Universitat de Lleida

DEGREE CURRICULUM

LINEAR ALGEBRA

Coordination: GRAU MONTAÑA, MARIA TERESA

Academic year 2019-20

LINEAR ALGEBRA 2019-20

Subject's general information

Subject name	LINEAR ALGEBRA
Code	101401
Semester	2nd Q(SEMESTER) CONTINUED EVALUATION
Typology	

Degree	Course	Character	Modality
Bachelor's Degree in Architectural Technology and Building Construction	1	COMMON	Attendance-based

Course number of credits (ECTS)	6
Type of activity, credits, and groups	

Activity type	PRAULA	TEORIA
Number of credits	3	3
Number of groups	1	1

Coordination	GRAU MONTAÑA, MARIA TERESA
Department	MATHEMATICS
Teaching load distribution between lectures and independent student work	40% at the classroom, 60% autonomous work See "Development plan".
Important information on data processing	Consult this link for more information.
Language	Catalan
Office and hour of attention	To concur Office 1.12 of the "Escola Politècnica Superior".

LINEAR ALGEBRA 2019-20

Teaching staff	E-mail addresses	Credits taught by teacher	Office and hour of attention
GRAU MONTAÑA, MARIA TERESA	maite.grau@udl.cat	6	

Subject's extra information

To follow this subject properly the previous knowledge taught in the subject area of Mathematics of the "Bachillerato Tecnológico" (see http://xtec.gencat.cat/ca/curriculum/batxillerat/curriculum/) is needed. In particular , the sections on arithmetic and algebra and geometry.

Suggestions

Subject that requires continuous work throughout the semester in order to achieve its goals. It requires critical thinking and capacity for abstraction. You can find collections of the materials at the Cappont Campus (Building Aulari) and the Virtual Campus: http://cv.udl.cat

- Collection set of exercises with the numerical solutions.

- Resolutions of exams in previous years.

It is recommended to frequently visit the site at the Virtual Campus since all the information is announced there.

The course as part of the academic plan

This course is in the 2nd semester of 1st year of teaching. It belongs to the module of "Basic Training", specifically in the field "Scientific Basis".

Learning objectives

- Perform elementary Gauss transformations in order to determine the rank of a matrix.
- Apply the Rouché-Frobenius Theorem and solve systems of linear equations.
- Describe vector space and vector subspace.
- Make vector calculations in different bases. In particular, calculating the components of a vector on different bases.
- Determine a linear map from its image on a base.
- Calculate the kernel and image of a linear map.
- Determine the eigenvalues and eigenvectors associated with an endomorphism and interpret them geometrically.
- Determine, classify and construct matrices of orthogonal transformations in the plane and in space.
- Apply vector calculus in the description of geometric objects.
- Classify conics and quadrics from its equation.

Competences

Cross-disciplinary competences of the degree:

EPS1. Capacity to solve problems and prepare and defence arguments inside the area of studies.

EPS2. Capacity to gather and interpret relevant data, within the area of study, to judge and think about relevant subjects of social, scientific and ethical nature.

EPS5. Capacity of abstraction and of critical, logical and mathematical thinking.

EPS6. Capacity of analysis and synthesis.

Specific competences of the degree:

GEE1. Aptitude to apply the knowledge related with numerical and infinitesimal calculus, linear algebra, analytical and differential geometry, techniques and probabilistic methods and statistical analysis.

GEE2. Applied knowledge of the principles of general mechanics, the statics of structural systems, the geometry of masses, the principles and methods of analysis of the elastic behaviour of the solid.

