COURSE SYLLABUS
2016-2017

GENERAL INFORMATION

Course information	
Name	Stochastic optimization
Code	MRE-524
Degree	Master's Degree in Research in Engineering Systems Modeling (MRE)
Year	1st
Semester	2nd (Spring) (even year)
ECTS credits	3
Type	Elective
Department	Industrial Organization
Area	Statistics and Operations Research
Coordinator	Andrés Ramos

Instructor	
Name	Andrés Ramos
Department	Industrial Organization
Area	Statistics and Operations Research
Office	SM26.D-103
e-mail	Andres.Ramos@comillas.edu
Phone	915406150
Office hours	Arrange an appointment by email

DETAILED INFORMATION

Contextualization of the course

Contribution to the professional profile of the degree

This subject introduces the student in simulation and data analysis techniques for supporting decision-making.

Specifically, the contributions of this course to the professional profile are the following:

- Knowing the application of system simulation in real environments, pros and cons of their use.
- Designing and developing stochastic optimization models using a simulation language
- Developing a practical work applied to support decisions in a realistic case study

This subject has both theoretical and practical components, based on the exposition and discussion of each topic but also on the application of the simulation and data analysis techniques to realistic case studies.

Prerequisites

Students willing to take this course should be familiar with linear algebra, and undergraduate-level programming. Previous experience with any modeling language is also desired although not strictly required.

CONTENTS

Contents
Theory
Chapter 1. Introduction
1.1 Generation expansion planning case study. Manufacturing case study. 1.2 Decision tree and scenario tree. 1.3 Two-stage and multistage linear optimization. Hydrothermal coordination problem case study
Chapter 2. Linear optimization
2.1. Simplex method. 2.2. Duality.
Chapter 3. Decomposition techniques
3.1 Fixed cost transportation problem. 3.2 Benders decomposition. Nested Benders decomposition. 3.3 Dantzig-Wolfe decomposition. Lagrangian relaxation. 3.4 Additional improvement in decomposition techniques. 3.5 Stochastic dual dynamic programming.
Chapter 4. Scenario tree
4.1 Characterization 4.2 Generation

Competences and Learning Outcomes

Competences

General Competences

Basic Competences

CB2. To know how to apply and integrate knowledge, the understanding of it, its scientific basis, and problem-solving capabilities in new and loosely defined environments, including multidisciplinary contexts, both for research and highly-specialized professions.

Specific Competences

CE9. To know techniques, methods and/or necessary tools to carry out a specific research topic in a sector or particular technological context.

Optional Competences

CO3. To understand the statistical concepts associated to the representation of random parameters.

CO4. To understand the mathematical principles of linear optimization, sensibility analysis and duality and the ability to use them.

Learning outcomes

At the end of the course the student must have the following competences:

RA1. Understand the concepts of stochastic optimization

RA2. Become familiar within the several topics where stochastic optimization can be applied

RA3. Know how to build an optimization model efficiently

RA4. Achieve mathematical rigorousness

RA5. Understand the mathematical techniques used

RA6. State and solve mockup problems

RA7. Analyze the solutions

RA8. Be prepared to extend their knowledge

RA9. Become familiar with an algebraic language used professionally

TEACHING METHODOLOGY

General methodological aspects	
The objective is improving the learning and incentivizing the autonomous and critical thinking of the students. For that purpose the following teaching resources are used. The teaching resources mentioned require the active participation of the student. It is indispensable that the class activity would be complemented with the personal work of the student and, coherently, it will be taken into account to assess the student performance.	
In-class activities	**Competences**
▪ **Master lectures (20h):** presentation of the contents of the subject.	CB1, CB2, CE2
▪ **Public presentation of the assignments (10h)**	CE3
Out-of-class activities	**Competences**
▪ **Personal work of the student (30h):** study of the contents provided in the master lectures. It requires a deep and critical analysis about modeling aspects of the optimization problems allowing different perspectives and incentivizing creativity and critical thought of the student.	CB1, CE2
▪ **Assignments (30h):** improve knowledge of the techniques presented.	CB2, CE3

ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Case study	▪ Practical case statement ▪ Model development ▪ Theoretical contribution ▪ Solution analysis ▪ Written communication skill ▪ Teamwork (if done in a team)	80%
Communication skill	▪ Oral presentation of the case study	15%
Classroom participation	▪ Attendance and active participation in class	5%

GRADING AND COURSE RULES

Grading

Regular assessment

- **Case study** will account for the 100%, of which:
  - Written report: 80%
  - Oral presentation: 15%
  - Participation: 5%

In case that the *written report mark* is equal or lower than 3.5, the final grade will be the *written report mark*. Otherwise, the final grade is computed weighting the different marks as the previously shown percentages. In order to pass the course, the final grade should be greater or equal to 5.0.

