ADVANCED METHODS IN MANAGEMENT ENGINEERING (EMaCS-01-06)				
DEGREE PROGRAM:		Master in Computer Science for the Human-Centric and Sustainable Industry		
SEMESTER: First	**TYPE:** Basic	**CREDITS:** 3 ECTS	**WORKLOAD:** 75 hours	**MENTORING:** 2 hours/week
LANGUAGE: English				

OBJECTIVES	
General	The student will acquire introductory knowledge of advanced methods in management engineering, focusing on complex systems approaches. This includes understanding the fundamental concepts of equilibrium analysis in game theory and the foundational principles of complex network analysis.

Specific	• Understand and Define Basic Concepts of Management Engineering:
	  ○ The student will be able to define what management engineering is and distinguish how it differs from other branches of engineering.
	  ○ The student will recognize the importance of adopting advanced approaches in management engineering, especially when dealing with complex systems.
	• Introduction to Game Theory:
	  ○ The student will understand the fundamental concepts of game theory, including dominant strategies, Nash equilibrium, and cooperative vs. non-cooperative games.
	  ○ The student will be able to identify and analyse real-life situations where game theory can be applied.
	• Apply Equilibrium Analysis in Game Theory:
	  ○ The student will learn to formulate and solve basic game theory problems using equilibrium analysis.
	  ○ The student will be able to explain how individual decisions can lead to equilibriums that are not necessarily optimal for all players.
	• Understand the Basic Principles of Complex Network Analysis:
	  ○ The student will be introduced to key complex network concepts such as degree distribution, short paths, and clustering.
	  ○ The student will learn to visualize and analyse real data using network analysis tools.
	• Practical Application of Learned Concepts:
	  ○ The student will be able to apply the learned concepts in case studies related to management engineering, identifying opportunities and challenges associated with complex systems.
	  ○ The student will engage in practical exercises and simulations to consolidate their understanding of the theory and their ability to apply it in practical situations.

SUSTAINABILITY

The course "Advanced Methods in Management Engineering" contributes to sustainability by focusing on the management of complex systems and their application in decision-making. Understanding fundamental concepts of game theory and the analysis of complex networks provides students with tools to address complex problems and find sustainable solutions. The emphasis on ethics when applying game theory, especially in decisions impacting others, reinforces the importance of ethical considerations in the field of management. Additionally, the focus on interdisciplinarity and openness to diverse perspectives and solutions highlights the importance of collaboration and teamwork in solving complex problems.

RESILIENCE AND HUMAN-CENTRIC DEVELOPMENT

The course promotes the development of skills to apply advanced methods in management engineering through case studies and practical exercises. These approaches allow students to acquire practical skills to address real-world situations and propose solutions. The ability to effectively communicate the results of network analysis and game theory to non-specialized audiences underscores the importance of clear and understandable communication in professional contexts. Appreciating the ethical relevance and considering different approaches and solutions proposed by colleagues and experts in the field emphasizes openness to diverse perspectives and collaboration.

<table>
<tr><th colspan="2">SUBJECT MATTER</th></tr>
<tr><td colspan="2">Block 1: Network Science
1. Introduction to Network Science
2. Graph Theory
3. Centrality and Prestige
4. Community Detection
5. Other Regularities in Networks
Block 2: Decision Making and Game Theory
1. Analysis of Individual Decisions
2. Classical Game Theory
3. Evolutionary Game Theory
4. Examples of Game Theory Applications</td></tr>
<tr><th colspan="2">COMPETENCES</th></tr>
<tr><td colspan="2">C3. MANAGING AND EVALUATING DATA, INFORMATION AND DIGITAL CONTENT
C6. USING MACHINE LEARNING AND A.I. TECHNIQUES
C12. IDENTIFYING NEEDS AND TECHNOLOGICAL RESPONSES
C13. CREATIVELY USING DIGITAL TECHNOLOGIES
C14. SOLVING TECHNICAL PROBLEMS
C15. MANAGING SYSTEMS and/or PROJECTS
C17. COMMUNICATING EFFECTIVELY</td></tr>
<tr><th colspan="2">LEARNING OUTCOMES</th></tr>
<tr><td>Knowledge</td><td>• Know what are the fundamental concepts of network science and how these relate to complex real-world systems.
• Know the underlying principles of graph theory and how it is used to model and analyse networks.
• Know which are the different methods of measuring centrality and prestige within a network.
• Know what are the theoretical foundations of game theory, including its classical and evolutionary variants.</td></tr>
<tr><td>Skills</td><td>• Recognize the practical and theoretical applications of game theory across various contexts and disciplines.
• Apply network analysis techniques to visualize, interpret, and address problems related to complex systems.
• Utilize mathematical and computational tools to analyse games and determine equilibriums.
• Design and conduct experiments or simulations to investigate phenomena related to networks and game theory.
• Critically evaluate literature and case studies related to network science and game theory.
• Effectively communicate the results of network analysis and game theory to a non-specialized audience.</td></tr>
<tr><td>Attitudes/values</td><td>• Value the importance of interdisciplinarity in studying complex systems and game theory.
• Develop a critical mindset towards modelling and simulation, recognizing their limitations and potentials.
• Appreciate the relevance of ethics when applying game theory, especially in decisions impacting others.
• Foster collaboration and teamwork when addressing complex problems that require a variety of perspectives and skills.
• Show respect and openness towards different approaches and solutions proposed by peers and experts in the field. Open to engage in collaborative processes to co-design and co-create new products and services based on AI systems to support and enhance the capabilities of human workers on</td></tr>
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	industrials settings, as well as improve services and help making better decisions for the sustainability of operations and respect of the environment.

TEACHING METHODS

Method	Class Workload	Individual Workload	Total
Theoretical Sessions	12	12	24
Laboratory Sessions	12	21	33
Research and writing of an applied project	1	10	11
Written Examinations	1	6	7
TOTAL	**26 hours**	**49 hours**	**75 hours**

EVALUATION

Evaluation Procedure	Percentage on the subject grade
Laboratory Programming Assignments and Reports	40%
Applied Project	20%
Written Examinations	40%
TOTAL	**100%**

In order to pass the course, it is necessary to obtain a minimum mark of 4 out of 10 in each of the three evaluation procedures and 5 out of 10 in their weighted average.

PRECONDITIONS

- Basic skills in programming.
- Knowledge of calculus and mathematics at a level of a graduate student (e.g. matrix and vector calculus, Boolean operations, etc.)

DEPARTMENT	Departamento de Ingeniería de Organización
LECTURERS	• José Manuel Galán Ordax • Virginia Ahedo García
LITERATURE	• E. Estrada, P.-A. Knight, A First Course in Network Theory (Oxford University Press, 2015). • M.E.J. Newman, Networks: An Introduction (Oxford University Press, 2010). • V. Nicosia, V. Latora, G. Russo, Complex Networks, CUP (2017) https://doi.org/10.1017/9781316216002 • A.-L. Barabási, Network Science (Cambridge University Press, 2016) http://networksciencebook.com/ • S. Fortunato, Community detection in graphs, Physics Reports 486, 75-174 (2010). • M.E.J. Newman, The structure and function of complex networks, SIAM Rev. 45, 167-256 (2003). • Colman, Andrew. Game Theory and Experimental Games. Oxford: Pergamon Press, 1982.