



## Teaching Guide

| Identifying Data              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                |                                                                                                                                                                                                            |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Subject (*)                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       | Code           | 2019/20                                                                                                                                                                                                    |
| Algebra                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       | 614G01010      |                                                                                                                                                                                                            |
| Study programme               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                |                                                                                                                                                                                                            |
| Grao en Enxeñaría Informática |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                |                                                                                                                                                                                                            |
| Descriptors                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                |                                                                                                                                                                                                            |
| Cycle                         | Period                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Year  | Type           | Credits                                                                                                                                                                                                    |
| Graduate                      | 2nd four-month period                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | First | Basic training | 6                                                                                                                                                                                                          |
| Language                      | SpanishGalicianEnglish                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |       |                |                                                                                                                                                                                                            |
| Teaching method               | Face-to-face                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       |                |                                                                                                                                                                                                            |
| Prerequisites                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                |                                                                                                                                                                                                            |
| Department                    | Ciencias da Computación e Tecnoloxías da InformaciónComputación                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |       |                |                                                                                                                                                                                                            |
| Coordinador                   | Vieites Rodriguez, Ana Maria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |       | E-mail         | ana.vieites@udc.es                                                                                                                                                                                         |
| Lecturers                     | Aguado Martin, Maria Felicidad<br>Barja Pérez, José María<br>Costoya Ramos, María Cristina<br>Doncel Juarez, Jose Luis<br>Perez Vega, Gilberto<br>Souto Salorio, Maria Jose<br>Vidal Martin, Concepcion<br>Vieites Rodriguez, Ana Maria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |       | E-mail         | felicidad.aguado@udc.es<br>j.m.barja@udc.es<br>cristina.costoya@udc.es<br>jose.luis.doncel@udc.es<br>gilberto.pvega@udc.es<br>maria.souto.salorio@udc.es<br>concepcion.vidalm@udc.es<br>ana.vieites@udc.es |
| Web                           | campusvirtual.udc.es/moodle                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |       |                |                                                                                                                                                                                                            |
| General description           | <p>This course is part of the basic training module in the Computer Engineering degree. It is intended for acquiring skills in formal and abstract thinking, which will be essential in the performance of the students future professions. The main purpose of this subject is to introduce the basic notions of modular arithmetic, matrix theory and linear algebra. Emphasis is given to topics that will be useful in other subjects: Computer Security, Computer Graphics, Artificial Vision, Digital Image Processing, and Networks.</p> <p>We are concerned with an algorithmic approach emerging from the interplay of Algebra and Computer Engineering. In this course, students will learn how to design and analyze efficient algorithms for elementary number theory and linear algebra.</p> |       |                |                                                                                                                                                                                                            |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                                                   |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1   | Capacidade para a resolución dos problemas matemáticos que se poden presentar na enxeñaría. Aptitude para aplicar os coñecementos sobre: álgebra linear; cálculo diferencial e integral; métodos numéricos; algorítmica numérica; estatística e optimización. |
| A3   | Capacidade para comprender e dominar os conceptos básicos de matemática discreta, lóxica, algorítmica e complexidade computacional e a súa aplicación para a resolución de problemas propios da enxeñaría.                                                    |
| B3   | Capacidade de análise e síntese                                                                                                                                                                                                                               |
| B6   | Toma de decisións                                                                                                                                                                                                                                             |
| C1   | Expresarse correctamente, tanto de forma oral coma escrita, nas linguas oficiais da comunidade autónoma.                                                                                                                                                      |
| C6   | Valorar criticamente o coñecemento, a tecnoloxía e a información dispoñible para resolver os problemas cos que deben enfrontarse.                                                                                                                             |
| C7   | Asumir como profesional e cidadán a importancia da aprendizaxe ao longo da vida.                                                                                                                                                                              |

## Learning outcomes

| Learning outcomes                                     | Study programme competences |  |  |
|-------------------------------------------------------|-----------------------------|--|--|
| Acquire basic concepts from Elementary Number Theory. | A1                          |  |  |
|                                                       | A3                          |  |  |



|                                                                                                                                                                                                                                                                 |          |    |          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----|----------|
| Interpret and apply the acquired knowledge from Elementary Number Theory to Cryptography.                                                                                                                                                                       | A1<br>A3 | B3 |          |
| Know some basic concepts of Linear Algebra: systems of linear equations, vectorial spaces, matrices and linear maps.                                                                                                                                            | A1       |    |          |
| Use Linear Algebra as a tool for modeling and solving processes related to computer science.                                                                                                                                                                    | A1       | B6 | C6       |
| Know the definitions and basic principles from Coding Theory related to Linear Algebra.                                                                                                                                                                         | A1       |    |          |
| Simulate coding and decoding processes using matricial techniques.                                                                                                                                                                                              | A1       | B6 | C6       |
| Learn how to use mathematical language in a proper way to express ideas.                                                                                                                                                                                        | A1       |    | C1       |
| Develop the capacities of abstraction, concretion, concision, imagination, intuition, reasoning, criticism, objectivity, synthesis and accuracy; put all of them in practice either in the academic or the professional life for solving problems successfully. |          | B3 | C7       |
| Apply basic concepts from the subject and relate to algorithmic and computational concepts in the light of the mathematical ones.                                                                                                                               | A1       |    | C6       |
| Acquire tools and skills for solving problems in a proper way. Express and interpret results in a rigorous way. Check the result and, in case of any incongruence, revise the process to detect the error.                                                      | A1       | B6 | C1<br>C7 |

