UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Fisica e Chimica - Emilio Segrè
ACADEMIC YEAR	2016/2017
BACHELOR'S DEGREE (BSC)	PHYSICS
INTEGRATED COURSE	MATHEMATICAL AND NUMERICAL METHODS FOR PHYSICS
CODE	16459
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	MAT/07
HEAD PROFESSOR(S)	REALE FABIO — Professore Ordinario — Univ. di PALERMO
OTHER PROFESSOR(S)	REALE FABIO — Professore Ordinario — Univ. di PALERMO FIORDILINO EMILIO — Cultore della Materia — Univ. di PALERMO
CREDITS	9
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	3
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**FIORDILINO EMILIO** Monday 13:00 14:00 Stanza di studio personale al secondo piano della sede di Via Archirafi 36 Thursday 13:00 14:00 Stanza di studio personale al secondo piano della sede di Via Archirafi 36 **REALE FABIO** Tuesday 12:30 14:30 Ufficio, Via Archirafi 36 Thursday 12:30 14:30 Ufficio, Via Archirafi 36

DOCENTE: Prof. FABIO REALE

PREREQUISITES	The prerequisites for profitable learning of numerical methods and achieve the objectives which it is intended are a basic knowledge of differential and matrix calculus, and of computer science, including C programming language. To profitably attend the part of mathematical methods the students must know the theory of complex and analytic functions and have practical experience of the integration by using the calculus of residues.
LEARNING OUTCOMES	Knowledge and understanding: Competence and basic management of numerical analysis topics. Knowledge and skills in the application to physical problems of the developed analytical tools. Applying knowledge and understanding: Design, implementation and testing of numerical algorithms in C programming. Evaluation of the areas of validity of methods and numerical errors. Creation and application of simple mathematical models to physical problems with particular attention to the accuracy of the procedure and of the solution. Making judgments: Acquisition of objective assessment tools through validation test programs. Assessment and selection of different numerical solutions according to the problem to be addressed. Reasoned assessment of the method of approach to mathematical problems. Communication skills: Acquisition of presentation skills through full answers to specific questions asked during the laboratory exercises. Clear and founded exposition of the problem to be solved, the assumptions made and the method used in the solution. Learning skills: Ability to apply computer science concepts in the practical implementation of algorithms and mathematical concepts in the elegant problem solving.
ASSESSMENT METHODS	The grading includes the independent intermediate assessments of the two modules, making an average of them. For the numerical part, the grading takes into account the outcome of laboratory exercises and an intermediate test at the end of the academic period. The mid-term test consists of a written test which is then discussed orally with the student. The test includes multiple choice, open and filling questions, and covers all of the topics covered in the course. The exercises test the application and managing of the methods and their results, especially with regard to uncertainties. The written test test the knowledge of the subjects in their theoretical and more critical aspects. The oral discussion allows the student to improve the weaknesses in the written test, with verification of the correct use of language and the ability of expression. The grades of the second module of the course are assigned through exams. For the aim of the module priority is given to the written solution of three problems on the topics of the course. The written material is corrected by the teacher and therefore discussed with the student. An oral session is not mandatory but may be required if sufficient information cannot be gathered for the final grade. The assessment criteria are shared with the module of numerical method. The grading will be given according to: 30-30 cum laude: Excellent knowledge of the topics, excellent use of language, good analytical ability, the student is able to apply the knowledge to solve problems proposed 26-29: Good mastery of the subjects, full use of the language, the student is able to apply knowledge to solve problems proposed 24-25: Basic knowledge of the main topics, discrete properties of language, with limited ability to independently apply the knowledge to the solution of the proposed problems 21-23: He/she does not have full mastery of the main issues but he/she has knowledge, satisfactory use of the language, poor ability to independently apply the knowledge acquired 18-20: Minimum basic knowledge of the main topics and the technical language, very little or no ability to independently apply the knowledge acquired Insufficient: He/she does not have an acceptable knowledge of the contents of the topics covered in the course
TEACHING METHODS	The teaching is divided into two modules, the first on numerical methods, the second on mathematical methods, sequentially one after the other, but independent one of the other. The module of numerical methods is half-year long and takes place in the first semester of the third year of the degree in Physical Sciences. The teaching

	activity develops through lessons and examples of application and programming of numerical methods. Five practice exercises are planned in the computer laboratory, covering different topics of the course: the student answers a numerical test by writing and running a program and providing the answers to the questions in a text file in which they discuss the results. The exercises are subject to individual grading. At the end of the academic period there is a written test with individual grading and multiple choice, open and filling questions. The test is then briefly discussed with the student, and then is given an intermediate grading valid for the one of the total course. The module of mathematical methods takes place in the second, final part, of the third year; its duration is shorter than the first module. The course is articulated into lessons and applications. Aim of the course is to give to the students the ability to solve common mathematical problems that are met in physics; thus attention is devoted to the application of the theory to problems of physical relevance. The level of understanding of the students is constantly monitored by requiring their participation to the problem solving.

