UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Matematica e Informatica
ACADEMIC YEAR	2020/2021
MASTER'S DEGREE (MSC)	COMPUTER SCIENCE
SUBJECT	MATHEMATICAL METHODS AND MODELS FOR APPLICATIONS
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20903-Attività formative affini o integrative
CODE	05044
SCIENTIFIC SECTOR(S)	MAT/07
HEAD PROFESSOR(S)	SCIACCA VINCENZO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	94
COURSE ACTIVITY (Hrs)	56
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	MATHEMATICAL METHODS AND MODELS FOR APPLICATIONS - Corso: MATHEMATICS MATHEMATICAL METHODS AND MODELS FOR APPLICATIONS - Corso: MATEMATICA
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**SCIACCA VINCENZO** Thursday 15:00 18:00 Dipartimento di Matematica e Informatica, via Archirafi 34, Ufficio n° 216 (2° piano)

DOCENTE: Prof. VINCENZO SCIACCA

PREREQUISITES	Real functions of one and two real variables. Elementary functions. Limits, continuity and differentiabiity. Series of functions. Vector spaces. Linear algebras.
LEARNING OUTCOMES	Knowledge and Understanding: Being able to deduce, on the basis of examples taken from continuum mechanics in specific conditions, simple models of applied mathematics. Knowledge of analytical and numerical solutions of relevant biomathematical and physical models. Knowledge of numerical software for the simulation of evolutive models. Being able to read and comprehend advanced texts of Mathematics and research papers. Being able to produce original results in the realm of applied mathematics. Applying knowledge and understanding: Being able to apply the main techniques of qualitative analysis of partial differential equations whose mathematical structure is analogous to the one treated during the course. Being able to rigorously formalize problems and provide proofs adopting known techniques from the mathematical literature. Being able to numerically simulate the systems introduced during the course. The verification of the acquired capabilities is done trought both the active participation of the student to the lectures and laboratory sessions and through the elaboration of a project, realized individually or in group. Making judgments: The full comprehension of the fundamental topics and techniques introduced during the course will lead the student to being able to formulate conjectures about possible behaviors of the solutions to some of the most important equations of Mathematical Physics, and to foresee possible pathways to rigorously prove such conjectures. The student will also acquire tools and methodologies that will allow him to find solutions to problems arising in diverse and multidisciplinary contexts. Finally the student will be able to critically analyze scientific texts and to model and mathematically formalize new problems. The fulfillment of the learning outcomes is achieved through frontal lessons and through the preparation of seminars on arguments related to the topics covered during the course. Communication skills: The student will acquire the capability of introducing the construction of a mathematical model representing a real process, starting from basic principles and adopting the proper mathematical tools. The student will acquire the capability of expose, in a clear and rigorous way, the results coming from the qualitative and numerical analysis, adopting the proper specific lexicon of the discipline. Learning skills: The student will acquire the capability of contextualize his knowledge in multidisciplinary fields, being able to autonomously adapt his skills. The aim of the course is to give the student the possibility of accessing a large part of the scientific literature on applied mathematics and modeling, so to develop a flexible mindset that will ease pathways towards academic or applied research.
ASSESSMENT METHODS	The acquirement of the learning outcomes is verified through the final exam, that consists in the preparation of a project and in an oral exam. The final verification aims to estimate: the knowledge and the understanding of the student about the contents of the course; the competence of the student to apply this knowledge and understanding; if the student owns autonomy of judgments and suitable communication and learning skills. The final verification consists also of a project where the student has to understand and reproduce the results of a scientific paper whose subject is consistent with the arguments covered during the course and an oral examination. The evaluation of the project will be expressed on a scale of 30. During the oral examination the student should correctly answer to two/three questions based on all the contents of the course. Moreover, the student should critically discuss the presented project. The evaluation of the oral exam will be formulated on a scale of 30. The final evaluation will be based on both the project and the oral examination and will be computed as the arithmetic mean of the project and oral exam scores. It will be scaled according to the following conditions: a) does not possess an acceptable knowledge of the contents of the presented topics (not sufficient); b) minimal base knowledge of the contents of the course and of the technical language, modest ability to independently apply the acquired knowledge (18-20); c) not have full mastery of the main contents of the course but possesses knowledge, satisfactory property of language, acceptable ability to independently apply the acquired knowledge (21-23); d) knowledge of base treated contents, discrete property of language, with

	limited ability to independently apply the competence to solve the proposed problems (24-25); e) good mastery of the contents of the course, very good property of language, good competence in problem-solving (26-29); f) optimal knowledge of the contents of the course, optimal property of language, very good analytic abilities and competence in problem solving (30-30 with honors).
EDUCATIONAL OBJECTIVES	The educational objectives of the course are the understanding and knowledge of the following topics: 1) Derive partial differential equations, starting from balance laws describing ideal physical processes, such as: heat equation, transport equation, traffic models, Burgers equation, reaction equations- diffusion, the Fischer equation. 2) Give some hints on the classical theory of partial differential equations to prove the existence and regularity of their solutions. 3) Implementations of numerical finite difference and spectral method for their numerical resolution.
TEACHING METHODS	The course is organized in frontal lessons and laboratory sessions. During the frontal lessons all the contents of the course will be rigorously presented and analyzed. Through the laboratory sessions the students will acquire a better understanding of the presented topics and will numerically simulate the models introduced during the course.
SUGGESTED BIBLIOGRAPHY	Libri di testo (Textbooks): Holmes, Introduction to the Foundations of Applied Mathematics, Springer, 2009; Quarteroni, Modellistica Numerica per Problemi Differenziali, Springer 2006 Libri di consultazione (Reference books): Haberman, Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow (Classics in Applied Mathematics) , SIAM, 1998. Salsa, Equazioni a derivate parziali, Springer 2007 Evans, Partial differential equations, AMS Pub. 1998 Hestaven, S. Gottlieb, D. Gottlieb, Spectral Methods for Time Dependent Problems, Cambridge Monographs on Applied and Computational Mathematics 2007 Morton & Meyers, Numerical solution of Partial differential equations Cambridge University Press, 2005 Tveito & Whinther, Introduction to Partial differential equations: A computational approach, Springer 1998 Trefethen, Spectral Methods in Matlab, Cambridge University Press 2001

SYLLABUS

Hrs	Frontal teaching
12	Derivation of partial differential equations of parabolic, hyperbolic and reaction-diffusion type, starting from balance laws describing ideal physical processes. Analytical methods for the study of the existence and regularity of their solutions.
10	Numerical finite difference methods for the resolution of partial differential equations of parabolic, hyperbolic type and reaction-diffusion equations.
10	Fourier series and discrete Fourier transform. Fourier and Chebyshev spectral and pseudo-spectral methods for the numerical resolution of parabolic, hyperbolic partial differential equations and reaction-diffusion equations.

Hrs	Practice
12	Use of MATLAB software for the implementation of finite difference algorithms for the simulation of evolutionary problems of hyperbolic, parabolic and diffusion type of reaction.
12	Use of MATLAB software for the implementation of spectral methods algorithms for the simulation of evolutionary problems of hyperbolic, parabolic and diffusion type of reaction.