# Statistics II

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***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

The course has a predominantly methodological content and aims at providing the main probabilistic tools for the treatment of random phenomena and of the fundamental methods of classical statistical inference.

The course is divided into two parts. The first part focusses on the study of the characteristics of the main random variables and of the concepts of convergence and the laws of large numbers. The second part illustrates the main tools of inferential statistics, both on estimation methods and hypothesis testing. Computational methods in the R language will be provided.

At the end of the course, participants will be able to apply the notions related to decision-making in case of uncertainty; they will be able to apply the inferential techniques to real problems and derive theoretical results. Students will become aware of the advantages and limits of the methodologies studied, in order to be able to critically evaluate the most suitable instruments in case of uncertainty.

***COURSE CONTENT***

Learning objectives that students should have achieved before attending the course

Before attending the course, students should be familiar with the mathematical methods provided in the first- and second-year courses (particularly useful will be the knowledge of the main properties of limit, series, derivative, integral operators) and with the statistics methods provided during the first year.

Learning objectives that students may achieve during the course

*Part 1: random variables and convergences*

– Review of probability calculations

– Random variables:

– Discrete random variables: *bernoulli, binomial, Poisson, geometric, negative binomial;*

– Continuous random variables: normal, inverse normal, uniform, exponential, Erlang, Gamma, Beta, Pareto;

– Multidimensional random variables: multivariate normal;

– Transformations and convolutions of random variables: probability integral transformation and Chi-square random variables, Student’s t, Fisher’s F, lognormal;

– Mixed random variables: Poisson–gamma, beta–binomial

– Moment-generating functions and cumulant-generating functions.

– Remarkable inequalities: *Jensen’s* inequalities, *Markov* and *Chebyshev* I nequalities*.*

– Sequences of random variables: convergence notions and the law of large numbers (central limit theorem).

*Part 2: inferential statistics*

– Introduction to sampling.

– Point estimate: properties of the estimators, method of moments and delta method.

– Likelihood function and maximum likelihood method.

– Interval estimation: construction of confidence intervals.

– Hypothesis testing: significance test, likelihood-ratio tests.

– Estimation techniques in specific situations: profile likelihood and EM algorithm.

– Selection of a statistical model: graphic techniques, distribution adaptation test, criteria based on the likelihood function.

– The R language: an introduction

***READING LIST***

Recommended textbooks:

D. Zappa-S. Facchinetti, Appunti di Statistica II, EDUCatt, 2017.

Further study textbooks:

B.V. Frosini, Complementi sulle variabili casuali, EDUCatt, 2014.

G. Cicchitelli-P. D’urso-M. Minozzo, Statistica: principi e metodi 3/Ed., Pearson, 2017.

S.M. Ross, Calcolo delle probabilità, Apogeo, 2013.

***TEACHING METHOD***

The course will alternate lectures on methodological topics with lectures with illustrative contents. Lessons will be combined with a cycle of practical exercises.

***ASSESSMENT METHOD AND CRITERIA***

The exam consists of a written test that will contain both exercises and theoretical questions aimed at assessing the full conceptual and operational knowledge of the topics presented during the course. The time of the test is 2 hours. The exam is only written.

The assessment also includes an interim test at the end of the first part of the course, which will contain both exercises and theoretical questions. The time of the interim test is 1 hour. Those who have successfully passed the first test, can take the exam related to the topics covered in the second part of the course.

***NOTES AND PREREQUISITES***

We recommend students take the exam after passing the Mathematics and Statistics I exams.

Further information can be found on the lecturer's webpage at http://docenti.unicatt.it/web/searchByName.do?language=ENG or on the Faculty notice board.