

## Course guide

# 270409 - MSS - Systems Modeling and Simulation

Last modified: 03/02/2025

<b>Unit in charge:</b>	Barcelona School of Informatics		
<b>Teaching unit:</b>	<b>Degree:</b>	BACHELOR'S DEGREE IN ARTIFICIAL INTELLIGENCE (Syllabus 2021). (Compulsory subject).	
<b>Academic year:</b> 2024	<b>ECTS Credits:</b> 6.0	<b>Languages:</b> Catalan	

### LECTURER

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<b>Coordinating lecturer:</b>	PAU FONSECA CASAS
<b>Others:</b>	Segon quadrimestre: PAU FONSECA CASAS - 11, 12 JOAN GARCIA SUBIRANA - 11, 12

### PRIOR SKILLS

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Notions of statistics and programming.

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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#### Specific:

- CE01. To be able to solve the mathematical problems that may arise in the field of artificial intelligence. Apply knowledge from: algebra, differential and integral calculus and numerical methods; statistics and optimization.
- CE20. To select and put to use techniques of statistical modeling and data analysis, assessing the quality of the models, validating and interpreting.
- CE21. To formulate and solve mathematical optimization problems.
- CE22. To represent, design and analyze dynamic systems. To acquire concepts such as observability, stability and controllability.

#### Generical:

- CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.
- CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.
- CG5. Work in multidisciplinary teams and projects related to artificial intelligence and robotics, interacting fluently with engineers and professionals from other disciplines.

#### Transversal:

- CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.
- CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.
- CT6. Autonomous Learning. Detect deficiencies in one's own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.
- CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

#### Basic:

CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of study.

CB3. That students have the ability to gather and interpret relevant data (usually within their area of study) to make judgments that include a reflection on relevant social, scientific or ethical issues.

CB4. That the students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.

## TEACHING METHODOLOGY

The subject follows the methodologies of cooperative learning and problem-based / project-based learning, complemented with expository method sessions, in which the necessary theory is explained so that the student can develop, in the best conditions, the set of deliverables that, basically, will determine the achievement of the aims of the asignatura.

## LEARNING OBJECTIVES OF THE SUBJECT

1. Model complex dynamic systems. Understand concepts such as observability, stability and controllability.
2. Validate and verify models and extract knowledge from them.
3. Express the behavior of complex systems using formal languages understandable by both specialized and non-specialized audiences

## STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	30,0	20.00
Hours small group	30,0	20.00

**Total learning time:** 150 h

## CONTENTS

### Introduction, system vs model

#### Description:

What is a simulation study? Practical approach by presenting real projects that will show the student the phases to follow for the development of a valid and useful simulation study. We will address the dichotomy between model and system and understand the need to detail the hypotheses to limit which is what will be the object of our study.

### Simulation and statistical methods

#### Description:

Randomness as the backbone of modeling and experimentation in simulation. Statistical distributions, generation of numbers and random variables. Some known distributions and their application in simulation models.

### Simulation paradigms

#### Description:

Presentation of the main simulation engines and their applicability.

### Main formal languages to define conceptual models.

**Description:**

The languages: Specification and Description Language (SDL) and Petri Nets will be detailed. The relationship they have with the Forrester diagrams used to create dynamic systems will be shown.

### Systems dynamics, continuous simulation

**Description:**

Approach to continuous simulation through systems dynamics, creation of Causal and Forrester diagrams.

### Parallel and distributed simulation

**Description:**

Introduction to existing techniques to be able to distribute simulation models.

### Experimental design and analysis of results

**Description:**

Basic concepts and methods for the design of simulation experiments. Evaluation and comparison of scenarios. Quality of results.

### Validation, verification and accreditation of simulation models

**Description:**

Description of the methodologies to be followed in order to obtain a verified model, validate it and a reflection on the accreditation of models.

## ACTIVITIES

### Basic fundamentals of simulation

#### Specific objectives:

1

#### Related competencies :

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CG4. Reasoning, analyzing reality and designing algorithms and formulations that model it. To identify problems and construct valid algorithmic or mathematical solutions, eventually new, integrating the necessary multidisciplinary knowledge, evaluating different alternatives with a critical spirit, justifying the decisions taken, interpreting and synthesizing the results in the context of the application domain and establishing methodological generalizations based on specific applications.

CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

CT6. Autonomous Learning. Detect deficiencies in one's own knowledge and overcome them through critical reflection and the choice of the best action to extend this knowledge.

CT5. Solvent use of information resources. Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty and critically evaluate the results of such management.

CT7. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs of graduates.

#### Full-or-part-time: 10h

Self study: 6h

Theory classes: 1h

Practical classes: 1h

Laboratory classes: 2h

## Discrete Event Simulation (DES)

### Specific objectives:

1

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### Full-or-part-time: 20h

Self study: 12h

Theory classes: 2h

Practical classes: 2h

Laboratory classes: 4h

## Randomness and Simulation

### Specific objectives:

1

### Related competencies :

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### Full-or-part-time: 8h

Self study: 4h

Theory classes: 1h

Practical classes: 1h

Laboratory classes: 2h

## Main formal languages to define conceptual models

### Description:

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### Specific objectives:

3

### Related competencies :

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### Full-or-part-time: 32h

Self study: 20h

Theory classes: 3h

Practical classes: 3h

Laboratory classes: 6h

## Experimental design and analysis of results

### Specific objectives:

2

### Related competencies :

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CG2. To use the fundamental knowledge and solid work methodologies acquired during the studies to adapt to the new technological scenarios of the future.

CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.

### Full-or-part-time: 32h

Self study: 20h

Theory classes: 3h

Practical classes: 3h

Laboratory classes: 6h

## Systems dynamics, continuous simulation

### Full-or-part-time: 28h

Self study: 16h

Theory classes: 3h

Practical classes: 3h

Laboratory classes: 6h



### Validation, verification and accreditation of simulation models

#### Specific objectives:

2

#### Related competencies :

CB2. That the students know how to apply their knowledge to their work or vocation in a professional way and possess the skills that are usually demonstrated through the elaboration and defense of arguments and problem solving within their area of ??study.

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#### Full-or-part-time: 12h

Self study: 8h

Theory classes: 1h

Practical classes: 1h

Laboratory classes: 2h

### Parallel and distributed simulation

#### Full-or-part-time: 8h

Self study: 4h

Theory classes: 1h

Practical classes: 1h

Laboratory classes: 2h

## GRADING SYSTEM

There will be two practices during the course, 60% of the grade.

There will be a final exam, 40% of the grade.

Reassessment: Only those who have failed the final exam may take the reassessment. The maximum grade that can be obtained in the reassessment is 7. The Q1 reassessments will take place during the Q2 exam period.



## BIBLIOGRAPHY

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### Basic:

- Law, Averill M. Simulation modeling and analysis. 5th International ed. New York: McGraw-Hill, 2015. ISBN 1259254380.
- Guasch, Antoni; Piera, Miquel Àngel; Casanovas, Josep; Figueras, Jaume. Modelado y simulación : aplicación a procesos logísticos de fabricación y servicios. 2a ed. Barcelona: Edicions UPC, 2003. ISBN 8483017040.
- Fonseca Casas, Pau. Formal languages for computer simulation : transdisciplinary models and applications. Hershey, PA: Information Science Reference, cop. 2014. ISBN 9781466643697.

### Complementary:

- Robinson, Stewart. Simulation : the practice of model development and use. 2nd ed. Basingstoke, Hampshire, [England] ; New York, [New York]: Palgrave Macmillan, 2014. ISBN 9781137328038.

## RESOURCES

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### Hyperlink:

- <http://www.wintersim.org/>