Teaching Guide				
Identifying Data				2021/22
Subject (*)	Mathematical Optimisation		Code	614G02020
Study programme	Grao en Ciencia e Enxeñaría de Datos			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	2nd four-month period	Second	Obligatory	6
Language	Spanish			
Teaching method	Face-to-face			
Prerequisites				
Department	Matemáticas			
Coordinador	Lorenzo Freire, Silvia	E-mail	silvia.lorenzo@udc.es	
Lecturers	Lorenzo Freire, Silvia	E-mail	silvia.lorenzo@udc.es	
Web				
General description	In this subject we intend to provide students with a practical knowledge of the basic methods of optimization that help to solve problems related to Data Science and Engineering. To this end, special emphasis will be placed on modeling optimization problems and on linear and integer programming and network optimization problem-solving techniques. Fundamentally, R, Julia and Python programming languages will be used.			
Contingency plan	1. Modifications in the contents There will be no modifications in the contents. 2. Methodologies *Teaching methodologies are maintained All teaching methodologies are maintained (master session, problem solving, tutored work and personalized attention). *Teaching methodologies that are modified There will not be any modification. 3. Mechanisms of personalized attention to the students - E-mail: It will be used daily for consultations and to request virtual meetings to solve doubts. - Teams: There will be 2-3 weekly sessions for tutorials or virtual classes. - On-line campus: It will be used approximately twice a week to provide students with the material. 4. Modifications in the evaluation There will be no modifications in the evaluation. *Evaluation observations 5. Modifications to the bibliography or webgraphy There will be no modifications.			

Study programme competences / results	
Code	Study programme competences / results
A29	CE29 - Capacidade para construír, analizar, validar e interpretar modelos de programación matemática a partir de problemas reais nos que se trata de optimizar un obxectivo suxeito a certas restricións, así como para achegar solucións a tales problemas.
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
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.

Learning outcomes			
Learning outcomes	Study programme competences / results		
Identify real problems that can be solved by using optimization techniques.	A29	B2 B3 B7 B8 B9 B10	C1
Formulate optimization models that describe the problem to be solved, identifying the objective function and making use of the appropriate variables and constraints.	A29	B2 B3 B7 B8 B9 B10	C1
Know how to use the basic tools for solving linear programming models, integer linear programming and network optimization.	A29	B2 B3 B7 B8 B9 B10	C1
Knowing and using the right software to solve problems of linear programming, integer linear programming and network optimization.	A29	B2 B3 B7 B8 B9 B10	C1

Contents	
Topic	Sub-topic
Introduction to mathematical optimization.	What is an optimization problem? Types of optimization problems.
Linear programming.	Formulation of linear programming problems. Graphic solution of linear programming problems. The Simplex method. Duality and sensitivity analysis.
Integer linear programming.	Formulation of linear integer programming problems. Resolution methods. The branch and cut algorithm. Computational aspects and introduction to heuristics.

Optimization in networks.	Flow problems in networks and applications. Other network optimization problems. Resolution methods.
Introduction to other mathematical optimization problems.	Introduction to non-linear programming. Introduction to multiobjective programming. Introduction to stochastic programming. Introduction to dynamic programming.

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Guest lecture / keynote speech	A29 B2 B3 B7 B8 B9 B10 C1	30	48	78
Laboratory practice	A29 B2 B3 B7 B8 B9 B10 C1	20	20	40
Seminar	A29 B2 B3 B7 B8 B9 B10 C1	10	10	20
Mixed objective/subjective test	A29 B2 B3 B7 B8 B9 B10 C1	3	3	6
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	The student will receive master classes in which the teacher, with the help of the relevant audiovisual media, will explain the theoretical and practical contents of the subject. Participation and debate will be encouraged at all times.
Laboratory practice	In the laboratory practices, students will learn to use the basic optimization tools: linear programming solvers, general linear programming interfaces and algebraic modeling languages. These tools are valid for several programming languages, but in this subject R, Julia and Python will be fundamentally taken into account.
Seminar	The seminars will reinforce both the applied nature of the subject and its interactivity. In the seminars the students will be able to expose their doubts and worries referred to the subject, and will have the opportunity to carry out, with the supervision of the teacher, problems similar to those of the exams.
Mixed objective/subjective test	The students must demonstrate their mastery of the theoretical aspects of the subject and their ability to solve problems in the field of optimization.

Personalized attention	
Methodologies	Description
Guest lecture / keynote speech Laboratory practice Seminar	In order to solve problems it will be important to personally attend to the students when they have doubts. This attention will also serve, on the one hand, the teacher to detect possible problems in the methodology used to teach the subject and, on the other hand, the students to consolidate theoretical knowledge and express their concerns about the subject.

Assessment			
Methodologies	Competencies / Results	Description	**Qualification**

Laboratory practice	A29 B2 B3 B7 B8 B9 B10 C1	To evaluate the degree of understanding and learning of the practices, each student will do an individual practice. To perform this practice, the student will have to solve an optimization problem using the software tools that have been provided throughout the course.	20
Seminar	A29 B2 B3 B7 B8 B9 B10 C1	Throughout the course, the student will demonstrate his interest in the subject and his mastery of it by taking a written test (control). This test will correspond to topics 1 and 2 of the subject.	20
Mixed objective/subjective test	A29 B2 B3 B7 B8 B9 B10 C1	The final exam, with a value between 60% and 80% (depending on the grade obtained in the control), will consist of a written theoretical-practical test.	60

Assessment comments

Sources of information	
Basic	- Ahuja, R.K., Magnanti, T.L. y Orlin, J.B. (1993). Network Flows. Theory, Algorithms and Applications. Prentice-Hall - Bazaraa, M.S., Jarvis, J.J. y Sherali, H.D. (2010). Linear Programming and Network Flows. Wiley - Hillier, F. y Lieberman, G. (2016). Introduction to operations research. McGraw-Hill - Martín, Q., Santos, M.T. y Santana, Y. (2005). Investigación Operativa. Problemas y ejercicios resueltos. Pearson - Pedregal, P. (2004). Introduction to Optimization. Springer
Complementary	- Bazaraa, M.S., Sherali, H.D. y Shetty, C.M. (2006). Nonlinear programming. Theory and algorithms. Wiley - Birge, J.R. y Louveaux, F. (2011). Introduction to Stochastic Programming. Springer - Chong, E.K.P. y Zak, S.H. (2013). An Introduction to Optimization. Wiley - Cortez, P. (2014). Modern optimization with R. Springer-Verlag - Fourer, R. Gay, D.M. y Kernigham, B.W. (2002). AMPL: A modeling language for Mathematical Programming. Duxbury Press - Hart, W.E., Laird, C., Watson, J.P. y Woodruff, D.L. (2012). Pyomo: Optimization Modeling in Python. Springer - Salazar-González, J.J. (2001). Programación Matemática. Díaz de Santos - Taha, H.A. (2012). Investigación de operaciones. Pearson

Recommendations
Subjects that it is recommended to have taken before
Linear Algebra/614G02001 Multivariable Calculus /614G02006 Probability and Basic Statistics/614G02003
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.