Universidad de Navarra

Algebra (English)

Teaching guide 2026-27

PRESENTATION

Brief description:

Linear algebra is the branch of Mathematics that focuses on the study of vector spaces and their linear applications. Matrix calculus makes it possible to tackle questions such as: solving a system of linear equations, decomposing a vector as a linear combination of other given vectors, linearly transforming the vectors of a vector space into others in the same space, finding out which vectors do not change direction when linearly transformed, and many others, all of which are relevant in practical applications.

Today's technological advances are closely linked to matrix calculus. For example, the Google search engine enables us to classify the information we want according to its relevance online, based on an original algorithm that is in turn based on an eigenvalue and eigenvector problem.

Qualification (Module/Subject):

- Industrial Technologies Engineering (Basic Training/ Basic Mathematics)
- Mechanical Engineering (Basic Training/ Basic Mathematicse)
- Electrical Engineering (Basic Training/ Basic Mathematics)
- Industrial Electronics Engineering (Basic Training/ Basic Mathematics)
- Telecommunication Systems Engineering (Basic Training/Mathematics and Computer Science)
- Industrial Management Engineering (Basic Training/Basic Mathematics)
- Industrial Design and Product Development Engineering (Basic Training/ Basic Mathematics)
- Biomedical Engineering (Basic Training/Basic Mathematics)
- Artificial Intelligence Engineering (Basic Training/Basic Mathematics)

Details:

- **ECTS**: 6 ECTS
- **Year, semester**: 1st year, 1st semester
- **Character**: Basic
- **Language**: Spanish

Lecturers in the subject:

Barasoain Echepare, Íñigo

LEARNING OUTCOMES

INDUSTRIAL TECHNOLOGIES ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study that builds on the foundation of general secondary education and is usually at a level which, while relying on advanced textbooks, also includes some aspects that involve knowledge deriving from the cutting edge of their field of study.

R2 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and in partial derivatives; numerical methods; numerical algorithms; statistics and optimisation.

MECHANICAL ENGINEERING

R1- Students will have demonstrated knowledge and understanding in an area of study that builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects involving knowledge deriving from the cutting edge of their field of study.

R24 - Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and provides them with the versatility to adapt to new situations.

R2- Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential and partial derivative equations; numerical methods; numerical algorithms; statistics and optimisation.

ELECTRICAL ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study that builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects that involve knowledge deriving from the cutting edge of their field of study.

R2 - Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and provides them with the versatility to adapt to new situations.

R3 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and in partial derivatives; numerical methods; numerical algorithms; statistics and optimisation.

INDUSTRIAL ELECTRONICS ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study which builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects involving knowledge deriving from the cutting edge of their field of study.

R22 - Knowledge in basic and technological subjects, which enables them to learn new methods and theories, and provides them with the versatility to adapt to new situations.

R2 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and in partial derivatives; numerical methods; numerical algorithms; statistics and optimisation.

TELECOMMUNICATION SYSTEMS ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study that builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects that involve knowledge deriving from the cutting edge of their field of study (Type: Knowledge or Content).

R2 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and in partial derivatives; numerical methods; numerical algorithms; statistics and optimisation. (Type: Knowledge or Contents)

INDUSTRIAL ORGANISATION ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study which builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects involving knowledge deriving from the cutting edge of their field of study.

R2 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and in partial derivatives; numerical methods; numerical algorithms; statistics and optimisation.

R40 - Provide a solid foundation in science, technology, operations management, production and business management.

INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study which builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects involving knowledge deriving from the cutting edge of their field of study.

R3 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; numerical methods; numerical algorithms; statistics and optimisation.

BIOMEDICAL ENGINEERING

R1 - Students will have demonstrated knowledge and understanding in an area of study that builds on the foundation of general secondary education, and is usually at a level which, while relying on advanced textbooks, also includes some aspects that involve knowledge deriving from the cutting edge of their field of study.

R31 - Training must provide the graduate with a solid scientific basis to enable them to rigorously address any professional challenges they may face in the biomedical sector.

R23 - Ability to solve mathematical problems that may arise in engineering. Ability to apply knowledge of: linear algebra; geometry; differential geometry; differential and integral calculus; numerical methods; numerical algorithms; statistics and optimisation.