Subject contents

1. Matrices, determinants and systems of linear equations.

1.1 Types of matrices and matrix operations.

1.2 Inversible matrices.

1.3 Determinant of a square matrix of order n. Cases n = 2, n = 3 and n> 3.

1.4 Rank of a matrix.

1.5 Elementary transformations by rows. Gauss elimination method.

1.6 Expression of a system of linear equations by matrices.

1.7 Rouché-Frobenius theorem.

1.8 Cramer Systems

2. Vector spaces.

2.1 Definition, properties and examples.

2.2 Linear combination: linear dependence and linear independence.

2.3 Generating system.

2.4 Basis of a vector space: definition, dimensions, components.

2.5 Vector Subspace. Linear varieties.

2.5.1 Description by using generators and equations.

2.5.2 Gauss Transformations.

2.5.3 Basis and dimension.

2.6 Basis change: matrix.

2.7 Operations on subspaces.

2.7.1 Containment and equality.

2.7.2 Intersection and sum.

2.7.3 Grassman formula.

2.7.4 Complementary and direct sum.

3. Linear transformations and endomorphism diagonalization.

3.1 Definition and properties of a linear transformation.

3.2 Determination by the image in a basis.

3.3 Kernel and image of a linear transformation.

3.4 Matrix representation of a linear transformation.

3.5 Changes of basis. Similar matrices.

3.6 Operations with linear applications.

3.6.1 Sum of applications.

3.6.2 Product by a scalar.

3.6.3 Composition of applications.

3.7 Diagonal matrix: eigenvalues and eigenvectors.

3.8 Characteristic polynomial of an endomorphism: definition and calculation.

3.9 Cayley-Hamilton theorem.

3.10 Algebraic multiplicity.

3.11 Subspace generated by an eigenvector: geometric multiplicity.

3.12 Characterization of diagonalizable endomorphisms.

4. Euclidean Geometry

4.1 Scalar product.

4.2 Norm induced by a scalar product.

4.3 Distances and angles.

4.4 Concepts of orthogonal and orthonormal.

4.5 Gram-Schmidt process of orthonormalization.

4.6 Gram's determinant. Volume of cuboid.

4.7 Vector Product.

4.8 Orthogonal transformations: in the plane and in space.

4.9 Isometries or rigid motions.

5. Classification of conics and quadrics.

5.1 symmetric endomorphisms and scalar product.

5.2 symmetric bilinear form.

5.3 Range and signature: definition and calculation of these invariants.

5.4 Quadratic forms.

5.5 Quadratic varieties: canonical equation.

5.6 Classification of Euclidean conics and quadrics.

5.7 Other examples of curves. Trajectories. Parametrized curves.

5.8 Homothetic transformations.

5.9 Similarities.

Methodology

Lectures: Classes to explain the theory and problem solving on the blackboard.

Resolution of problems: students solve problems individually during these sessions under the supervision of teachers of the subject.

Exam: two written tests are held during the semester. There is also a final retrieval test.

Delivery of exercises: Students deliver a weekly basis statement proposed by a teacher, who corrects and returns it to the student for his/her information.

Development plan

Week	Methodology	Contents	Hours at classroom	Hours of autonomous work
Weeks 1 - 3	Lectures	Chapter 1	6	9
Weeks 1 - 3	Resolution of problems	Chapter 1	6	9

Weeks 4 - 6	Lectures	Chapter 2	6	9
Weeks 4 - 6	Resolution of problems	Chapter 2	6	9
Weeks 7 and 8	Lectures	Chapter 3 (sections 3.1 – 3.6)	4	6
Weeks 7 and 8	Resolution of problems	Chapter 3 (sections 3.1 – 3.6)	4	9
Week 9	1ª test of evaluation (exam)	Contents until the moment	1.5	
Weeks 10 - 12	Lectures	Chapter 3 (sections 3.7 -3.12)	6	9
Weeks 10 - 12	Resolution of problems	Chapter 3 (sections 3.7 -3.12)	6	9
Weeks 13 and 14	Lectures	Chapter 4	4	6
Weeks 13 and 14	Resolution of problems	Chapter 4	4	6
Week 15	Lectures	Chapter 5	2	3
Week 15	Resolution of problems	Chapter 5	2	6
Weeks 16 and 17	2ª test of evaluation (exam)	Contents since the first test and until the moment	1.5	
Week 20	Retrieval test	All the contents of the subject	2	

Evaluation

Exam PA1
Written exam (individual and compulsory)
Date: april and following the school calendar http://www.eps.udl.cat/ca/informacio-academica/horaris-i-calendaris/calendaris-dexamens/l
Percent on the final mark: 40%
Remark: To consider the mark of the given exercises a mark of at least 4 (over 10) in PA1 and PA2 is required.

Exam PA2
Written exam (individual and compulsory)
Date: june and following the school calendar http://www.eps.udl.cat/ca/informacio-academica/horaris-i-calendaris/calendaris-dexamens/l
Percent on the final mark: 40%
Remark: To consider the mark of the given exercises a mark of at least 4 (over 10) in PA1 and PA2 is required.

