UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Scienze Economiche, Aziendali e Statistiche
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	STATISTICS AND DATA SCIENCE
INTEGRATED COURSE	NUMERICAL ANALYSIS AND OPTIMIZATION - INTEGRATED COURSE
CODE	20667
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	SECS-S/06
HEAD PROFESSOR(S)	CONSIGLIO ANDREA Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	TUMMINELLO MICHELE Professore Ordinario Univ. di PALERMO CONSIGLIO ANDREA Professore Ordinario Univ. di PALERMO
CREDITS	6
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**CONSIGLIO ANDREA** Tuesday 12:00 13:00 Edificio 13, I piano, stanza 108; Building 13, I floor, room 108 Thursday 12:00 13:00 Edificio 13, I piano, stanza 108; Building 13, I floor, room 108 **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. ANDREA CONSIGLIO

PREREQUISITES	Vectors in R^n and their properties. Function of several variables. Matrix algebra. Differential and integral calculus. Gradient and Hessian of a function of several variables. Convexity of a function of several variables. First and second order condition of optimality. Elementary programming in R.
LEARNING OUTCOMES	1. Knowledge and understanding Definition and description of unconstrained and constrained optimization. Ability to Identify and discuss for convex, linear and quadratic optimization models. Definition and vector representation of discrete optimization problems. Ability to Identify and discuss the properties of a network. 2. Applying knowledge and understanding Ability to Implement a GAMS model to solve a an optimization model. Ability to analyze the properties of a network using R. 3. Making judgements Ability to analyse a real optimization problem and choice of the appropriate mathematical model. Ability to analyse a real optimization problem and choice of the appropriate method to search for solutions. Ability to analyze e real network by choosing the appropriate indicators and metrics. 4. Communication skills Present the results in professional way through pictures and spreadsheets. 5. Learning skills Conduct research and analysis in the field of decision science using optimization and network models
ASSESSMENT METHODS	The exam is made up by two parts related to the two modules of the course. As far as the optimization model is concerned, the exam consists in implementing an optimization model using the software GAMS. The exam will be performed on a computer. A score sufficient to pass the exam will be assigned to students who prove to be able to input data, display the input data and properly recognizes the endogenous and exogenous variables of the problem. Concerning the Network unit, the exam consists of developing a project on a real network, preparing a short report to describe the performe analysis, and an oral presentation of the results. The project is agreed by the student and the instructor. A score sufficient to pass is given to students that demonstrate the ability to describe the main characteristics and properties of the analyzed network, through the metrics proposed in the course. The final mark is the arithmetic mean of the marks obtained in the two parts.
TEACHING METHODS	Lectures and practices

MODULE OPTIMIZATION *Prof. ANDREA CONSIGLIO*	
SUGGESTED BIBLIOGRAPHY	
A. Consiglio, S. Nielsen and S.A. Zenios. Practical Financial Optimization. Wiley Finance, 2003. All chapters.	
AMBIT	50608-Matematico applicato
INDIVIDUAL STUDY (Hrs)	54
COURSE ACTIVITY (Hrs)	21
EDUCATIONAL OBJECTIVES OF THE MODULE	
At the end of the course the student will be able: 1) To define a constrained and unconstrained optimization problem 2) To determine the maxima and minima of constrained and unconstrained optimization problem 3) To distinguish between linear and nonlinear programming 4) To implement a GAMS model to solve an optimization problem 5) To represent decision problems through optimization models.	

SYLLABUS

Hrs	Frontal teaching
2	Presentation of the objectives of the course. Unconstrained optimization. First and second order condition.
2	Introduction to GAMS. Description of the GAMS IDE. Creation of project. SET statement. Enumeration of a SET. SET as indices. ALIAS statement. SCALAR statement declaration and assignment. The DISPLAY statement.
2	Data representation. Vectors, matrices and multidimensional arrays. The PARAMETER and TABLE statement.The GDX file. Input data from a GDX file. Aggregation operators: SUM, PROD, ORD, CARD, SMAX, SMIN. The $-statement.
2	The VARIABLE statement. The EQUATION statement. Scalar and vector equations. The MODEL statement. The SOLVE statement. Linear (LP) and non-linear (NLP) models.
2	Equality constrained optimization. First and second order condition. Convex optimization. Lagrangian problem. Duality and Lagrange Duality
2	Inequality constrained optimization. First and second order condition. SVM non-linear separation and with soft margin. The kernel trick. Polynomail kernel and radial basis function

Hrs	Practice
2	GAMS implementation of a non-linear regression model.
4	Implementation of a quadratic optimization models. The Mean-Variance portfolio model. Supervised classification through Support Vector Machine.
3	Optimization with absolute values. Transforming an absolute value. Quantile regression. Regression models with quadratic and LASSO penalization.

MODULE
NETWORKS

Prof. MICHELE TUMMINELLO

SUGGESTED BIBLIOGRAPHY	
M. Newman, Networks: An Introduction, Oxford University Press. D. Pham, D. Karaboga, Intelligent Optimisation Techniques, Springer. D. Easley and J. Kleinberg, Networks, Crowds and Markets, Cambridge.	
AMBIT	50608-Matematico applicato
INDIVIDUAL STUDY (Hrs)	54
COURSE ACTIVITY (Hrs)	21
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) analyze the convergence of an iterative and stochastic algorithm that provides suboptimal solutions to the modularity optimization problem; 4) understand the difference between accuracy and precision of a solution; 5) describe the role of communities in a realization of the SIR model.	

SYLLABUS

Hrs	Frontal teaching
2	An introduction to networks. Descriptive analysis: degree, betweenness centrality, page rank, clustering coefficient.
2	Degree distribution, scale-free networks, Albert-Barabasi model
2	Stochastic processes on networks. Mean-field models. The SIR model.
2	Community detection through modularity optimization
2	Simulated annealing, genetic algorithms, taboo search, and extreme optimization to optimize modularity.
2	The infomap method

Hrs	Practice
4	Application of simulated annealing and genetic algorithms to real examples of optimization problems (e.g. the traveller salesman problem)
5	R and C tools for modularity optimization.