



## Teaching Guide

| Identifying Data         |  |        |                              |           | 2023/24 |
|--------------------------|--|--------|------------------------------|-----------|---------|
| Subject (*)              | Numerical methods and programming  |        | Code                         | 614855201 |         |
| Study programme          | Mestrado Universitario en Matemática Industrial (2013)   |        |                              |           |         |
| Descriptors              |  |        |                              |           |         |
| Cycle                    | Period   | Year   | Type                         | Credits   |         |
| Official Master's Degree | 1st four-month period  | First  | Obligatory                   | 6         |         |
| Language                 | Spanish  |        |                              |           |         |
| Teaching method          | Face-to-face   |        |                              |           |         |
| Prerequisites            |  |        |                              |           |         |
| Department               | Departamento profesorado máster Matemáticas  |        |                              |           |         |
| Coordinador              | García Rodríguez, José Antonio   | E-mail | jose.garcia.rodriguez@udc.es |           |         |
| Lecturers                | García Rodríguez, José Antonio<br>Pena Brage, Francisco José<br>Santamarina Ríos, Duarte   | E-mail | jose.garcia.rodriguez@udc.es |           |         |
| Web                      | <a href="http://www.m2i.es/docs/modulos/FBasica/4.Metodos%20Numericos%20y%20Programacion.pdf">www.m2i.es/docs/modulos/FBasica/4.Metodos%20Numericos%20y%20Programacion.pdf</a> |        |                              |           |         |
| General description      | In this subject, elementary numerical methods are presented to solve systems of linear and nonlinear equations, and to approximate functions, their derivatives and integrals. |        |                              |           |         |

## Study programme competences / results

| Code | Study programme competences / results   |
|------|---|
| A4   | Ser capaz de seleccionar un conjunto de técnicas numéricas, lenguajes y herramientas informáticas, adecuadas para resolver un modelo matemático.  |
| A8   | Saber adaptar, modificar e implementar herramientas de software de simulación numérica.   |
| B1   | Saber aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios, incluyendo la capacidad de integrarse en equipos multidisciplinares de I+D+i en el entorno empresarial. |
| B4   | Saber comunicar las conclusiones, junto con los conocimientos y razones últimas que las sustentan, a públicos especializados y no especializados de un modo claro y sin ambigüedades.   |
| B5   | Poseer las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo, y poder emprender con éxito estudios de doctorado.  |

## Learning outcomes

| Learning outcomes  | Study programme competences / results |                   |  |
|--|---------------------------------------|-------------------|--|
| 1. To know the elementary numerical methods for solving systems of linear and nonlinear equations, and to approximate a function, its derivatives and its definite integral.   | AC4<br>AC8                            | BJ1<br>BR1        |  |
| 2. Be able to efficiently use the calculus package MatLab for solving the problems studied in this subject.  | AC4<br>AC8                            | BJ1<br>BR1        |  |
| 3. Have a good predisposition for solving problems.  | AC4<br>AC8                            | BJ1<br>BC3<br>BR1 |  |
| 4. Be able to evaluate the difficulties involved in the process of solving a given problem, and taking them into account, be able to choose the more appropriate numerical method for solving it (among the studied ones). | AC4<br>AC8                            | BJ1<br>BR1        |  |
| 5. Be able to look up in the bibliography, to read and to understand the necessary information for solving a given problem.  | AC4<br>AC8                            | BJ1<br>BR1        |  |

## Contents

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



|                             |   |
|-----------------------------|---|
| Introduction to programming | <ol style="list-style-type: none"> <li>1. Introduction to matlab. Commands and basic functions.</li> <li>2. Vectors and matrices in Matlab. Sparse matrices. Graphical representation.</li> <li>3. Files .m and programming. Data structures in Matlab.</li> <li>4. Introduction to Fortran 90: data types and flow control.</li> <li>5. ?Arrays? in Fortran 90. Proceedings, modules and interfaces.</li> <li>6. Input/output of data in Fortran 90.</li> </ol>  |
| Numerical methods           | <ol style="list-style-type: none"> <li>7. Numerical solution of linear systems: Conditioning of a system of linear equations. Direct methods: LU, LL<sup>t</sup>, LDL<sup>t</sup> y QR. Classical iterative methods: Jacobi, Gauss--Seidel, SOR and SSOR. Convergence tests. Numerical methods for the calculus of eigenvalues and eigenvectors.</li> <li>8. Numerical solution of systems of nonlinear equations: review of numerical methods for solving nonlinear equations. Fixed point iteration method. Newton method. Computational comments.</li> <li>9. Interpolation. Lagrange interpolation. Hermite interpolation. Runge effect. Approximation using splines.</li> <li>10. Numerical differentiation and integration. Numerical derivatives of polynomial interpolation type. Numerical integration in one variable. Formulas of Newton-Cotes. Gauss formulas. Compound formulas.</li> <li>11. Interpolation and numerical integration in several variables.</li> </ol> |

| Planning                       |                        |                                      |                               |             |
|--------------------------------|------------------------|--------------------------------------|-------------------------------|-------------|
| Methodologies / tests          | Competencies / Results | Teaching hours (in-person & virtual) | Student?s personal work hours | Total hours |
| Guest lecture / keynote speech | A4 A8 B5 B1            | 20                                   | 40                            | 60          |
| Laboratory practice            | A4 A8 B5 B1            | 20                                   | 40                            | 60          |
| Supervised projects            | A4 B5 B1 B4            | 0                                    | 20                            | 20          |
| Objective test                 | A4 B5 B1               | 4                                    | 0                             | 4           |
| Personalized attention         |                        | 6                                    | 0                             | 6           |