Exercises
Exercises to be corrected by the professor
Date: on each week of lectures there will be a statement to be solved.
Percent on the final remark: 20% (two of the given exercises are evaluated, each of them with a percent of 10% on the final mark)
Remark: To consider the mark of the given exercises a mark of at least 4 (over 10) in PA1 and PA2 is required.

Retrieval exam
Written exam (individual and non compulsory)
Date: june/july and following the school calendar http://www.eps.udl.cat/ca/informacio-academica/horaris-i-calendaris/calendaris-dexamens/
Percent of the final mark: 80%
Remarks: The content of this exam is all the topics of the subject. To consider the mark of the given exercises a mark of at least 4 (over 10) in this resit exam is required. All the students are allows to do this exam in order to improve their mark.

Bibliography

BASIC BIBLIOGRAPHY

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RECOMMENDED BIBLIOGRAPHY

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Adaptations to the contents due to COVID-19

The contents of the subject are 5 topics. As a result of the situation due to Covid-19, the contents are reduced to the first three topics:

1. Matrices, determinants and systems of linear equations.
1.1 Types of matrices and operations with matrices.
1.2 Inversible matrices.
1.3 Determinant of a square matrix of order n. Cases n = 2, n = 3 and n> 3.
1.4 Range of a matrix.
1.5 Elementary transformations by rows. Gauss elimination method.
1.6 Matrix expression of a system of linear equations.
1.7 Rouché-Frobenius theorem.
1.8 Cramer Systems.

2. Vector spaces.
2.1 Definition, properties and examples.
2.2 Linear combination: linear dependence and independence.
2.3 Generating system.
2.4 Base of a vector space: definition, dimension, components.
2.5 Vector subspace. Linear manifolds.
2.5.1 Description by means of equations and by generators.
2.5.2 Gauss transformations.
2.5.3 Base and dimension.
2.6 Base changes: Base change matrix.
2.7 Operations with subspaces.
2.7.1 Containment and equality.
2.7.2 Intersection and addition.
2.7.3 Grassman's formula.
2.7.4 Direct and complementary sum.

3. Linear applications and diagonalization of endomorphisms.
3.1 Definition and properties of a linear application.
3.2 Determination by the image on a base.
3.3 Image and kernel of a linear application.
3.4 Matrix associated with a linear application.
3.5 Base changes in a linear application. Similar matrices.
3.6 Operations with linear applications.
3.6.1 Sum of applications.
3.6.2 Product by a scalar.

3.6.3 Application composition.
3.7 Diagonal matrix: eigenvalues and eigenvectors.
3.8 Characteristic polynomial of an endomorphism: definition and calculation.
3.9 Cayley-Hamilton theorem.
3.10 Algebraic Multiplicity.
3.11 Subspace generated by an eigenvalue: geometric multiplicity.
3.12 Characterization of diagonalizable endomorphisms.

Adaptations to the methodology due to COVID-19

Topics 1 and 2 of the subject were developed mainly through master classes and problem solving sessions as planned.

From the confinement, lectures and problem solving sessions are held using the virtual campus video conferencing tool. All sessions are recorded and can be downloaded at any time. In addition, the notes developed during the sessions are provided to students, scanned in PDF and can be found in the Resources area of the virtual campus.

Exercises are also requested to be delivered to students via the Virtual Campus Activities tool. Once the delivery is made, the teacher solves the most significant problems using the videoconference tool of the virtual campus. All sessions are recorded and can be downloaded at any time. In addition, the teacher returns an annotated and personalized correction to each student, using the Virtual Campus Activities tool.

Regarding the evaluation, the exams are carried out via a telematic way.

- At 9am on the date scheduled for the exam, the teacher posts the statement on the virtual campus (in the activities section).
Part 1: April 22, 2020.
Part 2: May 25, 2020 (date of the school calendar from the beginning of the course).
Recovery test: June 15, 2020 (date of the school calendar since the beginning of the course).

- The statement of the exams is analogous to that of other years: there are several problems to be solved on paper and by hand. The topics that come into the first part are topic 1 and topic 2 (other years a piece of topic 3 also came in, not this year). The topics that enter the second part are topic 3 (other years there were more topics, not this year).