Retakes

The final grade is computed based only in a new written report about the same or different case study. In order to pass the course, the final grade should be greater or equal to 5.0.

Course rules

- Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:
  - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.

Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE[1]

[1] A detailed work plan of the subject can be found in the course summary sheet (see following page). Nevertheless, this schedule is tentative and may vary to accommodate the pace of the class.

In and out-of-class activities	Date/Periodicity	Deadline
Case study sessions	Every week	
Review and self-study of the concepts covered in the lectures	After each lesson	
Problem-solving	Weekly	
Case study report writing	December	
Case study oral presentation	During the course and, in particular, the last part of the course	

STUDENT WORK-TIME SUMMARY			
IN-CLASS HOURS			
Lectures	Problem-solving	Case sessions	Practices
15	5	5	5
OUT-OF-CLASS HOURS			
Self-study	Problem preparation	Case preparation and evaluation	Final report
25	5	20	10
		ECTS credits:	3 (90 hours)

BIBLIOGRAPHY

Basic bibliography

- Notes prepared by the lecturer (available in Moodle).
- Birge, J.R. and Louveaux, F. (2011) Introduction to Stochastic Programming. Springer-Verlag.
- Ramos, A., A. Alonso-Ayuso, G. Pérez (eds.) (2008) Optimización bajo Incertidumbre Universidad Pontificia Comillas

Complementary bibliography

	IN-CLASS ACTIVITIES				OUT-OF-CLASS ACTIVITIES				LEARNING OUTCOMES
Week	h/w	LECTURE & PROBLEM SOLVING	LAB	ASSESMENT	h/w	SELF-STUDY	LAB PREPARATION AND REPORTING	OTHER ACTIVITIES	Learning Outcomes
1	2	Course presentation and topic 1. Introduction to stochastic optimization. Generation expansion planning study case. Production case study. Decision and scenario tree.	Problem solving		3	Review, self-study and problem-solving (2h)	Problem preparation (1 h)		RA1, RA9
2	2	Two-stage and multistage linear optimization. Application to hydrothermal scheduling problem.	Problem solving		4	Review, self-study and problem-solving (2h)	Problem preparation (2 h)		RA2, RA3, RA4
3	2	Application case: stochastic unit commitment	Problem solving		5	Review, self-study and problem-solving (3h)	Problem preparation (2 h)		RA2, RA3, RA4
4	2	Application case: medium-term hydrothermal scheduling	Case study and practice		1	Review, self-study and case-solving (1h)			RA5, RA6, RA7
5	2	Decomposition techniques.	Case study and practice	Presentation assessment	2	Review, self-study and case-solving (2h)			RA5, RA6, RA7
6	2	Linear optimization. Simplex method. Duality.	Case study and practice		5	Review, self-study and case-solving (1h)	Work preparation (4h)		RA5, RA6, RA7
7	2	Benders decomposition.	Case study and practice	Presentation assessment	2	Review, self-study and case-solving (2h)			RA5, RA6, RA7
8	2	Fixed cost transportation problem.	Case study and practice		5	Review, self-study and case-solving (1h)	Work preparation (4h)		RA5, RA6, RA7
9	2	Small examples of Benders decomposition.	Case study and practice	Presentation assessment	2	Review, self-study and case-solving (2h)			RA5, RA6, RA7
10	2	Nested Benders decomposition.	Case study and practice		5	Review, self-study and case-solving (1h)	Work preparation (4h)		RA5, RA6, RA7
11	2	Danztig-Wolfe decomposition.	Case study and practice	Presentation assessment	2	Review, self-study and case-solving (2h)			RA5, RA6, RA7
12	2	Lagrangian relaxation. Fixed cost transportation problem.	Case study and practice		5	Review, self-study and case-solving (1h)	Work preparation (4h)		RA5, RA6, RA7
13	2	Scenario tree.	Case study and practice	Presentation assessment	7	Review, self-study and case-solving (2h)	Final report (5)		RA5, RA6, RA7, RA8
14	2	Decomposition in two-stage and multistage stochastic planning.	Case study and practice		5	Review, self-study and case-solving (1h)	Work preparation (4h)		RA5, RA6, RA7
15	2	Improvements in decomposition techniques. Simulation in stochastic programming	Case study and practice		7	Review, self-study and case-solving (2h)	Final report (5)		RA5, RA6, RA7, RA8

RA1.	Understand where to use and concepts of stochastic optimization
RA2.	Become familiar within the several topics where stochastic optimization can be applied
RA3.	Know how to build an optimization model efficiently
RA4.	Achieve mathematical rigorousness
RA5.	Understand the mathematical techniques used
RA6.	State and solve mockup problems
RA7.	Analyze the solutions
RA8.	Be prepared to extend their knowledge
RA9.	Become familiar with an algebraic language used professionally