UAB
Universitat Autònoma de Barcelona

Vector Spaces

Code: 104343
ECTS Credits: 6

2025/2026

Degree	Type	Year
Data Engineering	FB	1

Contact

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

No required.

Objectives and Contextualisation

In order to acquire a good mathematical training in the treatment of data, it is essential to fully understand the theory of Vector Spaces. It is necessary to learn to manipulate the objects that are introduced and interpret its meaning. The tools that are provided in this course are essential not only in all branches of Mathematics but also in most of the engineering.

Among the training objectives we emphasize the following: understand and correctly use mathematical language, see the need for demonstrations and develop a critical sense in the face of mathematical affirmations.

As more specific objectives: the student will learn to manipulate arrays as a basic tool to analyze systems of linear equations, formalize the language necessary to understand the concepts of vector space and linear application, as well as manipulate bilinear forms. Diagonalization in linear applications, and some application in the world of data engineering. All this might be reinforced by the introduction of certain software.

Competences

- Demonstrate sensitivity towards ethical, social and environmental topics.
- Make a critical evaluation of work carried out.
- Search, select and manage information and knowledge responsibly.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Use the concepts and methods of algebra, differential and integral calculus, numerical methods, statistics and optimisation necessary for solving engineering problems.

Learning Outcomes

1. Be able to manipulate matrices.
2. Calculate and interpret the meaning of the representations given by projection in a vector subspace.
3. Demonstrate sensitivity towards ethical, social and environmental topics.
4. Make a critical evaluation of work carried out.
5. Search, select and manage information and knowledge responsibly.
6. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
7. Understand the concept of vector space, basis and linear representation both in finite dimension spaces and in infinite dimension spaces.

Content

The subject is structured in four blocks: a first more computational block where the algebraic manipulation of matrices is prioritized, introducing their basic operations. In the second block the concepts of abstract vector space and linear application will be formalized, relating them to the contents of the first block. The third block presents a factorization in linear applications that has different uses in the world of engineering. The fourth block is dedicated to more advanced concepts that take advantage of the structure of vector space with metrics.

Topic 1: Matrices and linear equations

(A) Operations with matrices. Invertible matrix.

(B) Elemental transformations in matrices.

(C) Rank of a matrix. Invertibility criterion. PAQ-reduction. Generalized Invers matrix.

(D) Resolution of systems of linear equations.

(E) Determinant of a square matrix.

Topic 2: Vector spaces and linear applications

(A) Definition of space and vector subspace. Scalar products in vector spaces. Linear independence, generators and bases. Dimension.

(B) Nucleus and image of a linear application. Composition.

(C) Vector coordinates and matrix associated with a linear application.

Topic 3: Diagonalization

(A) Characteristic polynomial. Eigenvalues.

(B) Eigenvectors associated with an eigenvector. Diagonalization of matrices.

(C) Minimum polynomial.

Topic 4: Orthogonality, normed spaces and quadratic forms.

(A) Bilinear forms and diagonalization in symmetric matrices.

(B) Singular values and SVD factoring (Singular Value Decomposition). Fitting Date.

(C) Hilbert spaces.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Solving exercises and Computer class with a mathematic programme.	24	0.96	4, 5, 2, 1, 7
theory class	26	1.04	2, 1, 3, 7
Type: Autonomous			
Computer work with Sage Math	27	1.08	5, 1, 7
Learn theoretical concepts and solving exercises.	65.5	2.62	5, 2, 1, 7

The subject has during the semester of 4 weekly hours grouped in blocks of 2 hours. Each of these blocks will be divided into a theoretical introduction of content and problem solving, which may be on paper or with the use of software.

To introduce the software, more time will be devoted to this part of the sessions at the beginning of the course.

This course will have the corresponding Moodle classroom within the UAB servers to offer complementary material. This will be the virtual platform for communication with the students.

Approximately 15 minutes of class time will be allocated to allow students to answer teaching evaluation questionnaires regarding performance and the evaluation of the subject or module.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes

Final exam	50%	3	0.12	2, 1, 7, 6
Mid term exam	35%	2.5	0.1	4, 5, 2, 1, 3, 7, 6
SageMath exam	15%	2	0.08	4, 1, 7, 6

Continuous Assessment:

During the course, at a time and date to be announced in advance, there will be a two-and-a-half-hour midterm exam. This exam will assess the theoretical and practical content of the course up to that point. This exam will be taken individually. The grade for this exam is denoted by EP.

