UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	
ACADEMIC YEAR	
ANNO ACCADEMICO EROGAZIONE	
SUBJECT	
CODE	
SCIENTIFIC SECTOR(S)	
HEAD PROFESSOR(S)	ADELFIO GIADA Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	ADELFIO GIADA Professore Ordinario Univ. di PALERMO TUMMINELLO MICHELE Professore Ordinario Univ. di PALERMO
CREDITS	
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	
TERM (SEMESTER)	
ATTENDANCE	
EVALUATION	
TEACHER OFFICE HOURS	**ADELFIO GIADA** Tuesday 11:00 13:00 ex DSSM secondo piano Thursday 11:00 13:00 ex DSSM secondo piano **TUMMINELLO MICHELE** Monday 14:00 16:00 Studio/Laboratorio: primo piano, ex DSSM Tuesday 14:00 16:00 Studio/Laboratorio: primo piano, ex DSSM

DOCENTE: Prof.ssa GIADA ADELFIO

PREREQUISITES	Vectors in R^n and their properties. Matrix algebra. Basic notions of calculus R^n. Knowledge of the statistical programming language R or Python. Knowledge of Inference and Probability
LEARNING OUTCOMES	1. Knowledge and understanding: At the end of the course, students should show knowledge and comprehension of the main topics of the course. In particular they should learn the specific language of probability theory and fundamentals of stochastic processes. Moreover, we refer to the ability to i) identify and discuss the properties of a network at the microscopic, mesoscopic, and macroscopic levels; ii) identify the characteristics of a complex real system and describe the interactions between the system's elements through a network model. 2. Ability to apply knowledge and understanding: Students should become able to apply their knowledge and comprehension to tackle problems of uncertainty by means of suitable stochastic models. Specifically, students should be able to: -classify a stochastic process; -interpret different forms of stochastic dependencies; -describe a time and space dependent random pattern with a suitable stochastic process; Moreover, we consider the ability to use Python or R software to i) describe the main properties of a network - in particular the emerging structures, and characterize them in terms of the attributes of nodes and links, ii) build network evolution models; iii) simulate processes occurring on a network. 3. Judgment skills: Students should become able to recognize with criticism the significant elements of a problem of uncertainty, thereby assessing the probabilistic tools used to tackle the problem. Also, the ability to analyze a real system through the selection of an appropriate network description, suitable network's growth models, and appropriate network indicators and measures. 4. Communication skills: Ability to explain the characteristics of probabilistic tools, highlighting the usefulness of their application, presenting results professionally through graphs and spreadsheets. 5. Learning skills: Ability to 1)read the national and international basic literature, 2) increase the acquired knowledge in attending higher level courses,3) conducting research and analysis in the field of decision science through network models.
ASSESSMENT METHODS	The exam consists of two parts related to the two modules taught. For the Stochastic Processes module, the test involves working on a project related to the use of stochastic processes in real contexts, preparing a brief report on the project (10 page long-maximum), and giving an oral presentation describing its content. For the Stochastic Networks module, the exam consists of working on a project related to the study of a real system that admits a network representation, preparing a brief report on the project, and giving an oral presentation describing its content. Both projects are agreed upon with the instructors. For the Stochastic Processes module, a passing grade will be assigned when the student shows knowledge and understanding of the subjects at least in the general lines (definition of concepts) and has minimal application skills, consisting of the examples of simple concrete cases. For the Networks module, a passing grade will be assigned to students who demonstrate their ability to describe the main properties of the network and its evolution, using the metrics considered during the course. For both modules, the more the student will show his/her argumentative and expository ability, as well as the property of language, the more the evaluation will be positive. The final grade is the arithmetic average of the grades obtained in both modules.
TEACHING METHODS	The course will be organized in frontal and practice classes, either in R or Python

