COURSE SYLLABUS
2016-2017

GENERAL INFORMATION

Course information	
Name	Quantitative Decision Methods
Code	DOI-TEL-581
Degree	Máster en Ingeniería Industrial (MII), Máster en Ingeniería de Telecomunicación (MIT), Máster in Business Administration (MBA)
Year	1st
Semester	1st (Fall)
ECTS credits	6
Type	Basic
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Area	Statistics and Operations Research
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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 a simulation case study using a simulation language
- Understanding the representation of the uncertainty in input data and analyzing the results for extracting conclusions
- Developing a practical work applied to support decisions in a realistic case study
- Understanding queuing theory applied to open and closed systems and the link with simulation
- Understanding different data analysis techniques to extract information from data available, being either static or dynamic
- Designing and developing a data analysis case study using a computer language
- Applying these data analysis techniques to some data sets and extracting conclusions about the information

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

Basic knowledge of Algebra and Statistics.

CONTENTS

Contents
Theory
Topic 1: DISCRETE EVENT SIMULATION MODELING
1.1 Components and Processes. **1.2** Modeling by Simulation. **1.3** Simulation languages.
Topic 2: SIMULATION OUTPUT ANALYSIS
3.1 Transient and stationary statistics. **3.2** Finite-Horizon Analysis. Infinite-Horizon Analysis. **3.3** Output analysis. **3.4** Comparison of System Designs.
Topic 3: QUEUEING THEORY
4.1 Poisson processes. **4.2** Queueing models.
Topic 4: MULTIVARIATE DATA ANALYSIS
5.1 Introduction to Multivariate Data Analysis. **5.2** Analysis of Variance. **5.3** Principal Component Analysis.
Topic 5: CLUSTERING AND CLASSIFICATION
6.1 Hierarchical Clustering. k-means. **6.2** Classification Trees.
Topic 6: REGRESSION
7.1 Regression models. Linear Regression. Additive Models. **7.2** Neural Networks. Multilayer Perceptron.
Topic 7: TIME SERIES FORECASTING
8.1 Decomposition Methods. **8.2** Exponential Smoothing. **8.3** ARIMA
Practices
Practice 1. Simulation Model
The student gets a real experience of the implementation of a simulation model in an appropriate language.
Practice 2. Simulation Output Analysis
With the previously defined simulation model, the student is able to use it to understand the performance of the system against different simulation parameters and do a sensitivity analysis with respect to some system parameters.
Practice 3. Multivariate Data Analysis, Clustering and Classification
The student implements several multivariate data analysis, clustering and classification techniques and performs some analysis of the relevant information extracted from the data.
Practice 4. Regression

The student implements several regression techniques and performs some analysis of the relevant information extracted from the data.

Competences and Learning Outcomes	
Competences	
General Competences	
CG1.	Know scientific and technologic topics such as mathematical, analytical and numerical methods for engineering, electrical engineering, energy engineering, chemical engineering, mechanical engineering, electronics engineering, …
CG4.	Research, develop and innovate products, processes and methods.
CG11.	Get self-learning and studying capabilities.
CTT2.	Capability to develop communications information systems.
CTT6.	Capability to model, design, implement, manage, operate and maintain networks, services and contents.
CTT7.	Capability to plan and take decisions in networks, services and application considering quality of service, direct costs, etc.
Learning outcomes:	
RA 1.	Knowing the application of system simulation in real environments, pros and cons of their use
RA 2.	Designing and developing simulation models using a simulation language
RA 3.	Understanding the representation of the uncertainty in input data and analyzing the results for extracting conclusions
RA 4.	Developing a practical work applied to support decisions in a realistic case study
RA 5.	Understanding queuing theory applied to open and closed systems and the link with simulation
RA 6.	Understanding different data analysis techniques to extract information from data available, being either static or dynamic
RA 7.	Applying these data analysis techniques to some data sets and extracting conclusions about the information

TEACHING METHODOLOGY

General methodological aspects

The best way of gaining a full understanding of Quantitative Decision Methods consists of showing and having real experiences on this topic. Consequently, all the proposed activities are focused on providing students real cases and practical experiences where implementation of decision methods is essential for the improvement on decision making.

In-class activities	Competences
▪ **Lectures and problem-solving sessions (40 hours)**: The lecturer will introduce the fundamental concepts of each topic, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class.	CG1, CG11
▪ **Case sessions (10 hours):** Under the instructor's supervision, students will apply the concepts and techniques covered in the lectures to real cases.	CG4, CTT2, CTT6, CTT7
▪ **Practice sessions (10 hours):** Under the instructor's supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures to real problems.	CG4, CTT2, CTT6, CTT7
Out-of-class activities	**Competences**
▪ Personal study of the course material and resolution of the proposed exercises (80 hours).	CG1, CG11
▪ Cases study session preparation to make the most of in-class time (30 hours).	CG4, CTT2, CTT6, CTT7
▪ Practice session preparation to make the most of in-class time (15 hours).	CG4, CTT2, CTT6, CTT7

ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Mid-term exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem and case solving. ▪ Critical analysis of numerical exercises' results.	10%
Final exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem and case solving. ▪ Critical analysis of numerical exercises' results.	50%
Cases study resolution	▪ Class participation. ▪ Test Results (Pre and post discussion in class).	35%
Class participation	▪ Class participation.	5%

GRADING AND COURSE RULES

Grading

Regular assessment

- **Exams** will account for 60%, of which:
  - o Mid-term: 10%
  - o Final exam: 50%

  The *Exam global mark* is computed weighting one fifth the mid-term mark and four-fifths the final exam
- **Cases** will account for 35%, of which:
  - o Cases study: 25%
  - o Presentations: 10 %
- **Class participation** will account for the remaining 5%

In case that the *exam global mark* is equal or lower than 4.0, the final grade will be the *exam global 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

Cases and class participation marks will be preserved. The resulting grade will be computed as follows:

- Final exam: 60%
- Cases: 35%
- Class participation: 5%

In case that the final exam mark is equal or lower than 4.0, the final grade will be the final exam 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.