| Contents                                                           |                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                              | Sub-topic                                                                                                                                                                                                                                                                                                             |
| Chapter 1: Modular arithmetic: application to Cryptography.        | Basic concepts from elementary number theory. Euclides' algorithm. Prime numbers. Linear diophantine equations. Congruences. Modular arithmetic. Definition of cryptosystem. Classical cryptography. Symmetrical and asymmetrical cryptography. Examples of cryptosystems. Numeration systems. Divisibility criteria. |
| Chapter 2: Systems of Linear Equations, Matrices and Determinants. | Definition and properties of systems of linear equations. Echelon row form of system. Gauss method. Matrices. Operations with matrices. Invertible matrix. Determinant of a square matrix, properties. Cramer's rule.                                                                                                 |
| Chapter 3: Vector Spaces.                                          | Definition and properties of a vector space. Bases and coordinates. Dimension. Rank of a set of vectors and matrix rank. Computation of the rank. Change of basis. Rouché-Frobenius theorem.                                                                                                                          |
| Chapter 4. Linear maps.                                            | Definición e propiedades das aplicacións lineais. Núcleo e imaxe de unha aplicación lineal. Matriz asociada a unha aplicación lineal. Teorema da dimensión.<br><br>Definition and properties of linear maps. Kernel and image of a linear map. Matrix associated to a linear map. Dimension theorem.                  |
| Chapter 5. Linear Codes                                            | Definition of linear codes. Parameters of a linear code. Hamming distance and Hamming weight. Generator matrix and parity-check matrix of a code. Error correction in linear codes. Binary Hamming codes.                                                                                                             |

| Planning                                                                                                                        |                |                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|----------------|----------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies   | Ordinary class hours | Student's personal work hours | Total hours |
| Guest lecture / keynote speech                                                                                                  | A1 A3 C6 C7    | 30                   | 45                            | 75          |
| Laboratory practice                                                                                                             | A1 B3 B6 C1 C6 | 20                   | 30                            | 50          |
| Objective test                                                                                                                  | A1 B3 C1       | 3                    | 0                             | 3           |
| Collaborative learning                                                                                                          | A1 B3 C1 C7    | 6                    | 11                            | 17          |
| 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>The chief means of communication for this course will be the platform Moodle. Students are expected to check this for up-to-date assignments-including material separate from the given at the blackboard-and announcements. Over the semester we will study many topics that form a central part of the language of modern science. Weekly problem sets with a mix of exercises will be given. These include problems requiring abstraction, understanding and/or synthesis of various concepts. In many ways, these constitute the heart of the course; rigor in their completion often yields the greatest understanding.</p> <p>We want the student to leave the course not only with computational ability, but with the ability to use these notions in their natural scientific contexts, and with an appreciation of their mathematical power.</p>                                                                                                                                                                                                                                                                                                                                                                                              |
| Laboratory practice            | <p>The laboratory work is the focal point of learning. A series of exercises related to the theoretical contents explained in the theoretical classes will be given to students at the beginning of every chapter. It ensures that:</p> <p>I) students work closely with the teacher helping them to grow in confidence, to develop their skills in analysis, and to encourage them to reinforce the learning of theoretical concepts through the resolution of the exercises.</p> <p>II) students gain capacity of abstraction and understanding.</p> <p>A typical laboratory practice is a 2-hour class, with small groups of students, discussing the resolution of the exercises. It gives students the chance to interact directly with teachers, to exchange ideas and argue between them, to ask questions, and of course, to learn through the discussion.</p> <p>Technology can play an important role in the learning of mathematics, and as such, graphing and scientific calculators are permitted for class and homework, though they will not be permitted on tests and quizzes, and thus it is emphasized that students learn not to rely on them. Subject to availability, some exercises may be designed to be solved with computers.</p> |
| Objective test                 | Realizarase un exame escrito que consistirá nunha colección de cuestións teóricas e/ou de problemas (do mesmo tipo que os propostos nos seminarios(TGR) e nos boletíns de exercicios).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Collaborative learning         | Collaboration is encouraged, for home and class assignments; however, all submitted assignments must be written up independently and represent the student's own work and understanding.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

