Universitat Autònoma de Barcelona

2023/2024

Methodological Advances

Code: 104866
ECTS Credits: 6

Degree	Type	Year	Semester
2503852 Applied Statistics	OT	4	2

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

Maria del Pilar Casado Lechuga

Oscar Blanch Bigas

Prerequisites

There are no formal prerequisites. Recommendations:

- have completed the core subjects of the first three years of the Degree
- basic knowledge of python programming
- Physics studies at least at the high school level

Objectives and Contextualisation

Humanity's vision of the Universe changed radically in the 20th century. The evolution of detection techniques has increased the number of objects visible in the sky from a few hundred to many billions. In addition, objects can be observed through electromagnetic radiation in a wide range of wavelengths, from radio and infrared to the visible band and X-rays. Experimental techniques from elementary particle physics have been adapted to extend observations of celestial objects, for example through higher energy photons (gamma rays). These techniques also allow, for the first time, the observation of the sky through non-electromagnetic messengers, that is, charged particles ("cosmic rays") and, very recently, neutrinos. Finally, gigantic, highly accurate laser interferometers have recently observed gravitational waves, providing another way of observing celestial objects.

All of these ways of looking at the Universe are producing enormous amounts of data that must be filtered, calibrated, analyzed, and compared with theoretical predictions. This requires data reduction in high throughput systems and simulations in high performance systems, combined with sophisticated statistical

analysis and uncertainty estimation. Big Data and Artificial Intelligence techniques are being increasingly applied in the field. The objective of the course is to explore these techniques in the context of the Degree.

Competences

- Design a statistical or operational research study to solve a real problem.
- Select statistical models or techniques for application in studies and real-world problems, and know the tools for validating them.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Summarise and discover behaviour patterns in data exploration.

Learning Outcomes

1. Establish the experimental hypotheses of modelling.
2. Identify the response, explanatory and control variables.
3. Plan studies based on time series.
4. Recognise the need to use models of stochastic processes.
5. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
6. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
7. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
8. Use summary graphs for multivariate data and temporal evolution data.

Content

1. Observing the sky: Physics, models and simulations, observations and instruments.
2. Case Study: Optical Sky Surveys: Measuring the expansion of the Universe
3. Case Study: Imaging Atmospheric Cherenkov telescopes: Measuring the non-thermal Universe
4. Case Study: The violent Universe: Neutrino astronomy with huge volumes of instrumented ice or water
5. Case Study: The violent Universe: Detecting gravitational waves with laser interferometers

Methodology

The course will be organized in 5 modules of 2-3 week duration. The introduction to each module will be given in Lectures. Afterwards the students will work on understanding a number of Case Studies, taking a critical look at existing solutions and proposing improvements.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	15	0.6	1, 8, 2, 3, 6, 4
Type: Supervised			
Case Studies	25	1	1, 8, 2, 3, 7, 5, 6, 4
Type: Autonomous			
Development of solutions and programs	50	2	1, 8, 2, 3, 7, 5, 6, 4
Study	45	1.8	1, 8, 2, 3, 4
Tutorials with professors	5	0.2	1, 8, 2, 3, 7, 5, 6, 4

Assessment

This subject does not provide for the single assessment system.

The more theoretical aspects will be evaluated through a Continuous Evaluation Assessment of 2 hour duration. The more practical aspects will be evaluated through Presentations and Participation in Debates, each of about 2 hour duration.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continuous Assessment Tests	14%	2	0.08	1, 2, 7, 4
Presentations and participation in debates	86%	8	0.32	1, 8, 2, 3, 7, 5, 6, 4

Bibliography

Física per a la ciència i la tecnologia Electricitat i magnetisme / La llum / Física moderna: mecànica quàntica, relativitat i estructura de la matèria / Paul A. Tipler, Gene Mosca; obra coordina per David Jou i Mirabent i Josep Enric Llebot Rabagliati. 2nd ed. Barcelona: Editorial Reverté, 2010. (versión electrónica disponible a través de la Biblioteca de la UAB).

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Python Pocket Reference, O'Reilly, Mark Lutz, ISBN: 0596158084, 2009.

Fundamental Astronomy, Hannu Karttunen, Pekka Kröger, Heikki Oja, Markku Poutanen, Karl Johan Donner. ISBN: 978-3-662-53045-0, 2016

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Resource Type:
Book
Subjects:
English Language

Software

Any type of spreadsheet (LibreOffice Calc, Google Sheets, Microsoft Excel, etc.)
Online pages that generate graphics (desmos.com, geogebra, etc.)
python
Jupyter notebooks