Course guide
200131 - TP - Probability Theory

Last modified: 01/06/2023

Unit in charge:	School of Mathematics and Statistics
Teaching unit:	749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN MATHEMATICS (Syllabus 2009). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 7.5 **Languages:** Catalan

LECTURER

Coordinating lecturer:	MARCOS NOY SERRANO
Others:	Primer quadrimestre:
	MARCOS NOY SERRANO - M-A, M-B
	MIQUEL ORTEGA SÁNCHEZ COLOMER - M-A, M-B
	JUAN JOSÉ RUE PERNA - M-A, M-B

REQUIREMENTS

It is recommended to take this course after completing the first two years of the Mathematics degree. In particular, those not having taken Real Analysis yet will have to cover some gaps by their own (references will be supplied).

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CE-2. Solve problems in Mathematics, through basic calculation skills, taking in account tools availability and the constraints of time and resources.
2. CE-3. Have the knowledge of specific programming languages and software.
3. CE-4. Have the ability to use computational tools as an aid to mathematical processes.

Generical:
5. CB-1. Demonstrate knowledge and understanding in Mathematics that is founded upon and extends that typically associated with Bachelor's level, and that provides a basis for originality in developing and applying ideas, often within a research context.
6. CB-2. Know how to apply their mathematical knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader or multidisciplinary contexts related to Mathematics.
7. CB-3. Have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements.
8. CG-1. Show knowledge and proficiency in the use of mathematical language.
9. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.
10. CG-3. Have the ability to define new mathematical objects in terms of others already know and ability to use these objects in different contexts.
11. CG-4. Translate into mathematical terms problems stated in non-mathematical language, and take advantage of this translation to solve them.
12. CG-6 Detect deficiencies in their own knowledge and pass them through critical reflection and choice of the best action to extend this knowledge.

Transversal:
4. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

TEACHING METHODOLOGY

(See the Catalan version of this guide.)

LEARNING OBJECTIVES OF THE SUBJECT

There are two main objectives: (1) to present Probability Theory as a rich, attractive and useful tool in modeling random phenomena and (2) to provide the necessary background in probability for other subjects in the Debree of Mathematics.

The particular goals of the subject are the achievement by the students of the following aspects:

* To know the notion of probability and its main properties.
* To know the basic discrete and continuous probability models .
* To use the concept of random variable in formalizing and solving problems in probability.
* To know the concept of moments of a random variable and the main results associated to this notion.
* To know the notion of convergence of random variables, particularly the Central Limit Theorem and the Laws of Large Numbers.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	24.00
Hours small group	30,0	16.00
Self study	112,5	60.00

Total learning time: 187.5 h

CONTENTS

Probability spaces

Description:
Random experiments, outcomes and events.Probability space.
Conditional Probability. Independence.
Product Spaces.
The Borell-Cantelli Lemas.

Full-or-part-time: 25h 30m
Theory classes: 6h
Practical classes: 4h
Self study : 15h 30m

Random variables

Description:
Random variable. Distribution function.
Mean, variance and other moments. Markov's and Chebyshev's inequalities.
Vectors of random variables.
Independence of random variables.

Full-or-part-time: 25h 30m
Theory classes: 6h
Practical classes: 4h
Self study : 15h 30m

Discrete random variables

Description:
Discrete variables. Probability function.
Probability generating function. Sums of random variables.
Models of Discrete Random Variables.
Conditional distributions. Conditional Expectation.
Ramification processes (Galton-Watson trees)
Random walks.

Full-or-part-time: 26h 30m
Theory classes: 6h
Practical classes: 5h
Self study : 15h 30m

Continuous random variables

Description:
Density Probability Function.
Models of Continous Random Variables.
Joint distributions. Marginal distributions.
Conditional distributions and mitxtures.
Multivariate Normal distribution.
Transformations of continuous variables

Full-or-part-time: 27h 30m
Theory classes: 6h
Practical classes: 6h
Self study : 15h 30m

Characteristic functions

Description:
Moment Generating Function.
Characteristic Function. Inversion theorem.

Full-or-part-time: 21h 30m
Theory classes: 5h
Practical classes: 2h 30m
Self study : 14h

Convergence of Random Variables

Description:
Modes of convergence
Laws of large numbers
Convergence in distribution. The Central Limit Theorem.

Full-or-part-time: 35h 30m
Theory classes: 9h
Practical classes: 4h
Self study : 22h 30m

GRADING SYSTEM

(See the Catalan version of this guide.)

BIBLIOGRAPHY

Basic:
- Grimmett, G.R.; Stirzaker, D.R. Probability and random processes. 3a ed. Oxford [etc.]: Oxford University Press, 2001. ISBN 9780198572220.
- Sanz, Marta. Probabilitats. Barcelona: Edicions de la Universitat de Barcelona, 1999. ISBN 8483380919.
- Pitman, Jim. Probability. New York: Springer, 1993. ISBN 0387979743.
- Gut, Allan. An Intermediate course in probability [on line]. 2nd ed. Springer, [Consultation: 27/06/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=571348. ISBN 9781441901620.

Complementary:
- Julià de Ferran, Olga [et al.]. Probabilitats : problemes i més problemes. Barcelona: Universitat de Barcelona, 2005. ISBN 8447529061.
- Feller, W. An introduction to probability theory and its applications (Vol. 1,2). 3rd ed. New York: John Wiley & Sons, 1968. ISBN 0471257117.
- Grinstead, Charles M.; Snell, L.J. Introduction to probability. American Mathematical Society, 2006. ISBN 0821807498.
- Chung, Kai Lai. A course in probability theory. New York: Academic Press, 1974. ISBN 012174650X.
- Cuadras, C. M. (Carlos María). Problemas de probabilidades y estadística. Vol 1: Probabilidad. Barcelona: EUB, 2000. ISBN 8483120313.
- Tabak, J. Probability and statistics : the science of uncertainty. New York: Facts On File, 2004. ISBN 0816049564.
- Fristedt, Bert E; Gray, Lawrence F. A Modern approach to probability theory. Boston [etc.]: Birkhäuser, cop. 1997. ISBN 3764338075.
- Durrett, Richard. Probability : theory and examples. 3rd ed. Thomson Brooks/Cole, cop. 2005. ISBN 0534132065.

RESOURCES

Hyperlink:
- The Probability Web (Teaching resources)

. http://www.mathcs.carleton.edu/probweb/probweb.html- Chance
. http://www.dartmouth.edu/~chance/- Grinstead, Charles M.; Snell,Laurie J. Introduction to Probability

. http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/book.html />
- The R Project for Statistical Computing
R is a free software environment for statistical computing and graphics.
. http://www.r-project.org/