

Operational Research

Code: 102150
ECTS Credits: 6

Degree	Type	Year	Semester
2501232 Business and Information Technology	OB	2	2

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Daniel Blabia Girau
Sergio Espluga Campabadal

Prerequisites

Basic knowledge of mathematics and quantitative techniques (equivalent to Mathematics II) would be advisable. Furthermore, a basic awareness of algorithmic techniques is equally convenient. Finally, the analysis of business and organizational situations in which the course focuses on requires a basic understanding of Business Economics.

Objectives and Contextualisation

This course constitutes, together with Introduction to Problem Solving and Algorithm Design, the "Quantitative Methods in Management" module.

The basic aims of the Operations Research (OR) course are:

- To introduce students to the methodological approach developed by OR professionals to help effective decision-making using quantitative methods;
- Study the key basic tools and techniques for solving optimization problems, including its main theoretical results and algorithms;
- Apply the studied methodologies to real life projects and problems arising in business and organizations, also making use of both generic and specific software tools (Excel, LINGO).

At the end of the course, students should be able to model real-world problems arising in businesses and organizations in which OR and optimization methods can be useful. In particular, they should be competent to decide on a significant set of items to include in the model, choose an appropriate type of mathematical model and use a computer to solve it and interpret the results, including sensitive analysis. They should also be able to present appropriate recommendations, both to OR professionals and to business managers. Moreover, they should be able to critically evaluate the use of OR models in the situations studied, considering the complexity and uncertainty of decision making in today's world.

Competences

- Applying the basic analytic models of optimisation and operational research to the resolution of complex problems, especially in the tactical and operational fields of a organisation using the knowledge of the modelling techniques.
- Capacity for working in teams.
- Demonstrating a concern for quality in the objectives and development of the work.
- Demonstrating the ability to plan in accordance to the objectives and available resources.
- Finding algorithmic solutions and using the appropriate programming tools in order to implement them in a organization environment.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.

Learning Outcomes

1. Applying the basic analytic models of optimisation and operational research to the resolution of complex problems, especially in the tactical and operational fields of a organisation using the knowledge of the modelling techniques.
2. Appropriately drawing up technical reports according to the customer's demands.
3. Carrying out different oral presentations for different audiences.
4. Communicating with experts of other fields and non-experts.
5. Demonstrating a concern for quality in the objectives and development of the work.
6. Demonstrating the ability to plan in accordance to the objectives and available resources.
7. Describing the functioning of the most common graphs and mathematical programming algorithms, and knowing how to use them for specific problems.
8. Working in teams, sharing knowledge and communicating it to the rest of the team and the organisation.

Content

The course is organized around six units. The first one (unit 0) will be developed across the entire length of the course while the following four will be introduced in a more linear way. Furthermore a final unit relates OR and IA.

Unit 0. Operational Research methodology

We will discuss the role of models in the decision-making process, together with the broad lines of the methodological process used in OR to help such process. It will involve the conceptual analysis of a project or problem, the use of various design tools to model it; as well as the process of definition, validation and planning the implementation of the recommended solution. Preparation and presentation of results, both in oral and written form, is also an important part of this process.

Unit 1. Multiple constraints on decision making: linear programming

The topic aims to the detailed study of linear programming, probably the most popular and widely used mathematical programming model. We will first study the basic features of linear problems and their solutions. Graphic resolution of two variable models will lead to the study of general algorithmic methods to compute optimal solutions (simplex method), and to the use of software. Sensitivity analysis is also considered, together with the review of several standard applications of linear programming.

Unit 2. Between the complexity for solving and the accuracy of the solution: Integer programming

The topic motivates the use of integer and binary programming models, as well as the difficulties inherent to different solving strategies. Basic branch and bound methods are presented and discussed.

Unit 3. Capturing significant non-linear features: Nonlinear programming

The unit presents some economic situations requiring relatively simple nonlinear models. We will review the theoretical conditions for finding the optimal solution (based on the Lagrange function and the Karush-Kuhn-Tucker conditions), and introduce the basic numerical methods for solving nonlinear problems in an algorithmic way.

Unit 4. Network models: a dissimilar decision-making tool

This unit presents some of the key classical problems that can be modeled through the use of graphs (networks), as well as the main algorithms for solving them.

Unit 5. Operational Research and Artificial Intelligence

The topic introduces some of the main basic concepts of AI, and in particular its use at the decision-making level; as well as some examples of applications and intersections in algorithms that include techniques from both disciplines.

Methodology

The teaching methodology focuses on problem-based learning, based on a range of problems connected with the reality of business management. In particular, a number of different classical meta-models will be used to boost the IO for its formal development (the diet problem, the problem of the traveling salesman, transportation, assignment and transshipment problems, etc.).

This approach requires a special involvement of the students in the development of the lectures of the course. Indeed, the students will be allowed to decide, up to a point, when and which of the main theoretical results of the field will be studied during the course. Therefore, the order of the units may not be strictly followed; and unit 0 will be in fact compiled as such towards the end of the semester.

The course will use generic software, including Microsoft © Excel Solver, but also more specific software. The objective is twofold: to serve as a help tool in understanding different mathematical techniques for solving IO models; and to allow the analysis of problems conceptually and numerically more complex without the difficulties of a manual resolution. The aim is to highlight both the modeling and the interpretation of all information provided by the software. It is therefore recommended for students to regularly bring their laptops to the classroom.

