UAB
Universitat Autònoma de Barcelona

Methodological Advances

Code: 104866
ECTS Credits: 6

2024/2025

Degree	Type	Year
2503852 Applied Statistics	OT	4

Contact

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Teachers

Maria del Pilar Casado Lechuga

Teaching groups languages

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

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.

Learning Outcomes

1. CM09 (Competence) Assess the suitability of the models with the correct use and interpretation of indicators and graphs.
2. CM09 (Competence) Assess the suitability of the models with the correct use and interpretation of indicators and graphs.
3. CM10 (Competence) Modify the existing software if required by the statistic model, or create new software, if necessary.
4. KM12 (Knowledge) Provide the experimental hypotheses of modelling, considering the technical and ethical implications involved.
5. KM12 (Knowledge) Provide the experimental hypotheses of modelling, considering the technical and ethical implications involved.
6. SM12 (Skill) Interpret the results obtained to formulate conclusions about the experimental hypotheses.
7. SM14 (Skill) Use graphs to visualise the fit and suitability of the model.

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

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	15	0.6	CM09, KM12, SM14
Type: Supervised			
Case Studies	25	1	CM09, CM10, KM12, SM12, SM14
Type: Autonomous			
Development of solutions and programs	50	2	CM10, SM12, SM14
Study	45	1.8	CM09, KM12, SM14
Tutorials with professors	5	0.2	CM09, CM10, SM12, SM14

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.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continuous Assessment Tests	14%	2	0.08	CM09, CM10, KM12, SM12, SM14
Presentations and participation in debates	86%	8	0.32	CM09, CM10, KM12, SM12, SM14

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.

Bibliography

Fisica per a la ciència i la tecnologia Electricitat i magnetisme / La llum / Fisica 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).

Statistical Data Analysis, G. Cowan, ISBN: 0198501552, 1998.

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

Particle Physics Reference Library: Volume 2: Detectors for Particles and Radiation / Edited by Christian W. Fabjan, Herwig Schopper. Ed. Christian W. Fabjan and Herwig Schopper. Cham, Switzerland: Springer Nature, 2020. Web.
Full Text Access:
https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010351516706709

Software

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

Language list

Name	Group	Language	Semester	Turn
(PLAB) Practical laboratories	1	Catalan/Spanish	second semester	morning-mixed
(TE) Theory	1	Catalan/Spanish	second semester	morning-mixed