



Teaching Guide

| Identifying Data | | | | | 2024/25 |
|---------------------|--|--------|-------------------------------|---------|-----------|
| Subject (*) | Numerical Methods for Data Science | | | Code | 614G02033 |
| Study programme | Grao en Ciencia e Enxeñaría de Datos | | | | |
| Descriptors | | | | | |
| Cycle | Period | Year | Type | Credits | |
| Graduate | 1st four-month period | Fourth | Optional | 6 | |
| Language | Spanish | | | | |
| Teaching method | Face-to-face | | | | |
| Prerequisites | | | | | |
| Department | Matemáticas | | | | |
| Coordinador | Gonzalez Taboada, Maria | E-mail | maria.gonzalez.taboada@udc.es | | |
| Lecturers | Gonzalez Taboada, María | E-mail | maria.gonzalez.taboada@udc.es | | |
| Web | campusvirtual.udc.gal | | | | |
| General description | In this subject students will learn numerical methods for solving nonlinear equations, large systems of linear and nonlinear equations, and to approximate eigenvalues of large matrices. They will also learn optimization methods for large dimension and interpolation techniques in one and several variables. | | | | |

Study programme competences / results

| Code | Study programme competences / results |
|------|--|
| A2 | CE2 - Capacidade para resolver problemas matemáticos, planificando a súa resolución en función das ferramentas dispoñibles e das restricións de tempo e recursos. |
| B2 | CB2 - Que os estudantes saiban aplicar os seus coñecementos ao seu traballo ou vocación dunha forma profesional e posúan as competencias que adoitan demostrarse por medio da elaboración e defensa de argumentos e a resolución de problemas dentro da súa área de estudo |
| B3 | CB3 - Que os estudantes teñan a capacidade de reunir e interpretar datos relevantes (normalmente dentro da súa área de estudo) para emitir xuízos que inclúan unha reflexión sobre temas relevantes de índole social, científica ou ética |
| B4 | CB4 - Que os estudantes poidan transmitir información, ideas, problemas e solucións a un público tanto especializado como non especializado |
| B7 | CG2 - Elaborar adecuadamente e con certa orixinalidade composicións escritas ou argumentos motivados, redactar plans, proxectos de traballo, artigos científicos e formular hipóteses razoables. |
| B8 | CG3 - Ser capaz de manter e estender formulacións teóricas fundadas para permitir a introdución e explotación de tecnoloxías novas e avanzadas no campo. |
| B9 | CG4 - Capacidade para abordar con éxito todas as etapas dun proxecto de datos: exploración previa dos datos, preprocesado, análise, visualización e comunicación de resultados. |
| B10 | CG5 - Ser capaz de traballar en equipo, especialmente de carácter multidisciplinar, e ser hábiles na xestión do tempo, persoas e toma de decisións. |
| C1 | CT1 - Utilizar as ferramentas básicas das tecnoloxías da información e as comunicacións (TIC) necesarias para o exercicio da súa profesión e para a aprendizaxe ao longo da súa vida. |
| C4 | CT4 - Valorar a importancia que ten a investigación, a innovación e o desenvolvemento tecnolóxico no avance socioeconómico e cultural da sociedade. |

Learning outcomes

| Learning outcomes | Study programme competences / results |
|-------------------|---------------------------------------|
| | |



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|--|----|----------------------------------|----------|
| Identify the potential of numerical methods in the solution of problems from data science. | A2 | B2 B3 B4 B8 B9 | C1 C4 |
| Understand the basis of numerical methods to be able to apply them with criteria, not being a mere user of the options of a software package as a black box. | A2 | B2 B3 B4 B7 B8 B9 | C1 C4 |
| Be able to decide which numerical methods can be applied to solve each problem and which ones are the most efficient. Have the basis to learn more advanced methods. | A2 | B2 B3 B4 B7 B8 B9 | C1 C4 |
| Manage software tools that implement the numerical methods studied and acquire the ability to implement them and make extensions. | A2 | B2 B4 B9 B10 | C1 C4 |

| Contents | |
|---|--|
| Topic | Sub-topic |
| Basic concepts in numerical methods: convergence, errors and order. | |
| Numerical methods for nonlinear equations | Bisection, secant method, Regula Falsilla, fixed point method and Newton-Raphson |
| Numerical methods for the solution of large linear systems | Direct and iterative methods |
| Numerical methods for approximating eigenvalues and eigenvectors | Power methods. QR method. |
| Methods for storing large matrices in the computer | |
| Numerical methods for solving nonlinear systems of equations | Fixed point methods. Newton's method. |
| Numerical methods for optimization | Gradient and Conjugate gradient methods. Line-search methods. Newton and quasi-Newton methods. Global optimization methods and two-phase methods. |
| Numerical interpolation in one and several variables. | |

| Planning | | | | |
|--------------------------------|-----------------------------------|--------------------------------------|-------------------------------|-------------|
| Methodologies / tests | Competencies / Results | Teaching hours (in-person & virtual) | Student?s personal work hours | Total hours |
| ICT practicals | A2 B2 B3 B4 B9 B10 C1 C4 | 14 | 35 | 49 |
| Supervised projects | A2 B2 B3 B4 B7 B8 B9 B10 C1 C4 | 2 | 11 | 13 |
| Problem solving | A2 B2 B4 B9 B10 | 7 | 14 | 21 |
| Objective test | A2 B2 B3 B4 B7 B8 C1 | 2 | 4 | 6 |
| Guest lecture / keynote speech | A2 B2 B3 B4 B8 B9 | 20 | 40 | 60 |
| Personalized attention | | 1 | 0 | 1 |