ARTIFICIAL INTELLIGENCE ENGINEERING

R1 - Describe the fundamentals of linear algebra; geometry, differential geometry, differential and integral calculus, differential equations and in partial derivatives, numerical methods, numerical algorithms, statistics and optimisation to solve mathematical problems applied to the field of engineering (Type: Knowledge or contents).

COURSE CONTENT

1. MATRICES: Definitions. Matrix operations. Inverse of a regular matrix. Block matrices. Special square matrices.

2. SYSTEMS OF LINEAR EQUATIONS: Definitions. Solution structure. Gaussian and Gauss-Jordan methods. Calculation of the inverse of a regular matrix. LU factorisation and its variants. Cholesky factorisation. Computational cost

3. DETERMINANTS: Definitions. Properties. Practical calculation of determinants.

4. VECTOR SPACES: Definitions. Vector subspaces. Generated subspaces. Linear dependence and independence. Bases and dimension. Implicit and parametric equations. Sum and intersection of subspaces. Change of basis.

5. LINEAR APPLICATIONS: Definitions. Properties. Linear transformations. Kernel and image of a linear application. Matrix of a linear application. Kernel and image of a matrix. Rank and nullity. Change of basis

6. SCALAR PRODUCT: Definitions. Orthogonality and induced norm. Orthonormal bases. Expression of the scalar product in an orthonormal basis. Components of a vector in an orthonormal basis. Induced metric. Orthogonal projection. Unitary and orthogonal matrices. Gram-Schimidt method. QR factorisation

7. Eigenvalues and eigenvectors: Definitions. Obtaining eigenvalues and eigenvectors. Diagonalisation of a square matrix. Diagonalisation criteria. Characteristic polynomial and Vieta's formulae. Cayley-Hamilton theorem. Power method. QR method.

8. DIAGONALISATION OF NORMAL MATRICES: Diagonalisation of Hermitian matrices. Classification of Hermitian matrices. Obtaining Q and D matrices. QR method for Hermitian matrices. Singular value decomposition (SVD). Real quadratic forms

9. DIFFICULTIES IN SOLVING Ax=b: Spectral norm. Stability analysis in systems of equations. Gaussian method using partial pivoting. The least squares problem and normal equations. Minimum norm solution. Pseudoinverse and orthogonal projection matrices.

TRAINING ACTIVITIES

Face-to-face classes

In face-to-face classes, theory content is alternated with examples to ensure students may better understand the concepts and at the same time work on the problems proposed on a weekly basis by lecturers. Students should attend class having assimilated the contents of previous classes in order to understand the new concepts being introduced.

Problem seminars

A problem seminar will be held every week to answer students' queries about the problems proposed.

Personal study

- Students should individually study the subject matter explained in each class as soon as possible, preferably before the next class, as each concept and topic usually builds on the previous ones.
- Students will combine their class notes, the subject notes prepared by lecturers and consultation of the recommended bibliography.
- In addition to the examples dealt with during classes, students will work on their own on the problems proposed by lecturers every week. In addition, there are theoretical modules from previous years and video-recorded problems accessible via the ADI content section.

EVALUATION

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ORDINARY EXAMINATION SESSION

The total for the ordinary examination session mark is obtained following completion of the final and mid-term exams. These exams will evaluate theoretical and practical content.

EXTRAORDINARY EXAMINATION SESSION

The total for the extraordinary examination mark is obtained following completion of the resit exam. This exam will evaluate theoretical and practical content.

OFFICE HOURS

Algebra lecturers will be available for individual consultations by appointment. The timetable will be established at the beginning of the course.

In addition, any queries will be answered collectively during the problem seminars.

BIBLIOGRAPHY

Basic bibliography

Teachers' notebook

Carl D. Meyer, "Matrix Analysis and Applied Linear Algebra" ISBN-13: 978-0898714548 Find it in the library

Flaquer, J., Olaizola, J., Olaizola, J. "Curso de Álgebra Lineal (Contiene Libro electrónico de Álgebra Lineal en CD-ROM)", EUNSA, 563 pp, 2004 (3rd Edition) Find it in the library

Supplementary bibliography

Strang, G. "Linear Algebra and its Applications". Find it in the library

David C. Lay, "Linear Algebra and its Applications", Pearson International Edition 2021(6ª edition) Find it in the library