Universidad Zaragoza

Academic Year/course: 2021/22

30113 - Operative Research

Syllabus Information

Academic Year: 2021/22
Subject: 30113 - Operative Research
Faculty / School: 175 - Escuela Universitaria Politécnica de La Almunia
179 - Centro Universitario de la Defensa - Zaragoza
Degree: 425 - Bachelor's Degree in Industrial Organisational Engineering
563 - Bachelor's Degree in Industrial Organisational Engineering
ECTS: 6.0
Year: 2
Semester: 563 - Second semester
425 - First semester
Subject Type: Compulsory
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.

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 Industrial Organization Engineering, which means that the student has acquired training in learning outcomes in Mathematics I, Mathematics II and Statistics. In addition, Operational Research 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: ??Operational Research. Operational Research 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.

Defense: This subject helps to the higher education of officers giving them the knowledge of cuantitative methods and models that they need in order to make decissions under risk.

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, as well as with the use of spreadsheets, especially EXCEL.

2. Learning goals

2.1. Competences

The student acquires the following skills upon passing the course:

- C04 - Ability to solve problems and take decisions with initiative, creativity and critical reasoning.
- C06 - Ability to communicate knowledge and skills in Spanish.
- C09 - Ability to work in a multidisciplinary group and in a multilingual setting.
- C11 - Ability to continue learning and develop self-learning strategies.
- C18 - Capacity to resolve the mathematical problems that can arise in engineering. Aptitude for applying knowledge on statistics and optimisation.
- C28 - Knowledge and capacities for applying qualitative methods of decision-making in organisations.

2.2. Learning goals

The student must show the following results in order to pass this course:

- To identify and to formulate operations research models based on the verbal description of the real system.
- To understand the mathematical fundaments that are needed to solve optimisation problems.
- To justify the chosen model and the resolution technique for a given optimisation problem.
- To use computer programs in order to solve the proposed models.
- To prepare a report that presents the model and the resolution technique, to analyze the results and to propose recommendations, in a language understandable for the decision making process in management and industrial organisation.

2.3. Importance of learning goals

Operations research, or operational research is a discipline based on scientific method and quantitative analysis to help make better decisions. It is applied to problems that refer to the management and coordination of activities within an organisation. It has been applied extensively in areas such as transportation, production or public services. The formulation of the problem, the construction of a mathematical model that summarizes the essence of the real problem, and the validity of that model are fundamental aspects in the optimisation of resources. The justification of the chosen model and the applied resolution technique, given an optimization problem, is what validates the result itself and allows for improvements in the system. On the other hand, it is fundamental not only to know how to formulate a problem and to solve it, but also to express the final solution in a language understandable to the people responsible for implementing it.

3. Assessment (1st and 2nd call)

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

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Specific evaluation activities

Written tests:

Throughout the course two main written tests will be conducted. They are focused on theoretical and / or practical aspects of the subject. Its weight in the rating is 65%. Learning results which are related are the 1, 2, 3 and 4.

In the written tests will be evaluated:

- The understanding of mathematical concepts used to solve problems
- The use of strategies and efficient 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 exhibition

Individual work:

The student must submit an individual work. The teacher may require oral defense of the work by the student. Its weight in the final grade will be 15%. Learning results which are related are 1,2, 3, 4 and 5.

In individual work will be evaluated:

- The correct domain and use of mathematical software commands needed to solve problems
- The proper resolution of the problem and mathematical methods and strategies employed
- Detail the code used in solving problems
- The correct interpretation of the results

- The ability to select the most appropriate method
- Explanations and / or clear reasoning and detailed to questions
- The final outcome and quality of work
- The quality and coordination in the exhibition of the same
- The mathematical language used
- The quality of bibliographical sources

Participatory controls:

Throughout the course, students will perform four participatory valued each of them at 5% of the final grade, which consist of conducting practical exercises or evaluative questionnaires scheduled through the virtual platform moodle. Learning results which are related are the 1, 2, 3 and 4.
In participatory controls will be evaluated:
- The understanding of mathematical concepts used to solve problems
- The use of strategies and efficient 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 exhibition

Overall evaluation.

Students who have not passed the subject with the system of continuous rating, must pass a written equivalent exam to controls described in paragraph 1 and 3, whose weight in the final grade is 85%, it will also be present the individual work which he has awarded throughout the course weight being 15% of the final grade.

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This section includes the description of the tasks which are part of the assessment of the Operative Research course in the Centro Universitario de la Defensa de Zaragoza, together with their weight in the final mark.

Assessment tasks

- Theoretical and practical tests: These tests include questions about the theory and problems of the subjects taught in the course. Namely, these tests include the following tasks:
    - Continuous assessment sytem for lessons 1-4. (45% of the final mark). Students will be informed well in advance on the date of the test.
    - Continuous assessment sytem for lessons 5-7. (35% of the final mark). Students will be informed well in advance on the date of the test.
- Practical assignment (20% of final mark)

  These practical assignments can be computer practices and group project. Students should deal with an actual application of the contents in the course which shows the relation among such contents.

  Students should submit a final report in which they offer solutions to the issues raised in the assignment.

