# Statistics II

## Prof. Diego Attilio Mancuso

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

The course has a predominantly methodological content and aims to provide an understanding of 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 indispensable tools of inferential statistics, both from the point of view of estimation and hypothesis testing, in order to provide a correct identification of the decision-making models in the presence of sample information.

At the end of the course, participants will be able to apply the notions related to decision-making procedures to conditions of uncertainty, they will be able to apply the inferential techniques to real problems and derive theoretical results in a formal way. 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 the specific situations to be analysed.

***COURSE CONTENT***

Learning objectives that students should have achieved before attending the course

Before attending the course, students should be familiar with the tools for mathematical analysis 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 ones 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.

***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 allowed for the test is 2 hours. The assessment does not include an oral exam.

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 duration 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, in one of the winter exam sessions. The marks obtained in the two parts will equally contribute to the final grade.

***NOTES AND PREREQUISITES***

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

In case the current Covid-19 health emergency does not allow frontal teaching, remote teaching will be carried out following procedures that will be promptly notified to students.

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.