W. Daniel Applied Linear Algebra, 3rd ed., Prentice Hall, 1988

BASIC ELECTRONIC RESOURCES

- Sergei Treil . Linear Algebra done wrong: https://www.math.brown.edu/~treil/papers/LADW/LADW.html