Universidad de Alcalá

TEACHING GUIDE

Linear Algebra

Degree in
Telecommunication Technologies Engineering (GITT)
Telecommunication Systems Engineering (GIST)
Telematics Engineering (GIT)
Electronic Communications Engineering (GIEC)

Universidad de Alcalá

Academic Year 2026/2027

1st Year - 1st Semester (GITT+GIST+GIT+GIEC)

Approved by the EPS School Board on June XXth, 2026

TEACHING GUIDE

Course Name:	**Linear Algebra**
Code:	**350000 (GITT+GIST+GIT+GIEC)**
Degree in:	**Telecommunication Technologies Engineering (GITT)** **Telecommunication Systems Engineering (GIST)** **Telematics Engineering (GIT)** **Electronic Communications Engineering (GIEC)**
Department and area:	**Física y Matemáticas** **Applied Mathematics**
Type:	**Basic (GITT+GIST+GIT+GIEC)**
ECTS Credits:	**6.0**
Year and semester:	**1st Year - 1st Semester (GITT+GIST+GIT+GIEC)**
Teachers:	See webpage: https://www.uah.es/es/estudios/estudios-oficiales/grados/asignatura/Linear-Algebra-350000/
Tutoring schedule:	To be determined at the beginning of the term.
Language:	English

1. COURSE SUMMARY

Preliminary Note. In accordance with Article 14.11 of Ley Orgánica 3/2007, of March 22, on the effective equality of women and men, consolidated in Ley 15/2022, of July 12, on equal treatment and non-discrimination, all designations that, by virtue of the principle of economy of language, are used in the inclusive masculine gender in this text and refer to holders or members of bodies or groups of people, must be understood to be used in both the feminine and masculine genders.

Linear algebra is one of the fields included in the basic formation in mathematics for engineers and scientists, and therefore is desirable that students appreciate from the beginning its importance and also its great applicability.

The subject Linear Algebra studies the fundamental problems of the field of linear algebra: systems of linear equations; vector spaces, subspaces and bases; linear transformations; eigenvalues, eigenvectors, and diagonalization of matrices; solution of linear differential equations; Euclidean spaces and orthogonality. The subject ends with a chapter devoted to Boolean algebra (a field which is not a part of linear algebra but has important applications, for instance in the subject Digital Electronics).

It is important that students appreciate that, beyond the abstraction of the various contents of the subject, the applications are fundamental. So it is essential to pay attention also to the algorithmic aspects.

To conclude, it would be good to transmit to the students the idea that “linear algebra is a fantastic subject” and ensure that they enjoy it.

Prerequisites and Recommendations

There is no prerequisite to take this subject. The subject is not required for taking other ones, although the contents included in Linear Algebra will be used in other subjects such as Calculus II, Statistics, or Digital Electronics.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

> **en_TR4** - Knowledge for the achievement of measurements, calculations, evaluations, appraisals, examinations, studies, reports, planning of tasks and other similar works in its specific ambience of the telecommunication.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

> **en_CB1** - Capacity for the resolution of the mathematical problems that could appear in the pathway of an engineer. Aptitude for applying the knowledge on: linear algebra; geometry; distinguishing geometry; differential and integral calculus; distinguishing equations and in partial derivatives; numerical methods; numerical algorithms; statistics and optimization.

Learning Outcomes

After succeeding in this subject the students will be able to:

RA1. Apply Gaussian elimination on a matrix for solving systems of linear algebraic equations.

RA2. Compute the dimension and a basis of a vector space, an to solve problems of change of basis.

RA3. Find the matrix of a linear transformation, and to use it correctly for finding the image of a vector.

RA4. Determine if a matrix is diagonalizable, and to apply matrix diagonalization for solving systems of linear differential equations.

RA5. Identify, in a vector space with inner product, the orthogonal complement of a given subspace, and to solve least squares approximation problems.

RA6. Compute the normal forms of a Boolean function and, starting from them, to carry out the minimization (simplification) of the Boolean function.

3. CONTENTS

Contents Blocks	Total number of hours
Vector Spaces	14 hours (8 theory + 6 practice)
Linear Transformations	8 hours (4 theory + 4 practice)
Diagonalization of Matrices	6 hours (3 theory + 3 practice)
Systems of Linear Differential Equations	10 hours (5 theory + 5 practice)
Euclidean Spaces	8 hours (4 theory + 4 practice)
Boolean Algebra	8 hours (4 theory + 4 practice)

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (54 hours on-site +4 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

Lectures:

- Lectures about the theoretical contents of the subject or about the practical aspects (problem solving), both in large groups or in small groups.
- In the classroom some problems could be solved with the aid of a symbolic computation system

(like Maple) or a numerical computing system (like MATLAB).

Autonomous work of the students:

- Reading.
- Problem solving, information search.

