

**Applied Modelling & Simulation**

Code: 43480  
ECTS Credits: 6

Degree	Type	Year	Semester
4313136 Modelling for Science and Engineering	OT	0	2

**Contact**

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**Teachers**

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**Use of languages**

Principal working language: english (eng)

**Prerequisites**

User knowledge of computer systems and (recommended) some knowledge of a programming language but not essential.

**Objectives and Contextualisation**

The present course aims to:

- Introduce students to the modelling and simulation techniques used in multidisciplinary areas.
- Apply the appropriate methodology for developing models in multidisciplinary areas.
- Evaluate modelling and simulation tools available for different areas.
- Model and simulation structures of different types.

**Skills**

- Analyse complex systems in different fields and determine the basic structures and parameters of their workings.
- Analyse, synthesise, organise and plan projects in the field of study.
- Formulate, analyse and validate mathematical models of practical problems in different fields.
- Present study results in English.
- Safeguard, manage, audit and certify the quality of advanced developments, processes, systems and software.
- Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
- Use appropriate numerical methods to solve specific problems.

**Learning outcomes**

1. Analyse, synthesise, organise and plan projects in the field of study.

2. Describe the different components of a system and the interactions between them.
3. Identify the parameters that determine how a system works.
4. Implement appropriate numerical methods to solve models in the field of engineering.
5. Model engineering systems using commercial tools.
6. Present study results in English.
7. Simulate the behaviour of complex systems.
8. Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
9. Validate the simulation results with the predictions of the models and the behaviour of the real system.

## Content

### Module 1: Introduction to applied models & simulation.

- Definition of systems. Abstractions. Models, Model Data & Simulators.
- From abstraction to practice: A basic queue simulator using SMPL.
- Discrete Event Simulation. Petri Networks.
- Agent Based Simulation (ABM). Netlogo Framework.
- High Performance Simulation: how reduce the simulation time of ABM.

### Module 2: Modelling and Simulation applied to engineering.

- Introduction to design process in engineering.
- From concept to manufacture: Frameworks and Tools.
  - Numerical Simulation in Engineering (FEA)
  - Virtual Prototyping - Concepts and Practise.
  - Industrial Process Modelling and Simulation
  - Cost Modelling and Simulation
- Design Optimization Introduction

### Module 3: Applications of Complex Physical Models

- Forest fire spread models: basic and Rothermel model, global models
- Input uncertainty: Data Driven Systems (Genetic Algorithms, Statistic Systems)
- Multi-model prediction system (Numerical Weather Prediction, Wind Field model, Fuels models..)
- Numerical weather forecast models: Numerical Weather Prediction (NWP)
- Basic concepts of Atmospheric Modelization. NWP models and computational power
- Applications of Numerical Weather Prediction at the Meteorological Service of Catalonia (SMC).
- Climate models, Earth System prediction: the EC-Earth model (Integrated Forecasting System (IFS), Ocean Model (NEMO), ..)

## Methodology

The course will be developed in classes, lab sessions and seminars with guest speakers.

## Activities

Title	Hours	ECTS	Learning outcomes
<b>Type: Directed</b>			
Lectures	26	1.04	2, 3, 5, 8
<b>Type: Supervised</b>			
Lab	12	0.48	1, 4, 7, 9

### Type: Autonomous

Collaborative work	20	0.8	1, 4, 7, 9
Individual (personal work)	40	1.6	1, 2, 4, 5, 7, 9
Preparation and study	48	1.92	2, 3, 5, 6

## Evaluation

In the case that the student has an evaluation of less than 5 points in some sections of the assessment (except the Lab), the student will have to do an additional (in person) test on the particular section. It is important to keep in mind that Laboratory sessions are not recoverable.

The evaluation will be made by developing the proposed case studies using the tools presented in the lectures sessions and laboratory. Group work and interaction will also be assessed.

### Academic Integrity

If the student use someone else's work (code, figures, research publications, etc.) to produce any work for this course, the student must:

1. indicate how this work was used,
2. acknowledge this work in a bibliography section.

Violation of these policies will be considered a breach of academic integrity, and the student will be subject to penalties outlined by the MsC studies coordination at the **Faculty of Sciences**. The student is subject to the rights and responsibilities that includes an academic (grade) penalty administered by the professor and/or disciplinary action through the UAB judicial process by plagiarism responsibilities.

## Evaluation activities

Title	Weighting	Hours	ECTS	Learning outcomes
ABM Simulation development	20	0.8	0.03	4, 7, 9
Cases Studies: Analysis & Presentation	40	1.6	0.06	1, 2, 3, 5, 6, 8
Labs	40	1.6	0.06	4, 7, 8, 9

## Bibliography

- M. P. Groover. Fundamentals of Modern Manufacturing, Materials, Processes, and Systems. Prentice Hall. 1996.
- Karl T. Ulrich and Steven D. Eppinger. Product Design and Development. Third Edition, McGraw-Hill, 2004
- Bernard P. Zeigler. Theory of Modeling and Simulation. Academic Press. 2000
- Sheldon Ros. Simulation. Academic Press. 2012.
- Angela B. Shiflet, George W. Shiflet (Author). Introduction to Computational Science: Modeling and Simulation for the Sciences. Princeton University Press. 2014.
- Byoung Kyu Choi, DongHun Kang. Modeling and Simulation of Discrete Event Systems. Wiley. 2013.
- Nigel Gilbert and Klaus Troitzsch. Simulation for the Social Scientist. Open University Press. 2005.
- Hazeleger W. et alter, EC-Earth: A seamless Earth-system prediction approach in action. American Meteorological Society, vol 91, 10, 1357-1368, 2010, doi: 10.1175/2010BAMS2877.1
- Andrés Cencerrado, Ana Cortés, Tomàs Margalef, "Response time assessment in forest fire spread simulation: An integrated methodology for efficient exploitation of available prediction time". Environmental Modelling and Software 54. 2014.

- Kerstin Wendt, Ana Cortés, Tomàs Margalef, "Parameter calibration framework for environmental emergency models", 10-21. Simulation Modelling Practice and Theory ,31. 2013.

**Websites:**

- Netlogo: <https://ccl.northwestern.edu/netlogo/>
- Jarp: Petrinets Analyzer, <http://jarp.sourceforge.net/us/index.html>
- Jpetrinet: Tool to model, analysis conventional Petri Nets and to simulate Timed Petri Nets, <http://jpetrinet.sourceforge.net/>
- Petri .NET Simulator: Tool for modelling and simulation of Petri nets and analysis of their behaviour <http://www.petrinetsimulator.com/>
- SMPL Simulation Toolkit: <http://ece.ut.ac.ir/Classpages/S86/ECE462/#Software>
- SMPL Examples, Source & complementary material: <http://www.csee.usf.edu/~christen/tools/toolpage.html>
- SMPL API description: <http://people.cs.vt.edu/~irchen/5214/pdf/p1-23.pdf>