Investigación Operativa

Operations Research

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Investigación Operativa (IO)
Operations Research 2023-24

Andrés Ramos
Despacho: SM26. D-603
Tel.: 91 540 6150
Andres.Ramos@comillas.edu

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Description

- Its purpose is to understand, define, and solve problems that support decision-making. It will show using quantitative methods to make rational decisions for companies (a.k.a., *Management Science*, *Business Analytics*, *Decision Science*). It can be divided into six parts:
  - Optimization
  - Solution algorithms
  - Decision and game theory
  - Simulation
  - Queuing theory
  - [Resource planning]
- Two main objectives:
  - Understand how to model certain decision-making problems and obtain the best decision
  - Be able to develop optimization/simulation models using advanced professional languages

Learning outcomes

- Recognize the situations and fields where operations research can be applied
- Model characteristic systems of different industrial sectors using operations research techniques
- Understand and apply techniques to make decisions that affect different systems
- Analyze and interpret obtained solutions!
- Develop and solve several prototype problems using an algebraic modeling language and simulation software
- Analyze results and be able to digest this information in an adequate form (verbally and in a written way)
- Learn how to work in a multi-lingual and multi-disciplinary team to carry out a case study

Grading method

- Continuous evaluation (5%):
  - Attendance, active participation in class
  - Periodical assignments
- Practical exercises/Case studies (25%):
  - Optimization case study in a team, using language GAMS/Pyomo, with a written report (20%)
  - Individual simulation case study in class, using Arena software (5%)
- Exams (70%): minimum average grade of exams: 4.0
  - Intermediate evaluation tests (October + November)
  - Final exam (December)
- Ordinary assessment: 5% cont. eval.; 25% practical exercises; 70% exams (50% final, 20% intermediate tests)
- Extraordinary assessment: 5% cont. eval.; 25% practical exercises; 70% final exam

Teaching method

- The classes are a mixture of theory and practical problems that are presented using slides or the blackboard
- Contents available in Moodle (Slides, Exercises, Exams of previous years)
- During the exam, any printed teaching material can be used. Note that only SIMPLE calculators are permitted during the exam!
- Almost all the material – which is updated continuously – can be found at https://pascua.iit.comillas.edu/aramos/IO.htm
- The practical case study of optimization will be written in an algebraic modeling language called GAMS/Pyomo, which is installed on each university PC. Furthermore, it can be downloaded from www.gams.com / https://pyomo.readthedocs.io/en/stable/
- The practical case study of simulation will be written using the software ARENA. It can be downloaded from https://www.rockwellautomation.com/es-mx/products/software/arena-simulation/academic.html

References

- A. Ramos, P. Sánchez, J.M. Ferrer, S. Wogrin (2013). *Modelos Matemáticos de Optimización*.
  https://pascua.iit.comillas.edu/aramos/simio/apuntes/a_mmo1a.pdf
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- F.S. Hillier, G.J. Lieberman (2021). *Introduction to Operations Research, 11/e*. McGraw-Hill Higher Education
- Sarabia, A. (1996) *La Investigación Operativa*. Universidad Pontificia Comillas
- W.D. Kelton, N. Zupick, and N. Ivey (2024) *Simulation with Arena 7th Edition* McGraw Hill Higher Education

Contents (i)

1. Optimization and modeling.
   - Linear and Mixed Integer Modeling.
   - Classical modeling problems.
   - Multicriteria Decision.
2. Linear, Mixed Integer, and Nonlinear Programming.
   - Simplex Method.
   - Branch and Bound Method.
   - KKT Optimality Conditions.
3. Decision and Game Theory.
   - Decision-Making Criteria. Decision Tree. Bayes Theorem.
   - Rectangular and Bi-personal Games.
   - Nash Equilibrium.
4. Simulation and Queueing Theory.
   - Discrete Event Simulation Modeling and Simulation Software.
   - Output Analysis.
   - Poisson process.
   - Classical Queueing Models.
   - Closed System Models.
5. Resource Planning and Optimization.
   - PERT.
   - Project Planning.
   - Project Planning Software.

Contents (ii)

Modules	Hours
Introduction	1
Modeling and Optimization	11
Multicriteria decision making	2
GAMS software	2
Linear programming	8
Mixed integer programming	1
INTERMEDIATE TEST	2
Nonlinear programming	4
Decision and game theory	8
INTERMEDIATE TEST	1
Simulation and queueing theory	5
ARENA software	3
ARENA Test in class	1
Resource planning and optimization	3
TOTAL	**52**

With each topic

- We should ask ourselves
  - What is this good for? When and how can it be applied?
  - How can I apply this as an engineer in the real world or my day-to-day life? *Life itself is a matter of OR*

Every university student must know how to:

1. Read (understand)
2. Write (make yourself understood)
3. Talk (to 1 or 100 people)
4. Be disciplined
5. Has a point of view international
6. Be creative
7. Know the appropriate tools of his/her discipline
8. Know his/her way around new technologies
9. Has a general culture
10. Think outside the box
11. Has an ethical vision

Source: J.R. Alonso *Una Universidad nueva*
El País 12/01/2009