Teacher office hours:

The students should take advantage of the teacher office hours to receive individual assistance when they find difficulties with the subject.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Learning Assesment Guidelines, LAG, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Learning Assesment Guidelines as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

Ordinary Call

Continuous Assessment

In this case, the evaluation procedure will be the following:

1. The final grade for each student will be obtained from the grades achieved in the two mid-term assessment tests (PEI1 and PEI2) and in the continuous assessment activities (AEC1 and AEC2). PEI1 will be held halfway through the semester and PEI2 at the end of the semester. AEC1 and AEC2 will take place throughout the semester.

2. PEI1 may be retaken at the end of the semester. In this test, each student may decide whether or not to submit the exam.

   • If the student does not submit it, the previous PEI1 grade will be retained.

   • If the student submits it, the PEI1 grade will be the one obtained in this last exam.

Remarks:

Each of the tests AEC1, AEC2, PEI1, and PEI2 will be graded on a scale of 0 to 10 points.
The final grade obtained by each student, denoted by NF, will be NF = (N1 + N2) / 2, where N1 and N2 represent the grades obtained as follows:

• N1 = 0.2*Grade(AEC1) + 0.8*Grade(PEI1)

• N2 = 0.2*Grade(AEC2) + 0.8*Grade(PEI2)

To pass the course, NF must be greater than or equal to 5. Additionally, both N1 and N2 must be greater than or equal to 3.5. Otherwise, the student's final grade will be the minimum between NF and 4.5.

Assessment through final exam

In the case of evaluation by means of a final exam, the student will have a single final exam. This will be a written exam held at the end of the semester.

Extraordinary Call

Independently of the chosen evaluation system (continuous assessment or final exam), the students who have not passed the subject in the ordinary call have the right to a new final exam in the extraordinary call. That exam will be a written exam.

5.2. EVALUATION

EVALUATION CRITERIA

The assessment criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined:

CE1. The student identifies the basic concepts necessary to tackle the problems corresponding to the contents of the subject.

CE2. The student correctly uses the techniques and the fundamental theoretical results of linear algebra.

CE3. The student shows precisión in the mathematical reasoning being used.

CE4. The student correctly solves the problems being proposed.

CE5. The student correctly answers the theoretical-practical questions being posed.

GRADING TOOLS

The work of the student is graded in terms of the assessment criteria above, through the following tools:

1. Ordinary call
   a. Continuous assessment, with two exams (PEI1, PEI2), and activities of continuous assesment (AEC1 y AEC2).
   b. Final assessment (PEF)
2. Extraordinary call. Final assessment (PEF)

GRADING CRITERIA

In the ordinary call, for the continuous assessment option, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows:

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR4, CB1	RA1, RA2, RA3, RA4	CE1- CE5	AEC1	10%
	RA1, RA2, RA4, RA5, RA6	CE1-CE5	AEC2	10%
	RA1, RA2, RA3, RA4	CE1- CE5	PEI1	40%
	RA1, RA2, RA4, RA5, RA6	CE1-CE5	PEI2	40%

In the case of continuous assessment, the grade "No Presentado" will be applied to those students who have participated in none of the two assessment exams.

In the ordinary call, for the final evaluation option, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows:

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR4, CB1	RA1, RA2, RA3, RA4, RA5, RA6	CE1, CE2, CE3, CE4, CE5	PEF	100%

In the case of final evaluation, the grade "No Presentado" will be applied to those students who have not participated in the final assessment exam.

Extraordinary call

In the case of the extraordinary call, the same criteria that have been established for the case of the evaluation by means of a final exam will be maintained.

In this case, the grade "No Presentado" will be applied to those students who have not participated in the exam corresponding to the extraordinary call.

The teaching-learning methodology and the assessment process will be adapted as needed, in accordance with the guidelines of the Diversity Support Unit, to implement curricular adaptations for students with specific needs.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- HIRSCH, M. W., SMALE, S., DEVANEY, R. L.: Differential Equations, Dynamical Systems, and and Introduction to Chaos (Third Edition). Academic Press, 2012.
- LAY, D. C.: Linear Algebra and Its Applications (Fourth Edition). Addison-Wesley, 2012.
- ROSEN, K. H.: Discrete Mathematics and Its Applications (Sixth Edition). McGraw-Hill International Edition, 2007.
- STRANG, G.: Linear Algebra and Its Applications (Fourth Edition). International Student Edition, Thomson Brooks/Cole, 2006.
- STRANG, G.: Introduction to Linear Algebra (5th edition). Wellesley-Cambridge Press, Wellesley, MA, 2016
- SENDRA, J. R., SENDRA, J., LASTRA, A., SALAZAR, J. M.: Álgebra Lineal: Ideas, Resultados, Métodos y Aplicaciones. Sanz y Torres, 2024.
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- TAKAHASHI, S., INOHUE, I.: The Manga Guide to Linear Algebra. No Starch Press, 2012.
- TREIL, S.: Linear Algebra Done Wrong (available at https://www.math.brown.edu/~treil/papers/LADW/LADW.html

6.2. Additional Bibliography

- MEYER, C. D.: Matrix Analysis and Applied Linear Algebra. SIAM, 2000.
- STRANG, G.: Differential Equations and Linear Algebra. Wellesley-Cambridge Press, Wellesley, MA, 2014.

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.