In all previous tasks, the following aspects will be assessed:

- The understanding of the concepts used in the resolution of the proposed problems.
- The lack of mathematical errors in the elaboration and the solutions.
- The correct use of terminology and notation.
- The exhibition of results in an ordered, clear and organized manner.
- The use of clear and detailed explanations.
- The correct interpretation of the obtained results.
- The ability to select the most appropriate method of resolution for each problem.
- The attitude shown during the development of the task, in the case of on-site tasks.
- The manner in which the obtained results are transmitted and expressed, through either oral or written means.

Computation of final marks

The computation of final marks will be different in the first and second calls:

Continuous call

FM = 0.2 MPract + 0.45 MMidEx + 0.35 MFinEx

In the formula above, each mark is given a value between 0 and 10, representing:

FM: Final mark of the course.

MPract: mark of the practical assignments proposed during the course.

MMidEx: mark of the examination of lessons 1-4.

MFinEx: mark of the examination of lessons 5-7.

First and Second call (June and August)

If a student does not pass the course in the continuous call, the student should be examined in a first and second call of all the contents of the course. The final mark of the course will be equal to the mark of this examination. No marks from the practical assignments will be considered in this second call.

Requirement level

In any of the two calls, the course will be passed if a final mark greater or equal to 5 is obtained.

4. Methodology, learning tasks, syllabus and resources

4.1. Methodological overview

If this teaching could not be done in person for health reasons, it would be done telematically.

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

The course is designed as an introduction to optimization theory and decision making. It is included in the credits of basic training of an engineer. The essential contents of operational research as linear programming, network flow models or multi-criteria decision techniques are collected.

The methodology includes theoretical sessions where main concepts are provided, also reinforced with practical sessions in the computer room. The practical sessions include the use of software R language programming and the libraries lpSolve, igraph.

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

- The presentation of the contents of the subject in masterclasses.
- Solving problems in class. As far as possible this activity will be performed by the students.
- Autonomous work and study.
- Individual of the contents by students.
- Practical work is undertaken by the students. During these practical activities, theoretical knowledge is complemented. These activities can be individual or group activities.

4.2. Learning tasks

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The program that the student is offered to help you achieve the expected results includes the following activities

The course is organized with 4 hours of class a week for the 15 weeks of the semester. All classes are taught in the computer room, where theoretical concepts are reinforced with practical work using the R programming language.

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There are two kinds of activities.

- Classroom activities: Masterclasses, practice session and tutorials.
- Non-contact activities: Guided assignments. This activity includes individual and group tasks. Autonomous work and study.

4.3. Syllabus

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- Introduction to Optimization: Phases of an optimization study: analysis and problem definition, development and validation of the model solution, implementation of the solution. Features of an optimization problem: Objective, variables, constraints, data, solution.
- Linear Programming: Formulation of linear programming problem (PPL), PPL graphical solution, canonical form and standard form. Basic matrix, optimal basic program. Simplex algorithm. Method of penalties, the two phases method. The dual problem: formulation, production scheduling, and shadow price. Sensitivity analysis: vector availability, cost vector, introducing a new activity, the introduction of a new restriction.
- Flow networks: Networks. Cost and adjacency matrix. The problem of the shortest route. Dijkstra algorithm. The problem of peak flow. Ford and Fulkerson algorithm. The problem of minimum spanning tree. Kruskal algorithm. The flow problem minimum cost. The problem of transportation. The allocation problem.

- Decision theory with uncertainty or risk: States of nature. Alternatives or decisions. Decision table. Expected value criterion, minimax or maximin, Hurwicz, Savage or opportunity costs. Decision trees: random nodes and decision nodes
- Multi-criteria decision: Attribute, objective, level of aspiration, goal, criteria. Pareto optimal or efficient alternative solution. Payoff matrix. Methods of resolution. Method of weights. Method of epsilon restrictions. Goal programming.
- Game Theory: Strategies and payments. Cooperative and non-cooperative games. Nash equilibrium. Mixed Strategies. Dominated strategies

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1. The methodology of Operations Research.
2. Linear programming.
    1. Modeling.
    2. Solving LP problems: graphical method, Simplex method, artificial variables, Simplex dual method, etc.
    3. Duality.
    4. Sensitivity analysis.
    5. Interpretation of results.
3. Multi-criteria optimization
    1. Modeling
    2. Solving methods: lexicographical, weights, goal programming, etc.
    3. Interpretation of results.
4. Integer programming.
    1. Modeling
    2. Solving methods
5. Graph theory and models of flow in networks.
    1. Task assignment.
    2. Introduction to graph theory.
    3. Shortest path problem.
    4. Minimum spanning tree.
    5. Maximum flow in networks.
6. Analysis of decisions in environments of uncertainty and risk.
7. Game theory
    1. Classification and representation of games.
    2. Strategies. Domination and saddle points.

4.4. Course planning and calendar

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The contents will be developed over 15 weeks teaching with the following weights:

1. The methodology of Operational Research. 0.5-1.5 credits
2. Linear optimization problems 2.5-3.5 credits
3. Techniques of multicriteria decision 0.5-1.5 credits
4. Analysis of decisions in the presence of uncertainty 1-2 credits

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Before the start of the semester, the calendar of activities will be published on the Moodle platform (http://moodle2.unizar.es).

4.5. Bibliography and recommended resources

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You can consult the bibliography in the following link:

http://psfunizar10.unizar.es/br13/egAsignaturas.php?codigo=30113

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