MODULE
MATHEMATICAL METHODS FOR PHYSICS

Prof. EMILIO FIORDILINO

SUGGESTED BIBLIOGRAPHY

P. Dennery, A. Krzywicki: Mathematics for Physicists, Dover
K. F. Riley, M. P. Hobson, S. J. Bence: Mathematical methods for physics and engineering, (Cambridge)

AMBIT	10699-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	64
COURSE ACTIVITY (Hrs)	36

EDUCATIONAL OBJECTIVES OF THE MODULE

Aim of the modulus is to give to the student those analytical concept useful in the solution of problems of theoretical and numerical analysis of the physics.
The modulus consists of lessons and practical applications; the students will learn how to use the theory to solve those problems that are met in their study. Care is devoted to the complete solution of the problems.

SYLLABUS

Hrs	Frontal teaching
6	Multivalued complex functions. Branch cuts. Integration of multivalued functions. Analytical continuation. Conformal mapping.
6	Infinite dimensional vectorial spaces. Introduction to the Lebesgue theory of integration. Hilbert space. Classical orthogonal polynomials. 4 hours) Fourier series and transforms.
4	Fourier series and transforms.
4	Introduction to the theory of distribution,. Dirac delta function.
4	Introduction to the group theory. representation of groups Lie groups: SU(2) and SO(3).

Hrs	Practice
4	Integrations of multivalued complex functions making use of the calculus of residues.
4	Expansion of function in terms of classical orthogonal polynomials- Gibb's phenomenon
4	Fourier series expansion and Fourier transforms of functions; The uncertainty principle.

MODULE
NUMERICAL METHODS FOR PHYSICS

Prof. FABIO REALE

SUGGESTED BIBLIOGRAPHY	
- J. Murphy, D. Ridout, B. McShane, Numerical Analysis, Algorithms, and Computation, Ellis Horwood, 1988. - P.R. Bevington, D.K. Robinson, Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill, 1992. - A. Rea, An Introduction to Parallel Computing, The Queen's University of Belfast, 1995.	
AMBIT	10699-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	77
COURSE ACTIVITY (Hrs)	48
EDUCATIONAL OBJECTIVES OF THE MODULE	
The purpose of the module is to provide students with the skills and knowledge that make them able to autonomously tackle the main problems of numerical analysis applied to physics. The module consists of lectures and practical exercises on the computer, in which students solve a numerical problem through the development and execution of a program and the analysis of the results obtained. The laboratory exercises, carried out underway, concur for the final grading.	

SYLLABUS

Hrs	Frontal teaching
1	Introduction: numerical representation and truncation errors
5	Non-linear equations: simple iterative methods, sequence generating functions, test for convergence. Rate of convergence. Bisection method. Newton-Raphson method. Examples and programming.
5	Interpolation: notation and difference operators. Finite difference formulae. Examples and programming.
4	Numerical integration: Newton-Cotes and composite formulae. Trapezium rule. Simpson rule. Open integration. Examples and programming.
5	Differential equations: introduction, initial value problems, multi-step predictor-corrector methods. Starting methods. Accuracy of multi-step methods: truncation error, convergence, stability. Runge-Kutta single-step methods. Examples and programming.
5	Systems of linear equations: substitution method. Gauss elimination method. Pivoting. LU factorization method. Iterative methods. Examples and programming.
5	Monte Carlo methods: simulation concept, random and pseudo-random numbers. Transformation method. Look-up table method. Rejection method. Gaussian distributions methods, Box-Mueller method. Methods for Poisson and exponential distributions. Examples and programming.
2	Notes on parallel computing: concept, approaches: decomposition, shared or distributed memory. Speedup, efficiency, communication times. Notes on parallel programming with message passing (MPI)

Hrs	Workshops
3	Non-linear equations: laboratory exercise
3	Numerical integration: laboratory exercise
3	Differential equations: laboratory exercise
4	Systems of linear equations: laboratory exercise
3	Monte Carlo methods: laboratory exercise