Course guide
200152 - PM - Mathematical Programming

Last modified: 14/05/2024

Unit in charge: School of Mathematics and Statistics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research.

Degree: BACHELOR'S DEGREE IN MATHEMATICS (Syllabus 2009). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 7.5 **Languages:** Catalan

LECTURER

Coordinating lecturer: JORDI CASTRO PÉREZ

Others: Primer quadrimestre:
JORDI CASTRO PÉREZ - M-A, M-B
MARC ESQUERRÁ COROMINAS - M-A, M-B
FRANCISCO JAVIER HEREDIA CERVERA - M-A, M-B
ALBERT SOLÀ VILALTA - M-A, M-B

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.
2. CE-3. Have the knowledge of specific programming languages and software.
3. CE-4. Have the ability to use computational tools as an aid to mathematical processes.

Generical:
4. CB-1. Demonstrate knowledge and understanding in Mathematics that is founded upon and extends that typically associated with Bachelor's level, and that provides a basis for originality in developing and applying ideas, often within a research context.
5. CB-2. Know how to apply their mathematical knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader or multidisciplinary contexts related to Mathematics.
6. CB-3. Have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements.
7. CG-1. Show knowledge and proficiency in the use of mathematical language.
8. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.
9. CG-3. Have the ability to define new mathematical objects in terms of others already know and ability to use these objects in different contexts.
10. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
12. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.

Transversal:
11. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

TEACHING METHODOLOGY

(Section not available)

LEARNING OBJECTIVES OF THE SUBJECT

(Section not available)

STUDY LOAD

Type	Hours	Percentage
Hours small group	30,0	16.00
Self study	112,5	60.00
Hours large group	45,0	24.00

Total learning time: 187.5 h

CONTENTS

Introduction

Description:
The Mathematical Programming. Building methodology of Mathematical Programming models. The paper of the models in the decision making process. Main types of Mathematical Programming: linears, integers, network flows, nonlinear, stochastics, etc.

Full-or-part-time: 23h 30m
Theory classes: 4h 30m
Practical classes: 3h
Self study : 16h

Linear Programming

Description:
Definition and examples of linear programming problems. The geometry of linear programming: feasible sets, convex sets and polyhedrons; optimal solutions, extreme points and basic solutions. The primal simplex algorithm: development, convergence and computational complexity. Duality theory: definition of the dual problem and examples, duality theorems. Duality and the max flow - min cut theorem. Dual simplex algorithm: development and convergence. Sensitivity analysis.

Full-or-part-time: 47h 30m
Theory classes: 13h 30m
Practical classes: 6h
Laboratory classes: 3h
Self study : 25h

Integer Linear Programming

Description:
Definition of linear integer programming problem and examples. Linear relaxation. Valid, strong and ideal formulations. Algorithms for linear integer programming: branch and bound, Gomory's cutting planes, branch and cut.

Full-or-part-time: 18h 30m
Theory classes: 6h
Practical classes: 4h
Self study : 8h 30m

Unconstrained Nonlinear Programming

Description:
Nonlinear optimization models. Existence and characterization of the optimization problems solutions. First and second order conditions. Line search methods: curve fitting, Armijo-Wolfe conditions. Basic methods of descent: the gradient method and Newton method.

Full-or-part-time: 28h 30m
Theory classes: 7h 30m
Practical classes: 5h
Self study : 16h

Constrained Nonlinear Programming

Description:
Constrained Nonlinear Programming Problems. Lagrangian function. Kuhn-Tucker conditions. Sufficient conditions. Sensitivity analysis.

Full-or-part-time: 34h 30m
Theory classes: 11h 30m
Practical classes: 7h
Self study : 16h

GRADING SYSTEM

There will be a non eliminatory midterm exam (ExP), and a final exam (ExF).The final mark NF of the course will be:

NF= max{ExF, 0.7 ExF + 0.3 ExP}

An extra exam will take place on July for students that failed during the regular semester.

If the student fails, the extra evaluation will only consist of a resit exam.

BIBLIOGRAPHY

Basic:
- Bertsimas, Dimitris; Tsitsiklis, John N. Introduction to linear optimization. Belmont: Athena Scientifc, 1997. ISBN 1886529191.
- Nocedal, Jorge ; Wright, Stephen J. Numerical optimization [on line]. 2nd ed. Springer Science + Business Media, 2006 [Consultation: 20/06/2023]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-0-387-40065-5. ISBN 0387303030.
- Wolsey, Laurence A. Integer programming. New York: John Wiley & Sons, 1998. ISBN 0471283665.
- Fourer, Robert; Gay, David M.; Kernighan, Brian W. AMPL : a modeling language for mathematical programming. 2nd ed. Pacific Grove, CA: Thomson/Brooks/Cole, 2003. ISBN 0534388094.

Complementary:
- Sra, Suvrit; Nowozin, Sebastian; Wright, Stephen J. Optimization for machine learning [on line]. Cambridge: MIT Press, 2011 [Consultation: 24/05/2024]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3339310. ISBN 9780262298773.