



## Teaching Guide

| Teaching Guide      |                                                                                                                                                                                                       |        |                         |           |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------|-----------|
| Identifying Data    |                                                                                                                                                                                                       |        |                         | 2016/17   |
| Subject (*)         | Álgebra lineal I                                                                                                                                                                                      |        | Code                    | 632G02007 |
| Study programme     | Grao en Tecnoloxía da Enxeñaría Civil                                                                                                                                                                 |        |                         |           |
| Descriptors         |                                                                                                                                                                                                       |        |                         |           |
| Cycle               | Period                                                                                                                                                                                                | Year   | Type                    | Credits   |
| Graduate            | 1st four-month period                                                                                                                                                                                 | First  | FB                      | 6         |
| Language            | Spanish                                                                                                                                                                                               |        |                         |           |
| Teaching method     | Face-to-face                                                                                                                                                                                          |        |                         |           |
| Prerequisites       |                                                                                                                                                                                                       |        |                         |           |
| Department          | Métodos Matemáticos e de Representación                                                                                                                                                               |        |                         |           |
| Coordinador         | Fuentes Garcia, Luis                                                                                                                                                                                  | E-mail | luis.fuentes@udc.es     |           |
| Lecturers           | Dominguez Perez, Xabier E.                                                                                                                                                                            | E-mail | xabier.dominguez@udc.es |           |
|                     | Fuentes Garcia, Luis                                                                                                                                                                                  |        | luis.fuentes@udc.es     |           |
|                     | Taboada Vazquez, Raquel                                                                                                                                                                               |        | raquel.taboada@udc.es   |           |
|                     | Villar Ferrer, Juan                                                                                                                                                                                   |        | jvillar@udc.es          |           |
| Web                 | caminos.udc.es/info/asignaturas/grado_tecic/101/AL1/index.html                                                                                                                                        |        |                         |           |
| General description | The aim of the course is to provide a solid background in linear algebra and mathematical foundation engineering. This first part of the course focuses on studying finite dimensional vector spaces. |        |                         |           |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1   | Capacidad para plantear y resolver los problemas matemáticos que puedan plantearse en el ejercicio de la profesión. En particular, conocer, entender y utilizar la notación matemática, así como los conceptos y técnicas del álgebra y del cálculo infinitesimal, los métodos analíticos que permiten la resolución de ecuaciones diferenciales ordinarias y en derivadas parciales, la geometría diferencial clásica y la teoría de campos, para su aplicación en la resolución de problemas de Ingeniería Civil. |
| B1   | Que los estudiantes hayan demostrado poseer y comprender conocimientos en un área de estudio que parte de la base de la educación secundaria general, y se suele encontrar a un nivel que, si bien se apoya en libros de texto avanzados, incluye también algunos aspectos que implican conocimientos procedentes de la vanguardia de su campo de estudio                                                                                                                                                           |
| B2   | Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio                                                                                                                                                                                                                                                 |
| B3   | Que los estudiantes tengan la capacidad de reunir e interpretar datos relevantes (normalmente dentro de su área de estudio) para emitir juicios que incluyan una reflexión sobre temas relevantes de índole social, científica o ética                                                                                                                                                                                                                                                                              |
| B4   | Que los estudiantes puedan transmitir información, ideas, problemas y soluciones a un público tanto especializado como no especializado                                                                                                                                                                                                                                                                                                                                                                             |
| B5   | Que los estudiantes hayan desarrollado aquellas habilidades de aprendizaje necesarias para emprender estudios posteriores con un alto grado de autonomía                                                                                                                                                                                                                                                                                                                                                            |
| B6   | Resolver problemas de forma efectiva.                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| B7   | Aplicar un pensamiento crítico, lógico y creativo.                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| B8   | Trabajar de forma colaborativa.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| B10  | Comunicarse de manera efectiva en un entorno de trabajo.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| B15  | Claridad en la formulación de hipótesis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| B16  | Capacidad de autoaprendizaje mediante la inquietud por buscar y adquirir nuevos conocimientos, potenciando el uso de las nuevas tecnologías de la información y así poder enfrentarse adecuadamente a situaciones nuevas.                                                                                                                                                                                                                                                                                           |
| B17  | Capacidad para aumentar la calidad en el diseño gráfico de las presentaciones de trabajos.                                                                                                                                                                                                                                                                                                                                                                                                                          |
| B18  | Capacidad para aplicar conocimientos básicos en el aprendizaje de conocimientos tecnológicos y en su puesta en práctica.                                                                                                                                                                                                                                                                                                                                                                                            |
| B19  | Capacidad de realizar pruebas, ensayos y experimentos, analizando, sintetizando e interpretando los resultados.                                                                                                                                                                                                                                                                                                                                                                                                     |
| C1   | Expresarse correctamente, tanto de forma oral como por escrito, en las lenguas oficiales de la comunidad autónoma.                                                                                                                                                                                                                                                                                                                                                                                                  |
| C2   | Dominar la expresión y la comprensión de forma oral e escrita de un idioma extranjero.                                                                                                                                                                                                                                                                                                                                                                                                                              |
| C3   | Utilizar las herramientas básicas de las tecnologías de la información y las comunicaciones (TIC) necesarias para el ejercicio de su profesión y para el aprendizaje a lo largo de la vida.                                                                                                                                                                                                                                                                                                                         |



