# 240011 - Linear Algebra

**Coordinating unit:** 240 - ETSEIB - Barcelona School of Industrial Engineering  
**Teaching unit:** 749 - MAT - Department of Mathematics  
**Academic year:** 2019  
**Degree:**  
- BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
- BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)  
**ECTS credits:** 6  
**Teaching languages:** Catalan, Spanish

## Degree competences to which the subject contributes

**Specific:**
- CE1. Capacity to solve mathematical problems that can appear in engineering. Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.

**Transversal:**
- 04 COE. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
- 05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
- 07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

## Teaching methodology

In the theoretical sessions, the basic theory is presented by showing them the most important notions and results by means of examples.  
In the practical sessions, the exercises and problems which has been solved previously by the students are commented in class in order to consolidate the concepts that have been seen in the theoretical class. Moreover, modelling problems are presented to see the importance of algebra when solving applied science and engineering problems.  
In the workshop sessions the students work with the software Matlab (or Octave) mathematical tool in order to introduce effective methods for calculating ranges matrices, solving systems of equations and computation of eigenvalues and eigenvectors. The students will present their work by means the e-portfolio, a guide will be show in class.

## Learning objectives of the subject

The objectives are:  
1) To provide a comprehensive treatment of the Theory of Matrices required by the various technological disciplines. In this sense the concepts and techniques that are introduced are illustrated with elementary engineering applications. Suitable for the treatment of cases with high-dimensional tools are presented in the same sense.
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ii) Sign in handling matrices for solving systems of equations apply to large differences in different areas of engineering.

iii) Acquisition of knowledge and basic principles on the geometry of vector spaces.

iv) Understanding the role of linear applications in the context of vector spaces and their relationship with matrix algebra.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Total learning time: 150h</th>
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<tbody>
<tr>
<td>Hours large group:</td>
<td>56h</td>
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<tr>
<td>Hours medium group:</td>
<td>0h</td>
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<tr>
<td>Hours small group:</td>
<td>4h</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
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<tr>
<td>Self study:</td>
<td>90h</td>
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## Content

<table>
<thead>
<tr>
<th>UNIT 1: ALGEBRAIC STRUCTURES</th>
<th>Learning time: 45h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 14h</td>
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<td></td>
<td>Laboratory classes: 1h</td>
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<tr>
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<td>Self study: 30h</td>
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**Description:**
- **COMPLEX NUMBERS:** operations; binomial and exponential forms; roots of complex numbers; applications
- **POLYNOMIALS:** roots; fundamental theorem of algebra; factorization in prime polynomials; Taylor's development.
- **MATRICES AND DETERMINANTS:** operations and particular types of arrays; elemental transformations (reduction of Gauss); rank of a matrix; determining an array (elementary properties, calculation); reverse matrices; applications
- **EQUATION SYSTEMS:** discussion of systems (Rouché-Frobenius); resolution (Gauss, Cramer); matrix systems; examples and applications

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<tr>
<th>UNIT 2: VECTOR SPACES AND LINEAR APPLICATIONS</th>
<th>Learning time: 48h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 16h</td>
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<tr>
<td></td>
<td>Laboratory classes: 2h</td>
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<td>Self study: 30h</td>
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**Description:**
- **VECTOR SPACES:** definition and examples (\(\mathbb{R}^n\), matrices, spaces of polynomials, etc.); bases; dimension (tma Steinitz); coordinates and base change matrix; examples and applications (color codes, crystal-logistic networks, vector physical magnitudes, electrical magnitudes, vibrations, demographic models for cohorts).
- **VECTOR SUBSPACES:** adapted bases; subspaces defined by equations and by generators; intersection and sum of subspaces direct sum; Grassmann formula.
- **LINEAR MAPS:** matrix of a linear map; Kernel and Image; Range of a linear application; injectivity, exhaustivity and bijectivitat; isomorphisms; Applications.

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<tr>
<th>UNIT 3: REDUCTION OF LINEAR APPLICATIONS</th>
<th>Learning time: 30h</th>
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<tr>
<td></td>
<td>Theory classes: 14h</td>
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<td>Laboratory classes: 1h</td>
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<td>Self study: 15h</td>
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**Description:**
- **DIAGONALIZATION:** invariant subspaces; vectors and eigenvalues; characteristic polynomial; algebraic and geometric multiplicity; diagonalizable matrices; diagonalization criterion; particular cases (different, symmetrical, circulating own values \(\ldots\)); calculation of powers of a matrix; calculation of values \(\xi\) and eigenvectors using Matlab / Octave; Applications.
- **NON-diagonalizable matrices:** canonical form and bases of Jordan in low dimension.
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UNIT 4: APLICATION OF LINEAR ALGEBRA TO SOLVE DISCRETE LINEAR SYSTEMS

<table>
<thead>
<tr>
<th>Learning time: 27h</th>
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<tbody>
<tr>
<td>Theory classes: 11h</td>
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<tr>
<td>Laboratory classes: 15h</td>
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<tr>
<td>Self study: 1h</td>
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Description:
- EQUATIONS IN DIFFERENCES: homogeneous linear EED; resolution by the characteristic polynomial; examples (Fibonacci, oscillations of prices, ...).
- DISCRETE DYNAMIC SYSTEMS: resolution by the powers of the system matrix; calculation in the diagonalizable case; dynamic properties (dominant own value, asymptotic behavior, points of equilibrium, stability, ...); examples and applications: population models, take / predator models, index of accessibility of the knots of a network, ...).

Planning of activities

<table>
<thead>
<tr>
<th>MATHEMATICS WORKSHOP</th>
<th>Hours: 10h</th>
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<tr>
<td>Laboratory classes: 10h</td>
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Description:
- Introduction to Matlab, introduction of vectors and matrices to the computer, symbolic manipulation, polynomials, zeros of polynomials, solving systems of linear equations. Obtention of eigenvalues and eigenvectors.

Support materials:
- Set of practices

Qualification system

The assessment will consist of three tests:
- A semi-semester partial test (EP), on the date determined by the School.
- A test about the Mathematics Workshop (ET).
- The final exam (EF), on the date set by the School.

The final grade (NF) will be calculated as follows:
NF = max (10% ET + 30% EP + 60% EF, 10% ET + 90% EF)

In case of not overcoming the subject, the student has the possibility to be re-assessed on the date set by the school (July).

The reassessment note will be calculated as follows:
NF = 10% ET + 90% ER
where ER is the grade obtained for the re-assessment exam and ET is the grade corresponding to the Mathematics Workshop.

Regulations for carrying out activities

IT material will just be allowed to use in the algebra workshop evaluation.
In all the other evaluations, a one sheet personal formulary will be allowed to check. (one DIN. A4 sheet maximum). calculator may not be used.
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Bibliography

Basic:


Complementary:


Others resources:

On the page of the subject that is located at Athena, the necessary resources for the subject, problems lists, bibliography, etc. will appear.