UCLouvain

lmat1271

2023

Calculation of probability and statistical analysis

6.00 credits	30.0 h + 30.0 h	Q2

Teacher(s)	von Sachs Rainer ;
Language :	French > English-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Courses LMAT1121 and LMAT1122 (real analysis/calculus, in particular bivariate integration).
Main themes	The general aim of the course consists in giving an introduction into the thinking and the tools of probability theory and statistical analysis, with a view towards applications. The addressed topics cover the basic notions of probability (and conditional probability) and the main distributions of random vectors. The course treats the concepts of independence and correlation, and some aspects of large sample properties. For the statistical analysis, priority is given to the parametric approach (estimation of the parameters of a probability distribution) and to methods of statistical inference (hypothesis testing and confidence intervals). The statistical concepts are applied to the specific problems of analysis of variance (ANOVA) and of (simple) linear regression.
Learning outcomes	**At the end of this learning unit, the student is able to :** **Contribution of the course to learning outcomes in the Bachelor in Mathematics programme.** **By the end of this activity, students will be able to :** Recognise and understand a basic foundation of mathematics. Choose and use the basic tools of calculation to solve mathematical problems. Recognise the fundamental concepts of important current mathematical theories. Establish the main connections between these theories, analyse them and explain them through the use of examples. Show evidence of abstract thinking and of a critical spirit. Argue within the context of the axiomatic method. Recognise the key arguments and the structure of a proof. 1 Distinguish between the intuition and the validity of a result and the different levels of rigorous understanding of this same result. Learning outcomes specific to the course. The general goal of the course is to introduce the student to the notion and the tools of probability theory and statistical analysis, with a view towards applications. **By the end of the course, students will be able to :** - Use the basic notions of probabilistic modelling, being able to worki with random variables : - Apply the most frequently used techniques of probability theory (conditional probabilities and expectation, normal, Poisson and exponential laws) in various fields of application - Explore structured data sets by the methods of statistical inference - Apply the techniques of confidence intervals and hypothesis testing
Evaluation methods	• **During the semester :** Continued evaluation via the preparation of a data-analysis project (in groups) using some statistical software and/or via some occasional tests (in groups) during the tutorials. • **During the exam sessions :** Assessment is based on a written examination that focuses on theory and on exercises. The examination tests knowledge and understanding of fundamental concepts and results, ability to construct and write a coherent argument, mastery of the techniques of calculation and, above all, the applicability of the methods covered in the course to problems in the statistical analysis of data.

Teaching methods	This second introductory course in probability and statistics will consist of : • lectures that will present the subject on the basis of examples and the development of mathematical reasoning, • exercise sessions aiming at systematically putting into practice the different notions seen in the course on well-targeted cases and with the help of a specialized software, • projects that will give the student the opportunity to integrate the different tools in the fields of application of mathematics and physics. The pedagogical approach used will privilege the active learning of the students and will try to respect the pedagogical orientations proposed by the Faculty.
Content	• Recalling the concepts of random variables, generalised to random vectors, of conditional probabilities and conditional moments and of the transformation of random variables (in particular the concept of the moment-generating function) • Derivation of the random sampling distributions (Chi squared, F, Student, …), necessary in order to derive the properties of the most common statistics (estimators) • Derivation and applications of asymptotic laws (Chebycheff inequality, law of large numbers, central limit theorem, ...) • Point estimation: method of moments, maximum likelihood method, least-squares method; theoretical properties of estimators (bias, variance, mean-square error, consistency, asymptotic normality, efficiency) • Confidance intervals (exact and asymptotical; based on the maximum likelihood estimator) • Statistical hypothesis testing (for the mean, variance, and proportion of one or two normal or binomial populations, respectively): method of pivots; likelihood ratio test,.. • Linear regresion (simple and multiple), general notion of model fitting • (Time permitting) Introduction into modern data analysis techniques (resampling techniques; principal component analysis; clustering/classification)
Inline resources	Site Moodle https://moodleucl.uclouvain.be/course/view.php?id=8921 On the website can be found : copies of transparencies, exercice problems and their solutions, a list of formulas and statistical tables, the help file for using the statistical software, a copy of a recent exam and the detailed table of contents of the course.
Bibliography	D. Wackerly, W. Mendenhall, R. Scheaffer : "Mathematical Statistics with Applications" (7th ed.) 2008, Brooks/Cole.
Faculty or entity in charge	MATH

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Additionnal module in Physics	APPHYS	6		
Master [120] in Data Science : Statistic	DATS2M	6		
Master [120] in Environmental Science and Management	ENVI2M	6		
Interdisciplinary Advanced Master in Science and Management of the Environment and Sustainable Development	ENVI2MC	6		
Bachelor in Mathematics	MATH1BA	6		
Master [120] in Physics	PHYS2M	6		
Certificat d'université : Statistique et science des données (15/30 crédits)	STAT2FC	6		