UAB
Universitat Autònoma de Barcelona

Research and Innovation

Code: 43475
ECTS Credits: 6

2024/2025

Degree	Type	Year
4313136 Modelling for Science and Engineering	OB	0

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

There are no specific prerequisites. Students must have mathematical skills at a graduate level of a scientific or technological degree.

Objectives and Contextualisation

The aim of this module is to show students the variety of fields in which they will be able to apply the tools acquired during the Master courses. Hopefully they will be able to use them as guidance when looking for Internships in Companies and Institutions and also when choosing a topic and an advisor for the Master's Thesis. We also expect that it will help them to find a career path.

Competences

- 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.

- Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
- Apply techniques for solving mathematical models and their real implementation problems.
- Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
- Formulate, analyse and validate mathematical models of practical problems in different fields.
- Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
- Isolate the main difficulty in a complex problem from other, less important issues.
- Look for new areas to open up within the field.
- Recognise the human, economic, legal and ethical dimension in professional practice.
- Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

Learning Outcomes

1. Analyse, synthesise, organise and plan projects in the field of study.
2. Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
3. Check the validity of the model with regard to the behaviour of the real system.
4. Communicate and justify conclusions clearly and unambiguously to both specialised and non-specialised audiences.
5. Describe the functional dependencies of the system with regard to the different parameters
6. Design mathematical models that represent the system and its behaviour.
7. Identify the parameters that determine how a system works.
8. Implement the proposed solutions reliably and efficiently.
9. Integrate knowledge and use it to make judgements in complex situations, with incomplete information, while keeping in mind social and ethical responsibilities.
10. Isolate the main difficulty in a complex problem from other, less important issues.
11. Look for new areas to open up within the field.
12. Recognise the human, economic, legal and ethical dimension in professional practice.
13. Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
14. Solve mathematical models efficiently.
15. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

Content

We have two types of activities during the semester: to attend a three innovative mini-courses and attend a series of lectures given by people who work for companies or researchers working in universities or research centres.

The courses are the following:

1. Modeling in the cloud. Introduction to asset impact, cat risk and early warning. How to model natural hazards. From the model to a cloud service.
2. Introduction to Python for analytical purposes. Python basics. Data with Python. Problem solving with Python. Machine Learning with Python.
3. Machine learning. Machine learning, artificial intelligence and data science: from deterministic to stochastic point of view. Supervised and unsupervised techniques: from trees to random forests. Introduction to neural networks and mathematical challenges: performance assessment. ROC curves and cross validation.

We will invite specialists in the fields of Modelling Complex Systems, Modelling of Engineering, Mathematical Modelling and Data Science. Among the others we will have talks from people coming from:

- IIIA, Institut d'Intel·ligència Artificial, https://www.iiia.csic.es
- CRM, Centre de Recerca Matemàtica, http://www.crm.cat
- Accenture, https://www.accenture.com
- DSBlab, Dynamical Systems Biology lab (UPF), https://www.upf.edu/web/dsb
- Meteosim, https://www.meteosim.com

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Attending Lectures	16	0.64	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Attending Mini-courses	22	0.88	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

The methodology of the three courses is based on master classes which consist in the presentation of the theory, examples and some case studies.

Relating the lectures, they will be announced previously on the virtual campus of the module Research and Innovation. There the students will find the title of the talk, the name of the speaker, a short summary and links of interest.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Attending Lectures	10%	16	0.64	3, 4, 5, 7, 9, 15
Making a report on Maching Learning	30%	32	1.28	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Making a report on Natural Hazards	30%	32	1.28	3, 4, 5, 7, 9, 15
Report on Python for analitical purposes	30%	32	1.28	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

Students must present three projects corresponding to the three courses taught, in groups of two or three people.

Each of these projects accounts for 30% of the grade.

On the other hand, attendance to the talks, which is mandatory, contributes 10% of the final grade.

Bibliography

- Bibliography and links of interest

- https://www.python.org/about/gettingstarted/
- https://www.learnpython.org/
- https://learntocodewith.me/posts/python-for-data-science
- Pitts W McCulloch W. A logical calculus of the ideas immanent in nervous activity. Bulletin of Mathematical Biophysics, 5, 1943.
- L. Breiman, J.H. Friedman, R.A. Olshen and C.J Stone. Classification and Regression Trees. Wadsworth, Belmont, Ca, 1988.
- Friedman, Jerome H. Data Mining and Statistics: What's the connection?". Computing Science and Statistics. 29. 1998.
- B Ripley. Pattern Recognition and Neural Networks, Cambridge University Press, Cambridge. 2002.
- T Hastie, R Tibshirani, J Friedman. The Elements of Statistical Learning. Data Mining, Inference and Prediction, Springer, New York. 2009.
- Bishop, C. M. Pattern Recognition and Machine Learning, Springer, ISBN 978-0-387-31073-2. 2006.
- Ethem Alpaydin. Introduction to Machine Learning (Fourth ed.). MIT. 2020.

Software

The software will be detailed in each one of the courses.

Language list

Name	Group	Language	Semester	Turn
(TEm) Theory (master)	1	English	first semester	afternoon