Teaching Guide				
Identifying Data				2022/23
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	García Rodríguez, José Antonio Gonzalez Taboada, Maria	E-mail	jose.garcia.rodriguez@udc.es maria.gonzalez.taboada@udc.es	
Web				
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	
Code	Study programme competences
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

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 matrix methods in high dimensions.	1. Storage of large matrices. 2. Direct and iterative methods for solving large linear systems of equations. 3. Numerical approximations of eigenvalues of large matrices.
Numerical methods to solve nonlinear equations and nonlinear systems of equations.	1. Numerical methods for nonlinear equations: bisection, secant, regula-falsi, fixed-point and Newton-Raphson. 2. Numerical methods for large systems of nonlinear equations: fixed point and Newton.
Numerical methods for optimization of large problems.	1. Gradient and Conjugate gradient methods. 2. Line-search methods. 3. Newton and quasi-Newton methods. 4. Global optimization methods and two-phase methods.
Numerical interpolation in one and several variables.	

Planning				
Methodologies / tests	**Competencies**	**Ordinary class hours**	**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	1.5	9.5	11
Problem solving	A2 B2 B4 B9 B10	7	14	21
Objective test	A2 B2 B3 B4 B7 B8 C1	3	6	9
Guest lecture / keynote speech	A2 B2 B3 B4 B8 B9	20	40	60

Personalized attention		0		0
(*)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	Studients 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	During ICT practicals, the teacher will review and discuss with each student his/her advances in the assigned practice. In the supervised project, the teachers will discuss and review the advances of students as well as the final result. The teacher will solve studients' questions on theoretical concepts and the practical applications during problema solving sessions. Finally, the teachers will solve the doubts raised by the students in their respective tutorial hours.

Assessment			
Methodologies	**Competencies**	**Description**	**Qualification**
ICT practicals	A2 B2 B3 B4 B9 B10 C1 C4	Several practical small projects will be proposed and evaluated along the course.	50
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
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
In order to pass the subject, it is mandatory to attain at least a qualification of 50%.

Sources of information	
Basic	- 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 (1995). Iterative Methods for Linear and Nonlinear Equations. SIAM - C.T. Kelley (1999). Iterative Methods for Optimization. SIAM - J Kiusalaas (2013). Numerical Methods in Engineering with Python 3. Cambridge University Press - A. Quarteroni & F. Saleri (2006). Calculo cientifico con Matlab y Octave. . Springer

Complementary	- C.T. Kelley (2003). Solving Nonlinear Equations with Newton's Method. SIAM - D.R. Kincaid & E.W. Cheney (2022). Numerical Analysis: Mathematics of Scientific Computing. AMS - J.W. Demmel (1997). Applied Numerical Linear Algebra. SIAM - M. Locatelli & F. Schoen (2013). Global Optimization. Theory, Algorithms and Applications. SIAM - J. Nocedal & S.J. Wright (2006). Numerical Optimization. Springer - G. Strang (2019). Linear Algebra and Learning from Data. Wellesley Cambridge Press

Recommendations
Subjects that it is recommended to have taken before
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.