MODULE NETWORKS AND OPTIMISATION *Prof. MICHELE TUMMINELLO*	
SUGGESTED BIBLIOGRAPHY	
M. Newman, Networks: An Introduction, Oxford University Press. A.L. Barabasi, Network Science, Cambridge University Press. D. Easley and J. Kleinberg, Networks, Crowds and Markets, Cambridge University Press.	
AMBIT	84544-Discipline Matematico-applicate
INDIVIDUAL STUDY (Hrs)	108
COURSE ACTIVITY (Hrs)	42
EDUCATIONAL OBJECTIVES OF THE MODULE	
OBJECTIVES OF THE UNIT are to: 1) construct a network model of a real world system and recognize its structure; 2) provide a vector representation of the space of solutions to the problem of modularity optimization and use heuristic stochastic optimization methods to identify sub-optimal solutions; 3) algorithmically define a model of network growth; 4) algorithmically define a model of diffusion on a network; 5) describe the role of communities in a realization of the SIR model; 6) represent a real-world dataset through a bipartite network and analyzing its properties.	

SYLLABUS

Hrs	Frontal teaching
2	Introduction to networks. The Konigsberg 7-bridge problem. The power-grid and the US west-coast black-out in 1996.
2	Network representation: weighted networks, directed networks, bipartite networks.
2	Descriptive analysis: degree, betweenness centrality, page rank, clustering coefficient, assortatitivity.
2	Degree distribution, scale-free networks.
2	Albert-Barabasi model and Dorogovtsev model
4	Introduction to stochastic processes on networks. Mean-field models: SI, SIS, and SIR models.
2	Simulated annealing, genetic algorithms, taboo search, and extreme optimization to optimize modularity.
2	Processes on networks for community detection: the infomap method
2	Community characterization by using node attributes
2	Bipartite networks and their projections
2	Statistically Validated Networks

Hrs	Practice
2	Network micro-motifs and their implications in the analysis of real complex networks: triadic closure and cliques in communication and criminal networks.
4	Diffusion on networks - simulation and comparison with SIR model prediction
3	Diffusion on networks with a controlled community structure (Lancichinetti model): simulation and comparison with SIR model prediction
4	Application of Infomap method to reveal communities (also hierarchically organized communities) in real complex networks.
5	Application of statistically validated networks to antifraud (high dimensional data)

MODULE
STOCHASTIC PROCESSES

Prof.ssa GIADA ADELFIO

SUGGESTED BIBLIOGRAPHY	
G. R. Grimmett, D. R. Stirzaker (2001). Probability and Random Processes (Third Edition). Oxford University Press. (capitoli 3, 4 e 6 - paragrafi 6.1-6.4, 6.7-6.9, capitoli 7, 8, 11- paragrafi 11.1 e 11.2, capitolo 12- paragrafi 12.1 e 12.4) Baddeley et al. (2015) Spatial Point Patterns: Methodology and Applications with R. Crc Press Dobrow R. (2016) Introduction to Stochastic Processes With R. John Wiley & Sons, Inc	
AMBIT	84542-Discipline Statistiche
INDIVIDUAL STUDY (Hrs)	108
COURSE ACTIVITY (Hrs)	42
EDUCATIONAL OBJECTIVES OF THE MODULE	
The course aims to provide a basic probabilistic preparation with the introduction of some useful concepts for the advanced use of probability theory and stochastic processes (SP) in discrete and continuous parameter, focusing on some of the most frequently exploited models in applied sciences. Therefore, at the end of the course, students should be able to apply the fundamental laws of the probability theory and to link them to the theory of SP. Moreover, students should be able to correctly define a SP, to distinguish between the different nature of a SP (discrete or continuous) and to understand their peculiarities and their possible applications. In particular they have to be able to get the main issues related to SPs (such as distributional properties, estimation, interpretation) and to understand also possible links among different processes, describing their main characteristics using R software	

SYLLABUS

Hrs	Frontal teaching
4	Introduction to stochastic processes: properties and definitions
6	Discrete Time Markov chains and properties
4	Discrete and Continuous MArtingales with applications
4	Continuous time Markov Chains and queue theory
2	Gaussian Processes and Brownian Motion
4	Spatio-temporal processes and Point Processes

Hrs	Practice
4	Markov Chains in R
4	Continuous time Markov Chains in R
2	Brownian Motion in R
4	Spatial and spatio-temporal processes
4	Point processes in R