During the course, both teamwork and the collaborative exchange of information and tools for modeling and solving problems will be encouraged. However, the final learning process must be individual, to complement and enrich the work initiated in the course's directed sessions. The supervised activity, around regular tutorials and sporadic consultations carried out during the course, is also an indispensable tool in acquiring the suitable knowledge and skills the subject should provide.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
A. Theoretical lectures	29.5	1.18	1, 5, 7
B. Classroom problems	8	0.32	1, 5, 7, 8
C. Laboratory classes	10	0.4	1, 6, 5, 7, 8
D. Oral presentations	2	0.08	5

Type: Supervised

E. Tutorials	15	0.6	6, 5
Type: Autonomous			
F. Independent study	31	1.24	1, 7
G. Modelling and solving case studies	25	1	1, 6, 5, 7, 2, 8
H. Drafting of written and oral reports	25	1	4, 5, 3, 2, 8

Assessment

The assessment of the course will be formative, thus carried out throughout the semester. It is based on the following learning evidences:

- Oral contributions of the students to the lectures, prepared both individually and in small groups, to stimulate the active participation of the students in their own learning process.
- Reports related to problems or projects worked out during the course, and in particular in the laboratory classes, to enhance equally the acquisition of specific and transversal competences. Both technical and non-technical (i.e. addressed to the involved business organization) reports will be requested.
- Small format tests and problems solved within the classroom, aiming at the reinforcement of the actual understanding of the methodologies and techniques described in the course.
- A final exam carried out in the last week of the semester, to favor the individual consolidation of the whole content of the course

The students' final grade will be obtained from the weighted sum of the assessments of the various evidences, considering specific weights for each of the four components:

$$N = 7\% \text{ (contributions)} + 40\% \text{ (reports)} + 18\% \text{ (small format tests)} + 35\% \text{ (final exam)}$$

subject to the two following constraints: (1) each one of the components of the assessment must be a strictly positive value, and (2) the score obtained in the final exam is at least 4.5 (out of 10).

Students having not passed the subject, i.e. with a grade less than 5.0 or not having met the above conditions to be graded, will be eligible for the retake process described below if one of the following situations apply:

(a) They met conditions (1) and (2) above, and the total grade obtained (N) falls between 3.5 and 5 ($3.5 \leq N < 5$).

(b) The mark of the final exam is less than 4.5, but the rest of the student's marks are higher enough such that if the average were calculated, a mark of 5 or higher would be obtained.

A student having not participated in any of the assessment activities will be considered "Not evaluable".

Calendar of evaluation activities

The dates of the evaluation activities (exercises, assignments ...) will be announced well in advance during the semester.

The dates of the final exam is scheduled in the assessment calendar of the Faculty.

"The dates of evaluation activities cannot be modified, unless there is an exceptional and duly justified reason why an evaluation activity cannot be carried out. In this case, the degree coordinator will contact both the teaching staff and the affected student, and a new date will be scheduled within the same academic period to make up for the missed evaluation activity." **Section 1 of Article 115. Calendar of evaluation activities (Academic Regulations UAB).** Students of the Faculty of Economics and Business, who in accordance with the previous paragraph need to change an evaluation activity date must process the request by filling out an Application for exams' reschedule at https://eformularis.uab.cat/group/deganat_feie/application-for-exams-reschedule

Grade revision process

After all grading activities have ended students will be informed of the date and way in which the course grades will be published. Students will be also be informed of the procedure, place, date and time of grade revision following University regulations.

Retake Process

"To be eligible to participate in the retake process, it is required for students to have been previously been evaluated for at least two thirds of the total evaluation activities of the subject." Section 3 of Article 112 ter. The recovery (UAB Academic Regulations). Additionally, it is required that the student achieves an average grade of the subject between 3.5 and 4.9.

The date of the retake exam is posted in the calendar of evaluation activities of the Faculty. Students taking this exam and passing will get a grade of 5 for the subject. The students having not passed the retake exam will be graded using his/her final exam grade, and hence, will fail the course.

Irregularities in evaluation activities

Despite other disciplinary measures deemed appropriate, and in accordance with current academic regulations, *"whenever a student makes any irregularity that could lead to a significant variation in the grade of an evaluation activity, it will be graded with a 0, regardless of the disciplinary process that can be instructed. In case of occurrence of various irregularities in the evaluation of the same subject, the final grade of this subject will be 0".* **Section 10 of Article 116. Results of the evaluation. (UAB Academic Regulations).**

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
1. Oral contributions during the lectures	7%	0	0	1, 5, 7
3. Small format tests and problems	18%	1.5	0.06	1, 6, 5, 7, 2
3. Written/Oral submission of solved problems and laboratory case studies	40%	0	0	1, 4, 5, 7, 3, 2, 8
4. Final exam	35%	3	0.12	1, 7, 2

Bibliography

Daellenbach, Hans G. (1995). *Systems and Decision Making. A Management Science Approach*. Wiley.

Eiselt, H.A. - Sandblom, Carl-Louis (2012). *Operations Research: A Model-Based Apporoach*. Springer.
<https://link-springer-com.are.uab.cat/book/10.1007%2F978-3-642-31054-6>.

Gordon, G. - Pressman, I. - Cohen, S. (1990). *Quantitative Decision Making for Business* (3rd. ed.). Prentice-Hall.

Liberatore, Matthew J. - Nydick, Robert L. (2003). *Decision Technology. Modelling, Software and Applications*. Wiley.

Taylor, Bernard, III. *Introduction to Management Science, EBook, Global Edition*, Pearson Education, Limited, 2019. ProQuest Ebook Central, <https://ebookcentral.proquest.com/lib/uab/detail.action?docID=5601327>.

Vanderbei, Robert J. (2020). *Linear Programming*. Springer.
<https://link-springer-com.are.uab.cat/book/10.1007%2F978-3-030-39415-8>.

Winston, Wayne W. (2003). *Operations Research. Applications and Algorithms* (4th. ed.). Duxbury Press.

Software

The course will use computer tools with implemented optimization algorithms, both generic, such as Microsoft © Excel Solver, and also more specific, such as LINGO.