Universitat Autònoma de Barcelona

2023/2024

Probability

Code: 104386
ECTS Credits: 6

Degree	Type	Year	Semester
2503740 Computational Mathematics and Data Analytics	FB	1	2

Contact

Name: Lluis Antoni Quer Sardanyons

Email: lluis.quer@uab.cat

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.

Prerequisites

- Calculus in One Variable
- Introduction to Programming

It is also very necessary that the student reaches throughout the semester the contents of the subject Calculus in Various Variables, which is taken simultaneously.

Objectives and Contextualisation

What has in common a draw of the lottery, a clinical trial to experimentally evaluate the efficacy and/or safety of a new medical treatment, the weather forecast of rain in a specific area, the management of the inventory of a company, the transmission of genes from parents to children, the estimate of the size of the whale population, an epidemiological study on the incidence of a certain disease, the inspection of batches of products that a company manufactures to verify their quality, an experiment to study the effect of pressure and temperature on the result of a certain chemical reaction, or the effect of the use of different fertilizers in the agricultural production of a farm, ...?

These are real situations in which chance intervenes.

To study them and to be able to extract reliable conclusions, we must use a suitable mathematical model. This model is provided by the Probability, which is the mathematical theory that allows modeling random phenomena, that is, situations where chance acts.

The objective of this subject is to introduce the theory of Probability as a mathematical theory that studies the models that allow to deal with randomness. The topics that will be introduced and will be developed in this subject include basic contents of the theory of Probability (development of the mathematical model for random phenomena), although without using advanced elements of the Measure Theory that correspond to a deeper

study of matter. But the emphasis will be on applications, when trying to find the best possible probabilistic model in a given real situation and, by using it appropriately, with the tools we will learn throughout the course, to extract valuable information, knowledge, and reach useful conclusions, because this is the objective that is sought when modeling is done.

Competences

- Apply a critical spirit and rigour for the validation or rejection of your own arguments and those of others.
- Demonstrate a high capacity for abstraction and translation of phenomena and behaviors to mathematical formulations.
- Formulate hypotheses and think up strategies to confirm or refute them.
- Make effective use of bibliographical resources and electronic resources to obtain information.
- Relate new mathematical objects with other known objects and deduce their properties.
- 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.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Using criteria of quality, critically evaluate the work carried out.
- Work cooperatively in a multidisciplinary context assuming and respecting the role of the different members of the team.

Learning Outcomes

1. "Explain ideas and mathematical concepts pertinent to the course; additionally, communicate personal reasonings to third parties."
2. Apply a critical spirit and rigour for the validation or rejection of your own arguments and those of others.
3. Contrast, if possible, the use of calculation with the use of abstraction in solving a problem.
4. Describe the concepts and mathematical objects pertaining to the subject.
5. Develop autonomous strategies for solving problems such as identifying the ambit of problems within the course, discriminate routine from non-routine problems, design an a priori strategy to solve a problem, evaluate this strategy.
6. Evaluate the advantages and disadvantages of using calculation and abstraction.
7. Identify the essential ideas in the demonstration of ceratin basic theorems and know how to adapt these to obtain other results.
8. In an orderly and accurately manner, draft brief mathematical texts (exercises, resolution of theoretical questions, etc.).
9. Make effective use of bibliographical resources and electronic resources to obtain information.
10. Read and understand a mathematical text at the current level of the course.
11. 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.
12. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
13. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
14. Using criteria of quality, critically evaluate the work carried out.
15. Work cooperatively in a multidisciplinary context, taking on and respecting the role of the distinct members in the team.

Content

1. Modeling randomness: the probabilistic model.

- Random phenomena and probability spaces.
- Properties of the Probability. Probability and Odds.
- Counting elements of a set: some combinatorics.
- Conditioned probability and independence of events.
- The Formula of Total Probability and the Bayes' Formula.
- Evidence Evaluation and Bayes Formula: The Odds Ratio.

2. Random variables.

- Introduction. Distribution function of a random variable.
- Discrete random variables. Probability function. Examples
- (Absolutely) continuous random variables. Density function. Examples.
- Functions of a random variable.
- Independence of random variables.

3. Mathematical Expectation, Variance and Moments.

- Expectation of discrete random variables.
- Expectation of (absolutely) continuous random variables.
- Expectation and independence of random variables.
- Variance of a random variable.
- Covariance of two random variables. The (Pearson) correlation coefficient.
- Moments of a random variable. Txevixev inequality.
- Moment generating function.

