Universidad Zaragoza

Academic Year/course: 2022/23

27018 - Operations Research

Syllabus Information

Academic Year: 2022/23
Subject: 27018 - Operations Research
Faculty / School: 100 - Facultad de Ciencias
Degree: 453 - Degree in Mathematics
ECTS: 6.0
Year: 3
Semester: First semester
Subject Type: Compulsory
Module:

1. General information

1.1. Aims of the course

To provide students with an introduction to optimization models, methods, and their applications. Students will develop the ability to conceptualize from real-world situations appropriate mathematical programming models. The students will model, analyze, solve, and interpret results of decision-making problems.

These approaches and objectives are aligned with the following Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda (https://www.un.org/sustainabledevelopment/es/), in such a way that the acquisition of the learning outcomes of the module provides training and competence to contribute to some extent to their achievement: (4) Quality education, (5) Gender equality, (8) Decent work and economic growth, (9) Industry, innovation and infrastructure, (10) Reducing inequality, (17) Partnerships for the goals.

1.3. Recommendations to take this course

It is recommended that students attend all classes. Students are expected to prepare the topics throughout the course and to do regular homework assignments to become familiar with the different concepts, some with economic implications, which are the core of the course.

2. Learning goals

2.2. Learning goals

At the end of the course, the student will be able to:

- Understand problems from narrative statements and convert narrative statements to mathematical models.
- Identify convex sets and convex functions from their definition or characterizations.
- Determine extreme points and extreme directions of a polyhedron.
- Apply optimality conditions to get a local/global optimal solution of a nonlinear (continuous) optimization problem.
- Identify systems which can be modelled as linear problems.
- Formulate and solve linear optimization problems.
- Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
- Formulate and solve the dual of a linear optimization problem and understand the relationship between a linear program and its dual.
- Perform sensitivity analysis.
- Solve specialized linear programming problems like the transportation, thansshipment and assignment problems.
- Formulate some basic models in integer programming.
- Use specialized software to solve optimization problems.

3. Assessment (1st and 2nd call)

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

- A written theory test in November, on a date to be specified at the beginning of the course. If the student wishes, the score obtained will be saved for the first call of the course. Otherwise, this test can be repeated in the first official exam (20%).
- A final written exam of problems and theoretical-practical questions in the first official exam (80%).
- None of the previous scores are saved for the second official call, which consists of a written exam of theory and problems (100%).

According to the University regulations, the students can refuse the aforementioned system and take only the exams in the official periods as a global test.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

The methodology followed in this course is oriented towards the achievement of the learning objectives. A wide range of teaching and learning tasks are implemented, such as lectures, problem-solving sessions and laboratory sessions.

4.2. Learning tasks

This course is organized as follows:

- **Lectures.** (50% sessions) Lecture slides and other important materials will be posted in Moodle. Please check the platform regularly.
- **Problem-solving sessions.** (40% classes) Practice sessions in small groups
- **Laboratory sessions.** (10% sessions) Computer practice sessions in small groups
- **Assessment tasks.** A midterm exam will take place as well as a final exam. Exams are closed book and closed notes.

The teaching activities and assessment tasks will take place in a face-to-face mode, except in the case that, due to the health situation, the dispositions emitted by the competent authorities and by the University of Zaragoza compel to take them to a greater or lesser extent in a telematic form.

4.3. Syllabus

- **Topic 1: Introduction to operations research.**
- **Topic 2: Convex analysis.**
  - Convex sets.
  - Polyhedra.
  - Extreme points and extreme directions of a polyhedron.
  - Convex functions
  - Convex functions optimization
- **Topic 3: Linear optimization.**
  - Problem formulation.
  - Basic concepts and fundamental theorems.
  - The simplex algorithm.
- **Topic 4: Duality and sensitivity analysis.**
  - Formulation of the dual problem.
  - Primal-dual relationships.
  - The dual-simplex algorithm.
  - Sensitivity analysis.
- **Topic 5: Special models in linear optimization.**
  - Transportation, transshipment and assignment problems.
- **Topic 6: Integer programming.**
  - Problem formulation.
  - Branch and bound algorithm.

- **Topic 7: Introduction to nonlinear optimization.**
    - Karush-Kuhn-Tucker optimality conditions.

4.4. Course planning and calendar

The midterm exam will take place in November.

Further information concerning the timetable, classroom, office hours, assessment dates and other details regarding this course will be provided on the first day of class or please refer to the Faculty of Sciences website and Moodle.

4.5. Bibliography and recommended resources

- Bazaraa, Mokhtar S.. Linear programming and network flows / Mokhtar S. Bazaraa, John J. Jarvis, Hanif D. Sherali . - 2nd. ed. New York [etc.] : Wiley & Sons, cop. 1990.
- Bazaraa, Mokhtar S.. Nonlinear programming : theory and algorithms / Mokhtar S. Bazaraa, Hanif D. Sherali, C. M. Shetty . - 3rd ed. Hoboken (New Jersey) : John Wiley & Sons, cop. 2006.
- Calvete Fernández, Herminia Inmaculada. Programación lineal, entera y meta : problemas y aplicaciones / Herminia I. Calvete Fernández, Pedro M. Mateo Collazos Zaragoza : Prensas Universitarias de Zaragoza, 1994.
- D.G. Luenberger. Linear and Nonlinear Programming. 4th edition Springer. 2016.
- Dantzig, George B.. Linear programming. Vol. 1, Introduction / George B. Dantzig, Mukund N. Thapa New York [etc.] : Springer, cop. 1997.
- Dantzig, George B.. Linear programming. Vol. 2, Theory and extensions / George B. Dantzig, Mukund N. Thapa New York [etc.] : Springer, cop. 2003.
- Hillier, Frederick S.. Introducción a la investigación de operaciones / Frederick S. Hillier, Gerald J. Lieberman ; Traducción, Jesús Elmer Murrieta Murrieta ; revisión técnica, Javier Enríquez Brito . - 8a. ed. México [etc.] : McGraw-Hill, cop. 2006.
- Hillier, Frederick S.. Introducción a la investigación de operaciones / Frederick S. Hillier, Gerald J. Lieberman ; revisión técnica, Guillermo Martínez del Campo V., Ernesto A. Pacheco . 9a. ed. México [etc.] : McGraw-Hill, cop. 2010.
- Winston, Wayne L.. Operations research : applications and algorithms / Wayne L. Winston . - 4th ed. Belmont, California : Thomson/Brooks/Cole, cop. 2004.

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=27018