(\*)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>In the theoretical sessions the teacher will present the theoretical contents of the subject, using illustrative examples for motivating the students and helping the comprehension and assimilation of the contents.</p> <p>The teacher will use dynamic presentations that the students will be able to download on beforehand from the virtual site of the subject in Moodle (And, if necessary, the data will be sent by e-mail).</p>           |
| Laboratory practice            | <p>During the course, several practical assignments will be proposed to the students.</p> <p>The students must implement in Matlab some of the numerical methods studied in this subject, validate their programs and prepare a report describing the developed codes. Also practical problems will be proposed using the numerical methods studied in the subject.</p> <p>All this practices will be taken into account for the final evaluation.</p> |
| Supervised projects            | Os alumnos deberán resolver exercicios teóricos relacionados coas técnicas que se estuden nas horas de docencia expositiva   |



|                |  |
|----------------|--|
| Objective test | <p>This is the final exam of the subject, and it has two parts.</p> <p>In the first part, several theoretical exercises will be proposed relating, for example, the range of application of the studied methods and their convergence properties. In the second part, the students will solve a practical case using the studied commands and the programs developed in Matlab or, if this is the case, implementing the necessary algorithms.</p> |
|----------------|--|

### Personalized attention

| Methodologies       | Description  |
|---------------------|--|
| Laboratory practice | Students will be able to ask the teachers of the subject any doubt arising during problems solving and also during the implementation of the laboratory practices. |

### Assessment

| Methodologies       | Competencies / Results | Description   | Qualification |
|---------------------|------------------------|---|---------------|
| Laboratory practice | A4 A8 B5 B1            | <p>The ability of student to solve the problems studied in the subject using the calculus package MatLab is evaluated, as well as, and their skills to efficiently implement the studied numerical methods.</p> <p>We also evaluate the knowledge of the students to apply the studied theoretical results.</p> | 50            |
| Objective test      | A4 B5 B1               | The theoretical and practical knowledges learnt by the student are evaluated.   | 50            |

### Assessment comments

#### CRITERIA FOR THE 1ST ASSESSMENT OPPORTUNITY

The first part (50% of the qualification) will consist on the evaluation of the Matlab and Fortran practical works; both works will have the same weight to calculate the qualification of this part.

The second part (the remaining 50%) will correspond to the exam, where the concepts acquired in the part II of the subject will be evaluated.

Students must pass both parts in order to pass the subject. If one of the parts is not passed the qualification will be 4 out of 10.

A student will be considered as 'presented' when the exam and/or two practical works are presented.

#### CRITERIA FOR THE 2ND ASSESSMENT OPPORTUNITY

The same as for the first opportunity. The deadline for handing in the tasks will be adapted to the date of the second exam

### Sources of information

|                      |   |
|----------------------|---|
| <b>Basic</b>         | <ul style="list-style-type: none"> <li>- Quarteroni, A. y Saleri, F. (2006). Cálculo Científico con MATLAB y Octave. Springer</li> <li>- Kincaid, D. y Cheney, W. (1994). Análisis numérico. Las matemáticas del cálculo científico. Addison Wesley Iberoamericana</li> <li>- Epperson, J.F. (2007). An introduction to numerical methods and analysis. John Wiley &amp; Sons</li> <li>- T. Aranda, J.G. García (1999). Notas sobre Matlab. Universidad de Oviedo, Servicio de Publicaciones</li> <li>- J.A. Infante del Río, J.M. Rey Cabezas (2007). Métodos numéricos. Pirámide</li> </ul> <p>Os libros de Infante del Río e Quarteroni y Saleri son os que se siguen para a maior parte dos contenidos.</p>   |
| <b>Complementary</b> | <ul style="list-style-type: none"> <li>- Golub, G.H. y van Loan, C.F. (1996). Matrix Computations. John Hopkins, University Press</li> <li>- Kelley, C.T. (2003). Solving Nonlinear Equations with Newton's Method. SIAM</li> <li>- Kiusalaas, J. (2005). Numerical Methods in Engineering with MATLAB. Cambridge University Press</li> <li>- Viaño, J.M. y Burguera, M. (1999). Lecciones de métodos numéricos. 3.- Interpolación. Tórculo Edicións</li> <li>- Viaño, J.M. (1997). Lecciones de métodos numéricos. 2.- Resolución de ecuaciones numéricas. Tórculo Edicións</li> <li>- D. Faires, R. Burden. (2011). Análisis Numérico. Thomson</li> <li>- P.G. Ciarlet (1989). Introduction to numerical linear algebra and optimisation.. Cambridge University Press</li> <li>- M. Metcalf, J.K. Reid (2011). Modern Fortran Explained. Oxford University Press</li> </ul> |



## Recommendations

### Subjects that it is recommended to have taken before

Elementos Finitos I/614455102  
Diferenzas Finitas/614455205  
Elementos de Contorno/614455207  
Elementos Finitos II/614455208  
Métodos Numéricos en Optimización/614455210  
Métodos Numéricos II/614455211  
Métodos Numéricos para Ecuacións Diferenciais Ordinarias (EDO)/614455212  
Cálculo Paralelo/614455202

### Subjects that are recommended to be taken simultaneously

Linguaxes e Contornos de Programación I/614455104

### Subjects that continue the syllabus

### Other comments

<p>To be able to understand the methods presented in this subject it is necessary to have elemental knowledge of linear algebra and differential and integral calculus. It is also recommended to study the contents developed in the subject at the time they are introduced, making the assignments and the proposed practices, and making use of the tutorials and consulting recommended bibliography.

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(\*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.