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]

In and out-of-class activities	Date/Periodicity	Deadline
Mid-term exam	Week 12	
Final exam	December	
Practice sessions	Weeks 3, 5, 11, and 13	
Review and self-study of the concepts covered in the lectures	After each topic	–
Problem-solving	After each topic which requires problem solving	–
Practice preparation	Before every practice	–
Practice output analysis (Test)	Few days after every practice	–
Final exam preparation	December	–

STUDENT WORK-TIME SUMMARY			
IN-CLASS HOURS			
Lectures	**Problem-solving**	**Case study sessions**	**Practices**
35	6	12	7
OUT-OF-CLASS HOURS			
Self-study	**Problem preparation**	**Case preparation and evaluation**	**Practice**
71	6	36	7
		ECTS credits:	**6 (180 hours)**

BIBLIOGRAPHY

Basic bibliography

- Rossetti, M. D., Simulation Modeling and Arena. Ed. Wiley. 2009
- Peña, D., Análisis de datos multivariantes. Ed. McGraw-Hill. Madrid. 2002

Complementary bibliography

- Law, A.M., Simulation Modeling and Analysis. Ed. McGraw-Hill. 2014
- Kelton, W.D., Sadowski, R.P., and Zupick N.B., Simulation with Arena, 6th. Ed. McGraw-Hill, 2015
- T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning: Data Mining, Inference and Prediction. 2nd Ed., Springer, New York, N.Y., 2009 (http://statweb.stanford.edu/~tibs/ElemStatLearn/printings/ESLII_print10.pdf)

[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-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 Quantitative Decision Methods. Topic 1. DISCRETE EVENT SIMULATION MODELING. Components and Processes. Modeling by Simulation.			2	Review and self-study (2h)			RA1	RA 1.	Knowing the application of system simulation in real environments, pros and cons of their use
2	4	Topic 1. Simulation languages. Arena.		Exercises	10	Review, self-study and case-solving (5h)	Work preparation (4h)	Tests: Pre and Post case discussion (1h)	RA1, RA2, RA4	RA 2.	Designing and developing simulation models using a simulation language
3	4	Topic 1. Arena	Practice 1. Simulation Modeling	Test of Practice 1	10	Review, self-study and problem-solving (5h)	Practice preparation (2h). Work preparation (4h)	Tests: Pre and Post case discussion (1h)	RA2, RA3, RA4	RA 3.	Understanding the representation of the uncertainty in input data and analyzing the results for extracting conclusions
4	4	Topic 3. Infinite-Horizon Analysis. Comparison of System Designs	Practice 2. Simulation Output Analysis	Test of Practice 2	10	Review, self-study and case-solving (3h)	Practice preparation (2h). Work preparation (4h)	Tests: Pre and Post practice (1h)	RA2, RA3, RA4	RA 4.	Developing a practical work applied to support decisions in a realistic case study
5	4	Topic 4. QUEUEING THEORY. Poisson processes		Problems	10	Review, self-study and case-solving (5h)	Work preparation (4h)	Tests: Pre and Post case discussion (1h)	RA5	RA 5.	Understanding queuing theory applied to open and closed systems and the link with simulation
6	4	Case study presentations		Exercises	8	Review, self-study and problem-solving (7h)		Tests: Pre and Post case discussion (1h)	RA1	RA 6.	Understanding different data analysis techniques to extract information from data available, being either static or dynamic
7	4	Topic 5. MULTIVARIATE DATA ANALYSIS. Introduction to Multivariate Data Analysis. Analysis of Variance. Principal Component Analysis		Exercises	8	Review, self-study and problem-solving (7h)		Tests: Pre and Post case discussion (1h)	RA6, RA7	RA 7.	Applying these data analysis techniques to some data sets and extracting conclusions about the information
8	4	Topic 5. Principal Component Analysis. Factor Analysis	Practice 3. Multivariate Data Analysis	Test of Practice 3	8	Review, self-study and problem-solving (5h)	Practice preparation (2h)	Tests: Pre and Post practice (1h)	RA6, RA7		
9	4	Topic 6. CLUSTERING AND CLASSIFICATION. Hierarchical Clustering. k-means.		Exercises	8	Review, self-study and problem-solving (7h)		Tests: Pre and Post case discussion (1h)	RA6, RA7		
10	4	Topic 6. Classification Trees	Practice 4. Clustering and Classification	Test of Practice 4	8	Review, self-study and case-solving (5h)	Practice preparation (2h)	Tests: Pre and Post practice (1h)	RA6, RA7		
11	4	Topic 7. REGRESSION. Linear Regression. Additive Models. Neural Networks		Mid-term exam	16						
12	4	Topic 7. Multilayer Perceptron. Topic 8. TIME SERIES FORECASTING.	Practice 5. Regression	Test of Practice 5	8	Review, self-study and case-solving (5h)	Practice preparation (2h)	Tests: Pre and Post practice (1h)	RA6, RA7		
13	4	Topic 8. Decomposition Methods. Exponential Smoothing. ARIMA		Exercises	4	Review, self-study and case-solving (3h)		Tests: Pre and Post case discussion (1h)	RA6, RA7		
14	4	Case study presentations		Exercises	8	Review, self-study and problem-solving (7h)		Tests: Pre and Post case discussion (1h)	RA1		