## Personalized attention

| Methodologies                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Guest lecture / keynote speech | The students have the possibility to revise the qualification obtained in the written final test, proving that this is adjusted to the criteria of evaluation established.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Laboratory practice            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Collaborative learning         | <p>Likewise, the evaluations of the answers to the questions and exercises formulated during the course, with the indications adequate in order to correct the errors and/or improve the answers with a view to a more solid formation, will justify.</p> <p>In the sessions in reduced groups, the doubts formulated by the students are solved in an individualized way, especially when they are common to several of them or illustrate an interesting case. If the question is more particular or does not completely remain solved for some pupil, it would be treated in the hours of individualized tuition.</p> <p>Students registered to partial time: Depending on the particularities of every specific case and the possibilities of the teaching staff put in charge of the group to the that it is a pupil registered in time partial assigned, the tests of the continuous evaluation will be adjusted so that this pupil can obtain the same qualification as a pupil of ordinary registration.</p> |



| Assessment          |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |               |
|---------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| Methodologies       | Competencies   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Qualification |
| Laboratory practice | A1 B3 B6 C1 C6 | <p>This section will consist of, at least, 2 structured or problem-solving questions based on the different topics, similar to exercises from the weekly 2-hour session classes. Correct answers as well as the presentation and clarity of the exposition will be valued.</p> <p>A participative attitude of the student in the resolution of the proposed exercises during the sessions will also be positively valued.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 20            |
| Objective test      | A1 B3 C1       | <p>Ao final do curso realizararase unha proba escrita. Esta proba inclúe:</p> <ul style="list-style-type: none"><li>- Preguntas curtas que permitan valorar se o alumno comprendeu os conceptos teóricos básicos.</li><li>- Problemas cun grao de dificultade semellante aos realizados na aula e aos presentados nas coleccións de exercicios propostos.</li></ul> <p>Avaliarase o dominio dos conceptos teóricos da materia, a comprensión dos mesmos e a súa aplicación na resolución de exercicios. Asimesmo, valorarase a claridade, a orde e a presentación dos resultados expostos.</p> <p>A presentación á proba final do curso supón que o estudante completou o proceso de avaliación continua.</p> <p>Hai que obter máis de 3 puntos, dos 8 posibles, na proba obxectiva para sumar a ésta a cualificación de evaluación continua (a cualificación final, neste caso, obténse sumando a cualificación da poeba obxectiva e a da avaliación continua). Noutro caso, a cualificación final do alumno é a nota da proba obxectiva.</p> | 80            |
| Others              |                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |               |

| Assessment comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Evaluation</p> <p>of the student registered in time partial: Depending on the particularities of every specific case and the possibilities of the teaching staff put in charge of the group to the that it is a student registered in time partial assigned, the tests of the continuous evaluation will be adjusted so that this student can obtain the same qualification as a student of ordinary registration. In the opportunity advanced to December, the examination will be qualified on ten points, being necessary to obtain at least one five to approve the matter.</p> |

| Sources of information |
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|------------------------|



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|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>         | <ul style="list-style-type: none"><li>- Grossman, S. I. (1996). Álgebra lineal con aplicaciones. McGraw-Hill Interamericana México.</li><li>- Grossman, S. I. (1994). Elementary Linear Algebra with Applications. Wiley</li><li>- Merino, L. y Santos, E. (2006). Álgebra Lineal con Métodos Elementales. Thomson.</li><li>- Cameron, P. J. (1998). Introduction to Algebra. Oxford University Press, Oxford.</li><li>- Rosen, K. H. (2004). Matemática Discreta y sus aplicaciones. McGraw-Hill Interamericana.</li><li>- Rosen, K. H. (2003). Discrete Mathematics and Its Applications. McGraw-Hill</li><li>- Biggs, N. L. (1994). Matemática Discreta. Madrid, Vicens Vives.</li><li>- Lay, D. C. (2011). Linear Algebra and Its Applications. Pearson</li><li>- Lay, D. C. (2007). Algebra Lineal y sus Aplicaciones. Prentice Hall</li></ul> |
| <b>Complementary</b> | <ul style="list-style-type: none"><li>- Hernández, E. (1994). Álgebra y Geometría. Addison-Wesley.</li><li>- Rojo, J. y Martín, I. (2005). Ejercicios y problemas de Álgebra Lineal. McGraw-Hill.</li><li>- Lidl, R. y Pilz, G. (1998). Applied Abstract Algebra. Nueva York, Springer.</li><li>- Torrecilla Jover, B. (1999). Fermat. El Mago de los Números. Nivola.</li><li>- Van Lint, J. H. (1999). Introduction to Coding Theory. Berlín, Springer.</li><li>- Singh, S. (2000). Los Códigos Secretos. Debate</li><li>- Nakos, G. y Joyner, D. (1999). Álgebra lineal con aplicaciones. Thomson.</li><li>- Nakos, G. y Joyner, D. (1998). Linear Algebra with Applications. Brooks Cole Publishing</li></ul>                                                                                                                                   |

| Recommendations                                          |
|----------------------------------------------------------|
| Subjects that it is recommended to have taken before     |
| Discrete Mathematics/614G01004                           |
| Subjects that are recommended to be taken simultaneously |
|                                                          |
| Subjects that continue the syllabus                      |
|                                                          |
| 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.