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| C4 | Desarrollarse para el ejercicio de una ciudadanía abierta, culta, crítica, comprometida, democrática y solidaria, capaz de analizar la realidad, diagnosticar problemas, formular e implantar soluciones basadas en el conocimiento y orientadas al bien común. |
| C6 | Valorar críticamente el conocimiento, la tecnología y la información disponible para resolver los problemas con que deben enfrentarse.                                                                                                                          |
| C7 | Asumir como profesional y ciudadano la importancia del aprendizaje a lo largo de la vida.                                                                                                                                                                       |
| C8 | Valorar la importancia que tiene la investigación, la innovación y el desarrollo tecnológico en el avance socioeconómico y cultural de la sociedad.                                                                                                             |

| Learning outcomes                                                                                                                   |  |                             |                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------|--|-----------------------------|-----------------------------------------------------|
| Learning outcomes                                                                                                                   |  | Study programme competences |                                                     |
| To know and to understand the basic theory of linear algebra required in civil engineering , especially the study of vector spaces. |  | A1                          | B1<br>B6<br>B7<br>B8<br>B15<br>B18<br>C3<br>C7      |
| Know, understand and manage elementary mathematical notation.                                                                       |  | A1                          | B1<br>B3<br>B5<br>B6<br>B7<br>B18<br>C1<br>C3<br>C6 |
| Learn to express with precision and rigor.                                                                                          |  | A1                          | B4<br>B7<br>B10<br>B17<br>C1<br>C2                  |
| Learn to use the basic techniques of mathematical reasoning.                                                                        |  | A1                          | B2<br>B3<br>B6<br>B7<br>C1                          |
| Understanding the importance of justifying the thesis and results in science .                                                      |  | A1                          | B1<br>B3<br>B16<br>B19<br>C4<br>C6                  |
| Develop critical thinking and analytical skills .                                                                                   |  | A1                          | B2<br>B3<br>B7<br>C1<br>C4<br>C8                    |
| Learn to pose and solve mathematical problems of Linear Algebra,                                                                    |  | A1                          | B2<br>B3<br>B6<br>B7<br>B8<br>B10<br>B15<br>C1      |