(*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

| Methodologies | |
|--------------------------------|---|
| Methodologies | Description |
| ICT practicals | The teacher will help students deepen the concepts and numerical methods presented during the guest lectures using Python. |
| Supervised projects | Students will develop a supervised project in which they will combine the use of the different learning outcomes acquired in the subject. |
| Problem solving | Students will solve problems that help them to understand how the studied numerical methods work. |
| Objective test | There will be an exam on the dates decided by the Faculty Board. The exam will focus essentially on the solution of practical problems. |
| Guest lecture / keynote speech | During guest lectures, the teacher will present the different contents. She will motivate the need of the different numerical methods using real problems, and she will present the necessary concepts and different numerical methods, discussing their main features. |

| Personalized attention | |
|--|--|
| Methodologies | Description |
| ICT practicals Supervised projects Problem solving | <p>During ICT practicals, the teacher will review and discuss with each student his/her advances in the assigned practice.</p> <p>In the supervised project, the teachers will discuss and review the advances of students as well as the final result.</p> <p>During problem-solving sessions, the teacher will solve students' questions on theoretical concepts and their practical applications.</p> <p>Finally, the teachers will solve the doubts raised by the students during their respective tutorial hours.</p> |

| Assessment | | | |
|---------------------|-----------------------------------|---|---------------|
| Methodologies | Competencies / Results | Description | Qualification |
| ICT practicals | A2 B2 B3 B4 B9 B10 C1 C4 | Several practical small projects will be proposed and evaluated along the course. | 30 |
| Supervised projects | A2 B2 B3 B4 B7 B8 B9 B10 C1 C4 | Teachers will propose a supervised project to each student that he/she will have to defend at the end of the subject. | 20 |
| Problem solving | A2 B2 B4 B9 B10 | During the course there will be some small tests. They will consist on solving problems of the same type as those studied during the classes. | 20 |
| Objective test | A2 B2 B3 B4 B7 B8 C1 | There will be a written exam on the dates set by the Faculty Board. | 30 |

| Assessment comments |
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| <p>In order to pass the subject, it is mandatory to attain at least a qualification of 50%.</p> <p>In the extraordinary call there will be an objective test. It will not be possible to recover the part of the final mark corresponding to continuous assessment.</p> <p>Part-time students and those with academic dispensation of attendance exemption that have not been evaluated of ICT practicals can do a specific exam to recover 70% of the final mark; they can obtain 30% of the final mark with the objective test.</p> <p>Fraudulent performance of the tests or evaluation activities, once verified, will directly imply a mark of "0" in the subject, invalidating any grade obtained in all the evaluation activities.</p> |

| Sources of information |
|------------------------|
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|----------------------|---|
| Basic | <ul style="list-style-type: none"> - R. Barrett, M. Berry, T.F. Chan, J. Demmel, J.M. Donato, J. Dongarra, V. Eijkhout, R. Pozo, C. Romin (1994). Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods. SIAM - R.L. Burden, D.J. Faires & A.M. Burden (2017). Análisis Numérico. CENCAGE Learning - C.T. Kelley (2003). Solving Nonlinear Equations with Newton's Method. SIAM - S. Linge & H.P. Langtangen (2020). Programming for Computations - Python. Springer - J. Nocedal & S.J. Wright (2006). Numerical Optimization. Springer - A. Quarteroni & F. Saleri (2006). Calculo científico con Matlab y Octave. . Springer |
| Complementary | <ul style="list-style-type: none"> - J.W. Demmel (1997). Applied Numerical Linear Algebra. SIAM - C.T. Kelley (1995). Iterative Methods for Linear and Nonlinear Equations. SIAM - C.T. Kelley (1999). Iterative Methods for Optimization. SIAM - D.R. Kincaid & E.W. Cheney (2022). Numerical Analysis: Mathematics of Scientific Computing. AMS - J Kiusalaas (2013). Numerical Methods in Engineering with Python 3. Cambridge University Press - M. Locatelli & F. Schoen (2013). Global Optimization. Theory, Algorithms and Applications. SIAM - G. Strang (2019). Linear Algebra and Learning from Data. Wellesley Cambridge Press |

Recommendations

Subjects that it is recommended to have taken before

Linear Algebra/614G02001

Multivariable Calculus /614G02006

Fundamentals of Programming I/614G02004

Subjects that are recommended to be taken simultaneously

Subjects that continue the syllabus

Other comments

Students are recommended to take the subject up to date and consult with the teachers any doubts that may arise.

(*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.