- The teacher is in the Chat Room of the virtual campus for the duration of the exam to answer questions and answer student comments.

- The exam must be done without a calculator. All calculations must be visible in the resolution. If the calculations are not seen, the result is not valued. Nor can you look at the notes or the material of the subject.

- The use of any device that carries stored information or can transmit it is not authorized during evaluation tests. Thus, the use of mobile phones is strictly prohibited.

- Students are asked to explain well what they are doing. An explanation of more is better than one of less.

- Students need to scan the resolution of the exam and create a PDF with all the sheets. It needs to look good. What cannot be read well is not valued. It is advised that if they have a scanner (many printers have), to use it. And if they do not have, from the UdL they have advised two applications to scan from the mobile: camscanner (for android) and the Notes application (for iOS).

- It is necessary for students to post the PDF file with the resolution in the corresponding Activity on the virtual campus (within the Activities section, NOT by email).

- The deadline to upload this PDF file is 10:30am on the exam date.

- Once the file is posted, students are asked to write a message in the chat in order to make an appointment with the teacher to do the validation test.

- The validation test consists of an interview with image and sound that the teacher does with each student using the videoconference tool of the virtual campus.

- In the interview with image and sound, the teacher asks each student some part of the exam and also some other question related to the subject. The incorrect or incomplete answer to these questions will invalidate all or several problems of the exam (that is, it will count as 0 regardless of what is written in the resolution). The teacher's decision in this regard is final.

- In the validation test, students must have paper and a pen on hand. They have to write some answers and then scan and post them on the virtual campus in the activities section.

- The video of the validation test is recorded. Students are provided with the document Information on data protection.pdf provided by the UdL authorities.

- Students are asked not to throw away any sheet: neither the resolution of the exam nor the validation test. They are asked to save them (at least) until October 2020.

- Students are asked in current circumstances to try to be honest and consistent with the knowledge they have actually obtained in the subject. No copying. Do each your exam. More important than passing is learning the contents of the subject.

- In any case, all students have the right to go to the recovery exam. This recovery test will always be to improve grade. The contents that enter the recovery test are topics 1, 2 and 3. Following the guidelines of the UdL, the recovery exams planned for the end of June have been scheduled online. However, depending on the evolution of the pandemic and on instructions from government authorities, these exams may be face-to-face.
in those subjects/degrees that the Center considers. These recovery exams must be done before July 3, 2020.

- In the case of students authorized to the Alternative Evaluation, it will be planned following the regulations and guidelines dictated by the UdL authorities. In the case of a non-face-to-face exam, there is a single exam with all the contents and the same guidelines as previously described are followed: resolution of a statement + validation test. The date of this exam is set with the student, before July 3, 2020.

To answer questions and to facilitate the study, students have:

- Contact the teacher via email maite.grau@udl.cat The teacher responds to messages within a day or two.

- Some notes of the subject that are posted in the Resources area of the virtual campus.

- Detailed resolution of all exams from previous years.

- Videoconference sessions that are registered and can be downloaded at any time, along with the corresponding notes.

- The teacher makes regular use of the Virtual Campus Announcements to inform students of news and descriptions of changes in the subject. Reminders are also posted on the assessment and/or delivery of exercises. These announcements are also sent by email to the address of the students.

Adaptations to the development plan due to COVID-19

Topics 1 and 2 have been developed following the Development Plan planned at the beginning of the course, except for a couple of problem sessions that were held a week later by videoconference. Exercises are also requested to be delivered to the students, which are subsequently solved by the teacher through videoconference and from which a commented and personalized correction is also returned to each student.

The first partial examination is carried out on the date described in the methodology section (addendum).

From this partial exam, videoconference sessions are held in order to develop topic 3. These sessions contain master classes and problem solving. Exercises are also requested to be delivered to the students, which are subsequently solved by the teacher through videoconference and from which a commented and personalized correction is also returned to each student.

The second partial examination is carried out on the date described in the methodology section (addendum).

The recovery exam is performed on the date described in the methodology section (addendum).

Adaptations to the evaluation due to COVID-19

The evaluation does not change. Only the face-to-face exams are passed to a non-face-to-face form, as described in the methodology section (addendum).