| Contents |           |
|----------|-----------|
| Topic    | Sub-topic |



|                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I. Preliminars.                | <ul style="list-style-type: none"><li>1. Correspondences and maps.<ul style="list-style-type: none"><li>1.1 Sets, Definition and notation. Operations with sets.</li><li>1.2 Correspondences. Maps. Definition, properties and classification.</li></ul></li><li>2. Combinatorics.<ul style="list-style-type: none"><li>2.1. Product rule.</li><li>2.2. Variations.</li><li>2.3. Permutations.</li><li>2.4. Combinations.</li></ul></li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| II. Matrices and determinants. | <ul style="list-style-type: none"><li>1. Matrices.<ul style="list-style-type: none"><li>1.1 Basic definitions.</li><li>1.2 Operations with matrices.</li><li>1.3 Special matrices.</li></ul></li><li>2. Determinants.<ul style="list-style-type: none"><li>2.1 Preliminars on permutacions.</li><li>2.2 Determinant of a square matrix: definition and properties.</li><li>2.3. Development of a determinant by adjoints.</li><li>2.4. Rank of a matrix.</li><li>2.5. Inverse of a matrix.</li></ul></li><li>3. Equivalence and congruence of matrices.<ul style="list-style-type: none"><li>3.1 Elementary transformations.</li><li>3.2 Row equivalence of matrices.</li><li>3.3 Column equivalence of matrices.</li><li>3.4 Matrix equivalence.</li><li>3.5 Matrix congruence.</li></ul></li><li>4. Systems of linear equations.<ul style="list-style-type: none"><li>4.1 Cramer's rule.</li><li>4.2 Rouché-Frobenius' Theorem.</li><li>4.3 Gaussian elimination.</li></ul></li></ul> |



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|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| III. Vectorial spaces. | <p>1. Vectorial spaces and subspaces.</p> <p>1.1 Definition and properties.</p> <p>1.2 Vectorial subspaces.</p> <p>2. Spanning systems. Free linear systems. Basis.</p> <p>2.1 Linear combinations of vectors.</p> <p>2.2 Linear dependence and independence of vectors.</p> <p>2.3 Basis, dimension and coordinates.</p> <p>2.4 Rank of a vector set.</p> <p>2.5 Change of basis.</p> <p>2.6 Equations of a subspace.</p> <p>2.7 Dimension formula.</p> <p>3. Linear maps.</p> <p>3.1 Definitions and properties.</p> <p>3.2 Matrix form of a linear map.</p> <p>3.3 Change of basis.</p> <p>3.4 Kernel and image of a linear.</p> <p>3.5 Composition of homomorphisms.</p> <p>4. Endomorphisms.</p> <p>4.1 Introduction.</p> <p>4.2 Eigen values and eigen vectors.</p> <p>4.3 Diagonalization by similarity.</p> <p>4.4 Triangularization by similarity. Jordan form</p> |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| Planning                                                                                                                        |              |                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|--------------|----------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies | Ordinary class hours | Student's personal work hours | Total hours |
| Guest lecture / keynote speech                                                                                                  | A1 B2 B3     | 27                   | 32                            | 59          |
| Seminar                                                                                                                         | A1 B2 B3     | 27                   | 33                            | 60          |
| Mixed objective/subjective test                                                                                                 | A1 B2 B3     | 3                    | 3                             | 6           |
| Problem solving                                                                                                                 | A1 B2 B3     | 0                    | 10                            | 10          |
| Workbook                                                                                                                        | A1 B2 B3     | 0                    | 10                            | 10          |
| Personalized attention                                                                                                          |              | 5                    | 0                             | 5           |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. |              |                      |                               |             |

| Methodologies                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Guest lecture / keynote speech | <p>New mathematic concepts will be developed from examples familiar for the students, or explaining the questions are wished to be solved with them; from this their common characters will be abstracted causing its more accuracy definition. The theory which allows to solve the questions described at the beginning will be developed after.</p> <p>Students participation is desirable, sharing their doubts or comments as the class progresses.</p> |
| Seminar                        | <p>Simultaneously to the theoretical development of the matter collections of exercises are given.</p> <p>The goal is allowing students to practise the knowledge acquired at theoretical classes.</p> <p>At seminars the most important problems will be discussed.</p>                                                                                                                                                                                     |