4. Sequences of random variables.

- Types of convergence.
- Laws of large numbers (LLN).
- The central limit theorem (TCL).

IMPORTANT: To include the gender perspective in the teaching of this subject, we have reviewed the possible androcentric biases and questioned hidden gender assumptions and stereotypes. This revision involves including in the contents of the subject, as far as possible, knowledge produced by women scientists, often forgotten, seeking the recognition of their contributions, as well as that of their works in the bibliographical references.

Methodology

In this subject, it is not made the classic distinction in the face-to-face activities of: classes of theory, of problems and of practices with computer, but they will be combined according to the teaching needs in each moment, thanks to the facility that supposes the fact that students bring their own computer in class.

In this way, the teacher will introduce the concepts and examples, while when appropriate, the problems will be worked on in class, or the statistical software and R programming language will be used to carry out some practice related to the topic that is being studied in class. The aim is to use a comprehensive system that incorporates the three classical aspects of face-to-face activities in an optimal manner to facilitate student

learning and achieve the objectives set, while making the class as participatory as possible, following the principle that you only learn what you are trying to do.

IMPORTANT: To work more comfortably with R, it is recommended to use the RStudio interface: it is free, "open source" and works with Windows, Mac and Linux.
https://www.rstudio.com/

REMARK: Although we have already discussed the gender perspective in teaching in previous sections, we go further by reviewing the teaching methodology and the interactions between students and teachers. In this sense, a participatory teaching methodology will be implemented, where an egalitarian, less hierarchical classroom environment is generated, avoiding stereotyped examples in gender and sexist vocabulary, with the aim of developing critical reasoning and respect for diversity and plurality of ideas, people and situations, it will be more favorable to the integration and full participation of the students.

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			
Problems in the classroom	10	0.4	2, 14, 6, 3, 4, 5, 1, 13, 12, 11, 8, 15, 9
Theory in the classroom	27	1.08	2, 4, 5, 1, 7, 10, 13, 12, 11, 8, 9
Type: Supervised			
Practical sessions	12	0.48	2, 14, 6, 3, 4, 5, 1, 13, 12, 11, 8, 15, 9
Type: Autonomous			
Personal work	92	3.68	2, 14, 6, 3, 4, 5, 1, 7, 10, 13, 12, 11, 8, 15, 9

Assessment

See the Catalan version

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Continuous Assessment Test	0.30	3	0.12	2, 14, 6, 3, 5, 1, 10, 13, 12, 11, 8, 15, 9
Practice exam	0.20	2	0.08	2, 14, 6, 3, 4, 5, 1, 7, 10, 13, 12, 11, 8, 15, 9
Problems exam	0.50	4	0.16	2, 6, 3, 4, 5, 1, 7, 10, 13, 12, 11, 8, 9

Bibliography

BASIC BIBLIOGRAPHY:

Bardina, Xavier. Càlcul de Probabilitats. Servei de Publicacions UAB, 2004.

DeGroot, Morris H., Schervish, Mark J. Probability and statistics. Pearson, 2012, 4th ed., international ed.

Devore, Jay L. Probabilidad y Estadística para ingeniería y ciencias. Cengage Learning, 2016

Julià, Olga; Márquez, David; Rovira, Carles i Sarrà, Mónica. Probabilitats: Problemes i més problemes. Publicacions i edicions de la Universitat de Barcelona, 2005.

Kai Lai, Chung. Teoría elemental de la probabilidad y los procesos estocásticos. Reverté, cop., 1983.

Sanz-Solé, Marta. Probabilitats. Edicions de la Universitat de Barcelona, 1999.

COMPLEMENTARY BIBLIOGRAPHY:

Ross, Sheldon M. Introduction to Probability Models, Academic Press, 12th Edition. Elsevier, 2019.

Rao, C. Radhakrishna. Estadística y verdad. Aprovechando el azar. Colección Universitas-73. Serie Estadística y Análisis de datos. PPU, S.A., 1994.

Software

In this subject the R software will be used (https://cran.r-project.org/)
R is a programming environment consisting of a set of very flexible tools that can be easily expanded through packages, libraries, or by defining our own functions. It is also free and open source, an Open Source part of the GNU project, and this is one of its main advantages. Any user can download and create their code for free, without restrictions of use, the only rule is that the distribution is always free (GPL). Because it can freely access its code, R software has no limited functions, unlike other commercial statistical tools.
Preferably, we will use it using the RStudio platform (https://www.rstudio.com/)