COURSE DATA

Data Subject	
Code	34154
Name	Mathematical programming
Cycle	Grade
ECTS Credits	6.0
Academic year	2023 - 2024

Study (s)

Degree	Center	Acad. year	Period
1107 - Degree in Mathematics	Faculty of Mathematics	2	First term
1928 - D.D. in Physics-Mathematics	Double Degree Program Physics and Mathematics	3	First term

Subject-matter

Degree	Subject-matter	Character
1107 - Degree in Mathematics	4 - Mathematical programming	Obligatory
1928 - D.D. in Physics-Mathematics	3 - Tercer Curso (Obligatorio)	Obligatory

Coordination

Name	Department
BELENGUER RIBERA, JOSE MANUEL	130 - Statistics and Operational Research
CAMPOY GARCIA, RUBEN	130 - Statistics and Operational Research
PARREÑO TORRES, CONSUELO	130 - Statistics and Operational Research

SUMMARY

This course presents an introduction to Mathematical Programming. Its main aim is that students learn to formulate and solve real systems using mathematical models in the context of Optimization. The three basic models of Mathematical Programming, linear, integer and non-linear, will be studied, with particular attention to methods and solvers.

The program is divided into three parts, which correspond to each of the models to be studied. In the first part, Linear Programming is reviewed, and then its extensions are addressed. In the second part, the Integer Linear Problem is studied, where we deal with the difficulty introduced into the linear problem when considering integer variables. For this, classical resolution methods will be introduced, studying their efficiency. In addition, some structured problems for which specific resolution procedures have been designed will be considered. In the last part of the course, an introduction to Nonlinear Programming is

studied. Specifically, the two general models of this discipline, unconstrained and constrained, will be considered.

Finally, it is worth noting the use of specific software packages in the practical sessions to learn to formulate and solve optimization problems computationally.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

Have approved the subjects Linear Algebra and Discrete Mathematics.

OUTCOMES

1107 - Degree in Mathematics

- Capacity for analysis and synthesis.
- Capacity for organization and planning.
- Solve problems that require the use of mathematical tools.
- Ability to work in teams.
- Apply the knowledge in the professional world.
- Argue logically in decision-making.
- Expressing mathematically in a rigorous and clear manner.
- Capacity of abstraction and modeling.
- Participate in the implementation of software and learn mathematical software.
- Knowing the time and the historical context in which occurred the great contributions of women and men in the development of mathematics.
- Visualize and interpret the solutions obtained.

LEARNING OUTCOMES

- To Know the Operation Research area and its applications.
- To know how to use the Linear Programming model, its mathematical basis and how to use the basics tools to solve and analyse different problems using Simplex Algorithm, Duality and sensitivity analysis.
- To know integer Linear Programming, its applications, complexity and the main algorithms.
- To know some flow networks.
- To know basic knowledge in Nonlinear Programming and its resolution methodologies.

DESCRIPTION OF CONTENTS

1. Introduction

Introduction to Operations Research.
The optimization problem.
Linear Programming Model.

2. The simplex method

Convex sets and polyhedrons.
Simplex Methodology.
Initial solution and convergence.

3. Duality

Duality Theory.
Dual Simplex Method.
Sensitivity Analysis.

4. Introduction to the Integer Linear Programming

Integer Linear Programming.
Structure Problems in Combinatory Optimization.

5. ILP algorithms

Cutting-Plane Method.
Branch and Bound Method.

6. Nonlinear programming

Introduction to Non linear Programming.
Resolution algorithms.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	30,00	100
Computer classroom practice	22,50	100
Other activities	7,50	100
Attendance at events and external activities	2,00	0
Development of group work	5,00	0
Development of individual work	10,00	0
Study and independent work	12,00	0
Readings supplementary material	2,00	0
Preparation of evaluation activities	12,00	0
Preparing lectures	20,00	0
Preparation of practical classes and problem	13,00	0
Resolution of case studies	7,00	0
TOTAL	**143,00**	

TEACHING METHODOLOGY

In the lectures, the main Mathematical Programming concepts, results and methods will be introduced, accompanied by examples and exercises.

Practice sessions will take place in computer labs and will be synchronized with lectures. Students will deepen their understanding of the content introduced in the lectures, model problems, develop and use commercial codes to solve problems with specific data, and duscuss the results.

Seminar sessions, in small groups, will be used to deepen concepts previously unseen

For the preparation of the course, students will have the bibliographic references and a collection of exercises, separated by units, to be solved autonomously.

EVALUATION

The educational evaluation of knowledge and skills achieved will be done continuously throughout the course, and will consist of the following blocks:

Block 1: One or more partial exams, with a practical and/or theoretical-practical nature, not being eliminatory of contents. The total weight of this block is 20% of the grade of the course.

Block 2: Participation and evaluation in the seminar sessions, with a total weight of 10% of the grade of the course.

Block 3: Final exam with theory content, problems and theoretical-practical exercises. The exam may consist of two different parts splitted in theory and practice, in which case it will be necessary to obtain a minimum score of 4 points out of 10 in each of the parts to compute the average. If the minimum required score is not achieved in any of the parts, the maximum grade for the block will be 4 points out of 10. The total weight of this block is 70% of the grade for the course.

The final grade for the course will be the weighted average of blocks 1, 2 and 3, provided that the grade for block 3 is greater than or equal to 5 points out of 10. Otherwise, the final grade will be that corresponding to block 3 with a weight of 100%.

The grades obtained in blocks 1 and 2 will only be kept in the two examination periods of the academic year in which they were made and cannot be retaken since, by their nature, the evaluation of these blocks is only possible during the teaching period.

REFERENCES

Basic

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- Wolsey, L.A. Integer Programming. Wiley (2021).
- Garfinkel, R., Nemhauser, G., Integer Programming. Wiley (1972)
- Papadimitriou, C., Steiglitz, K. Combinatorial Optimization: Algorithms and Complexity. Prentice Hall (1982).
- Williams, H., Model Building in Mathematical Programming. Wiley (2013).
- Winston, W.L. Introduction to Mathematical Programming: Applications and Algorithms. Duxbury Press (1995).
- Luenberger, D. Programación lineal y no lineal. Addison-Wesley (1989).
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- Bazaraa, M., Sherali, H., Shetty, C. Nonlinear Programming: Theory and Algorithms. Wiley (2006).

Additional

- Calvete Fernández, H. I. y Mateo Collazos, P. M.: Programación Lineal, Entera y Meta. Problemas y Aplicaciones. Prensas Universitarias de Zaragoza (1994).
- Hillier, F.S. y Lieberman, G.J.: Introducción a la Investigación de Operaciones. McGraw-Hill (1991).

- Murty, K.G.: Linear and Combinatorial Programming. Wiley (1976).
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- Vanderbei, R.J., Linear Programming. Foundations and Extensions. Kluwer (2001).