Universidad Zaragoza

Academic Year/course: 2022/23

29508 - Optimization Theory

Syllabus Information

Academic Year: 2022/23
Subject: 29508 - Optimization Theory
Faculty / School: 175 - Escuela Universitaria Politécnica de La Almunia
Degree: 625 - Bachelor's Degree in Industrial Processes' Data Engineering
ECTS: 6.0
Year: 2
Semester: First semester
Subject Type: Basic Education
Module:

1. General information

1.1. Aims of the course

The course includes various quantitative techniques aimed at decision making in the field of logistics and production management. The development of these techniques focuses on theoretical issues and manly on their practical application.The modeling of real problems and their resolution through optimization theory introduces the student to the decision making process.
It is intended that the student is able to identify, analyze, formulate and solve real decision problems related to the organization and management of production systems.It will be essential that the student acquires the ability to determine the best strategy in order to optimize a system and know how to make decisions based on the solution of a problem.

A practical character is pursued in the course, being essential the resolution of problems and the handling of basic computer tools for the development of the proposed subjects.

These approaches and objectives are in line with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/), in such a way that the acquisition of the course learning outcomes provides training and competence to contribute to their achievement to some degree:

- ODS 8. Decent work and economic growth.
- ODS 12. Responsible consumption and production.

1.2. Context and importance of this course in the degree

The subject referred to in this teaching guide is mandatory and forms part of the basic training of students. It fits into the second year of the curriculum of the Degree in Data Engineering, which means that the student has acquired training in learning outcomes in Mathematics I, Mathematics II. In addition, the optimization theory provides skills in tools that will be useful in different subjects of later courses.

Almost all the professional outputs in management engineering, involve decision-making processes, in addition to requiring a certain skill in the knowledge of basic mathematical models. For all these reasons, basic training in the "science of decisions" is necessary. The optimization theory has had an impressive impact on improving the efficiency of numerous and diverse organizations around the world. One could cite their contributions to the problems of production, the efficient use of materials and reliability of them, basic research and the development of new products. As in the other sciences, Operations Research becomes a key tool for engineers, since it allows them to understand phenomena subject to variations and predict or control them effectively.

1.3. Recommendations to take this course

It is recommended that the student possess basic knowledge of Linear Algebra and basic notions of Statistics. It is also highly valuable that you are familiar with the use of symbolic and numerical calculation programs.

2. Learning goals

2.1. Competences

CG03 - Apply techniques for the acquisition, management and processing of data in Engineering.
CG06 - Build solutions derived from data analysis that optimize production processes in industry

CB2 - That students know how to apply their knowledge to their work or vocation in a professional way and have the competences that are usually demonstrated through the elaboration and defense of arguments and the resolution of problems within
your area of ??study
CB4 - That students can transmit information, ideas, problems and solutions to both specialized and non-specialized audiences
specialized
CB5 - That students have developed those learning skills necessary to undertake further studies
with a high degree of autonomy
CT03 - Search, select and manage information and knowledge responsibly.
CT04 - Develop critical thinking and reasoning.
CT05 - Effective communication of results.
CT07 - Analyze and solve problems autonomously, adapt to unforeseen situations and make decisions
CE04 - Solve mathematical problems that may arise in engineering.

2.2. Learning goals

- Learn the basics necessary to solve mathematical problems that can arise in Linear Algebra; Graphic Schema Theory; Differential and Integral Calculus, Numerical Methods and optimization.
- Know the reflective use of symbolic and numerical calculation tools
- Know the optimization techniques associated with linear and non-linear problems.
- Possess skills of scientific-mathematical thinking, which allow them to ask and answer certain mathematical questions.
- Have the ability to handle mathematical language; in particular, symbolic and formal language.

2.3. Importance of learning goals

The Optimization Theory is a way of approaching decision making, which is based on the scientific method and uses quantitative analysis. It applies to problems that refer to the conduct and coordination of activities within an organization. It has been widely applied in areas as diverse as transportation, manufacturing, or utilities, to name a few. The formulation of the problem, the construction of a mathematical model that summarizes the essence of the real problem, and the validity of said model are fundamental aspects in the optimization of resources. Justifying the chosen model and the resolution technique used given an optimization problem is what validates the result itself and allows the improvement of the system. On the other hand, it is essential not only to know how to formulate a problem and solve it, but also to express the final solution in a language understandable by the group of people whose function is to implement the proposed solution to said model.