Exam-type Assessment:

During the month of May, at a time and date to be determined, there will be a computer-based practical assessment. The level achieved in the course will be assessed with the help of laptop software. The exam will be individual, is non-recoverable, and requires a minimum score of 1 point out of 10 to assess the course; otherwise, the course will be failed. Therefore, it is mandatory to take this exam; see the grading section. This grade is denoted by P, ranging from 0 to 10.

At the end of the course, there will be a final exam for the entire course. The final exam score out of 10 points is denoted by E.

Course Grading (excluding resit exams):

If the grade E is equal to or greater than 3.5 and the grade P is equal to or greater than 1, then the student currently has a grade of N = 0.35*EP+0.15*P+0.5*E. If the grade is equal to or greater than 5, the student passes the course with grade N.

If P<1 or E<3.5 (or the student has not taken the practical or final exam for the course), the student obtains the minimum grade between N and 4.5 points.

The student receives a grade of Not Evaluable if they do not take one or more of the exams (including the practical exam) without justified cause.

Repeating students will not be treated differently from other students.

Grade Review: Each assessable activity will have a review date, announced in advance on the day of the exam or at least 24 hours after the grades are published.

Single Assessment: Students who choose to opt for a single assessment will take a written test onthe same day as the final exam,assessing the entire course content. They will also take another computer-based practical test on the same day. These tests can be made up on the day of the make-up exam, in the same format. The practical exam will carry 15% of the weight, while the written test will carry the remainder of the grade.

Resit Exams:

Students with a grade of N < 5 or E < 3.5 (and always with a grade of P >= 1) must take the resit exam to pass the course; otherwise, their grade will be as described above. Note that a grade of P >= 1 is required to be eligible for the resit exam.

The resit exam is a full-course exam, with the same weight as the final exam, as stated in the grade for this make-up exam by Erec.

Final course grade (students taking resits):

Denote by Nfin: = 0.15*P+0.85*Erec. The student's grade will therefore be Nfin. To pass the course, Nfin must be greater than or equal to 5.

Annex on the qualification of the subject:

Students who have more than a 9.25 in the final qualification will have a Matricula d'Honor (MH) until reaching the limit of 5% of those enrolled. If there aremore than 5% of students above 9.25, those with the highest marks will have MH.

Use of artificial intelligence: In this course, the use of Artificial Intelligence (AI) technologies is not allowed in any of its phases. Any work that includes fragments generated with AI will be considered a lack of academic honesty and may lead to a partial or total penalty in the grade of the activity, or greater sanctions in serious cases.

"Without prejudice to other disciplinary measures that are deemed appropriate, andin accordance with current academic regulations, irregularities committed by a student that may leadto a variation of the qualification will be graded with a zero (0). The activities of 'assessment graded in this way and by this procedure will not be recoverable.If it is necessary to pass any of these assessment activities to pass the subject, this subject will be suspended directly, with no opportunity to recover it in the same course. These irregularities include, among others:
- the total or partial copy of a practice, report, or any other assessment activity;
- let copy;
- present a group work not done entirely bythe group members;
- present as own materials prepared by a third party, even if they are translations or adaptations, and in general works with non-original and exclusive elements of the student;
- have communication devices (such as mobile phones, smart watches, etc.) accessible during individual theoretical-practical assessment tests (exams)."

In case of discrepancy, the version that maintains validity is the version in Catalan.

Bibliography

Bretscher,O. "Linear Algebra with Applications", 1997, Prentice-Hall International, Inc.

Nart,E.;Xarles,X."Apunts d'àlgebra lineal", 2016, col.lecció Materials UAB, num.237.

Seasone,G"Elementary notions of Hilbert Spaces" 1991, NewYork, Dover.

Virtual Bibliography:

Bars, F.:Uns apunts de càlcul matricial i resolució de sistemes lineals. https://ddd.uab.cat/record/73660

Bars.F: Una pinzellada del polinomi mínim. https://ddd.uab.cat/record/236746

Bars, F: Espais normats i Espais de Hilbert, per a primer curs. https://ddd.uab.cat/record/236744

Masdeu, M, Ruiz, A: Apunts d'Àlgebra Lineal,
https://mat.uab.cat/~masdeu/wp-content/uploads/2022/06/ApuntsAlgebraLineal.pdf

Software

Use of SageMath with the computations inputs of the different subjects given in the course.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	811	Catalan	second semester	morning-mixed
(PAUL) Classroom practices	812	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	811	Catalan	second semester	morning-mixed
(PLAB) Practical laboratories	812	Catalan	second semester	morning-mixed
(TE) Theory	81	Catalan	second semester	morning-mixed