|                                 |                                                                                                                                                                                                                                                                    |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mixed objective/subjective test | Exam where concepts are methods of the subjects are evaluated.                                                                                                                                                                                                     |
| Problem solving                 | Each student must solve individually some of the proposed problems.                                                                                                                                                                                                |
| Workbook                        | Before the beginning of each item, some notes about the contents are available for the students. The notes are intended as a complement of teacher's explanations.<br><br>A previous reading of students familiarize them with an outline of what they will study. |

| Personalized attention                                          |                                                                                                                 |
|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Methodologies                                                   | Description                                                                                                     |
| Problem solving<br>Seminar<br>Guest lecture /<br>keynote speech | We recommend using tutorials to ask any question regarding the subject, both theoretical and practical aspects. |

| Assessment                      |              |                                                                     |               |
|---------------------------------|--------------|---------------------------------------------------------------------|---------------|
| Methodologies                   | Competencies | Description                                                         | Qualification |
| Problem solving                 | A1 B2 B3     | Each student must solve individually some of the proposed problems. | 10            |
| Mixed objective/subjective test | A1 B2 B3     | Exam where concepts are methods of the subjects are evaluated.      | 90            |
| Others                          |              |                                                                     |               |

| Assessment comments |
|---------------------|
|                     |

| Sources of information |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>           | <ul style="list-style-type: none"> <li>- Juan de Burgos (2000). Álgebra Lineal. McGraw-Hill</li> <li>- Fuentes, Saleté y Cruces (1980). Álgebra vectorial y Tensorial. ETSICCP Madrid</li> <li>- F. Granero (1992). Álgebra y Geometría Analítica. McGraw-Hill</li> <li>- Anzola, Caruncho y Pérez-Canales (1981). Problemas de Álgebra (Tomos 1,3). Madrid</li> <li>- S. Lipschutz, M.L. Lipson (2000). Teoría y problemas de probabilidad. McGraw-Hill</li> <li>- Luis Fuentes García (2005-). Apuntes y ejemplos (<a href="http://caminos.udc.es/info/asignaturas/grado_tecic/101/AL1/index.html">http://caminos.udc.es/info/asignaturas/grado_tecic/101/AL1/index.html</a>). A Coruña</li> </ul>                                                               |
| <b>Complementary</b>   | <ul style="list-style-type: none"> <li>- J. Rojo (2001). Álgebra lineal. McGraw-Hill</li> <li>- F. Ayres Jr. (1991). Teoría y problemas de matrices. McGraw-Hill</li> <li>- J. Rojo e I. Martín (1994). Ejercicios y problemas de álgebra. McGraw-Hill</li> <li>- S.I. Grossman (1995). Álgebra lineal. McGraw-Hill</li> <li>- J. Flaquer y otros (1996). Curso de álgebra lineal. Ediciones Universidad de Navarra</li> <li>- P. Sanz y otros (1998). Problemas de álgebra lineal. Prentice Hall</li> <li>- M. Castellet e I. Llerena (1991). Álgebra lineal y geometría. Reverté</li> <li>- J. Arvesú y otros (1999). Álgebra lineal y aplicaciones. Síntesis</li> <li>- J. Pérez Vilaplana (1991). Problemas de cálculo de probabilidades. Paraninfo</li> </ul> |

| Recommendations                                      |
|------------------------------------------------------|
| Subjects that it is recommended to have taken before |
|                                                      |



| Subjects that are recommended to be taken simultaneously                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cálculo infinitesimal I/632G02001                                                                                                                                       |
| Subjects that continue the syllabus                                                                                                                                     |
| Álgebra lineal II/632G02008<br>Cálculo de probabilidades e estatística/632G02013<br>Fundamentos de mecánica computacional/632G02015<br>Ecuacións diferenciais/632G02017 |
| Other comments                                                                                                                                                          |
|                                                                                                                                                                         |

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.