3. Assessment (1st and 2nd call)

3.1. Assessment tasks (description of tasks, marking system and assessment criteria)

Main Exams:
Throughout the course there will be two main exams. They will cover theoretical and/or practical aspects of the subject. Its weight in the qualification is 80%.

The written tests will assess:

- understanding of mathematical concepts used to solve problems

- the use of efficient strategies and procedures in its resolution

- clear and detailed explanations

- the absence of mathematical errors in the development and solutions

- correct use of terminology and notation

- orderly, clear and organized exposition

Participatory controls:

Throughout the course the student will carry out 4 participatory controls valued at 5% of the final grade, which will consist of carrying out practical exercises.

In the participatory controls, the following will be evaluated:

- understanding of mathematical concepts used to solve problems

- the use of efficient strategies and procedures in its resolution

- clear and detailed explanations

- the absence of mathematical errors in the development and solutions

- correct use of terminology and notation

- orderly, clear and organized exposition

Overall evaluation.

Students who have not passed the subject with the continuous grading system must take a mandatory written test in official calls equivalent to the written tests and participatory controls described in points 1 and 2, whose weight in the final grade will

be 100%.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The learning process that has been designed for this subject is based on the following:

The course is designed as an introduction to optimization theory and an approach to system simulation and decision making. It is included within the basic training credits of an engineer. Essential contents of operational research are collected, such as linear programming, multi-criteria decision techniques or dynamic programming.

The course has a clearly practical focus, as optimization theory is an applied subject within the field of Engineering.

The approach, methodology and assessment of this guide are intended to be the same for any teaching scenarios. They will be adapted to the social-health situation at any particular time, as well as to the instructions given by the authorities concerned.

4.2. Learning tasks

The subject is articulated with 4 hours of face-to-face class per week during the 15 weeks that the semester lasts. All hours are taught in the computer room, theoretical concepts are taught that are reinforced with practical work through the use of statistical analysis programs.

4.3. Syllabus

- Introduction to optimization: Phases of an optimization study: Analysis and definition of the problem, formulation, solution and validation of the model, implementation of the solution. Characteristics of an optimization problem: Objective, Variables, constraints, data, solution.
- Linear programming: Formulation of the Linear Programming Problem (PPL), graphical solution of the PPL, canonical form and standard form. Basic matrix, optimal basic program. Simplex algorithm. Method of penalties, method of the two phases. The dual problem: formulation, production programming and shadow prices. Sensitivity analysis: availability vector, cost vector, introduction of a new activity, introduction of a new restriction.
- Integer Programming: Binary, integer and mixed integer programming. Branching and bounding techniques. Auxiliary variables in PPL: Selection of restrictions. Functions with m possible values. Selection of continuous variables. Fixed cost problem.
- Non-linear programming: Local and global optimum. quadratic programming. Karush-Kuhn-Tucker (CKKT) conditions. Qualification conditions. Convex set, convex function, convex programming. Numerical methods: SQP algorithm.
- Multi-criteria decision: Attribute, objective, level of aspiration, goal, criterion. Efficient or pareto optimal alternative. efficient set. Payment matrix. Weighting method. Method of the e restrictions. Commitment programming. Satisfying methods: programming by weighted goals, minimax, lexicographical.
- Dynamic programming: The diligence problem. Bellman's optimality principle. Optimization by phases or sequences. Assignment problems. The backpack problem. Resource allocation. Continuous dynamic programming.

4.4. Course planning and calendar

The contents will be developed throughout the 15 school weeks with the following weights:

1. Operations Research Methodology. 0.5-1.5 credits
2. Linear optimization problems 2.5-3.5 credits
3. Nonlinear optimization problems 1-2 credits
4. Multi-criteria decision techniques 0.5-1.5 credits
5. Dynamic programming: 0.5- 1 credits

4.5. Bibliography and recommended resources

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=29508