



Teaching Guide

| Identifying Data | | | | | 2022/23 |
|---------------------|---|--------|--|---------|---------|
| 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 | López Igrexas, Macías Lorenzo Freire, Silvia | E-mail | macias.lopez@udc.es 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. | | | | |

Study programme competences

| Code | Study programme competences |
|------|--|
| 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 | | |
|---|-----------------------------|-----------------------------------|----|
| 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 | Ordinary class hours | 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 | 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 |
|---|
| The fraudulent performance of the assessment tests or activities, once verified, will directly imply the qualification of failing "0" in the subject in the corresponding exam session, thus invalidating any qualification obtained in all the assessment activities for the extraordinary exam session. |

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



| | |
|----------------------|---|
| Basic | <ul style="list-style-type: none"> - 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 | <ul style="list-style-type: none"> - 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 Kernighan, 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.