SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babes-Bolyai University
1.2 Faculty	Physics
1.3 Department	Biomedical Physics, Theoretical Physics and Molecular Spectroscopy
1.4 Field of study	Physics
1.5 Study cycle	Master
1.6 Study programme / Qualification	Master Computational Physics

2. Information regarding the discipline

2.1 Name of the discipline	Symbolic Computation in Physics						
2.2 Course coordinator	dr. Alexandru Marcu (Lecturer)						
2.3 Seminar coordinator	dr. Alexandru Marcu (Lecturer)						
2.4. Year of study	**II**	2.5 Semester	**I**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**F**

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	14
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					28
Additional documentation (in libraries, on electronic platforms, field documentation)					28
Preparation for seminars/labs, homework, papers, portfolios and essays					28
Tutorship					14
Evaluations					14
Other activities:					-

3.7 Total individual study hours	112
3.8 Total hours per semester	154
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Physics Courses, Applied Informatics
4.2. competencies	• Software for analyzing and processing

5. Conditions (if necessary)

5.1. for the course	• Computer room, computers, appropriate software
5.2. for the seminar /lab activities	• Computer room, computers, appropriate software

6. Specific competencies acquired

Professional competencies	• Apply knowledge of physics and related fields in virtual experiments, using specialized software • Solving problems of modern physics, with imposed conditions, using specialized software tools and models • The development and the use of software and virtual instrumentation in solving various applications in physics and related fields • Interdisciplinary approach for theoretical and experimental physics projects • Using Mathematica package and skills in communicating with external programs
Transversal competencies	• Understanding and applying proper software to solve interdisciplinary problems • Capability in efficient use of information sources and data • Familiarize students with the type of applications in physics that can be addressed through academic software and initiate their research in more complex -simulation programs • Selection of the interest graduate research projects , understanding and application of specific packages, following the usage rules, linear approximations, interactive work with data files, graphics, numerical computation, etc.

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• Training skills needed to use SCMP (symbolic computational methods in physics) to solve research problems and to simulate physical phenomena • Interactive use of Mathematica
7.2 Specific objective of the discipline	• A new level of knowledge that would allow special applications • Master skills to develop and operate software packages that allow numerical calculations and simulations of fundamental processes in physics and related fields • Development of interdisciplinary directions

8. Content

8.1 Course	Teaching methods	Remarks
1. INTRODUCTION. General description of the basic concepts in symbolic calculus formalism. Mathematica and Maple Overview, Structure of Mathematica	Combined lecture, use blackboard and visual aids	2 hours
2. BASICS OPERATIONS on numbers, expressions and specific functions. Basic rules of Mathematica syntax	Combined lecture, use blackboard and visual aids	2 hours
3. NUMERICAL CALCULATIONS and Built-in functions, elementary algebra, defining and evaluating function,	Combined lecture, use blackboard and visual aids	2 hours
4. GRAPHING FUNCTIONS functions of a single Variable, Parametric and Polar plots, Parametric Curves and Surfaces Space, Solving Equations, Animations	Combined lecture, use blackboard and visual aids	2 hours
5. SPECIAL FUNCTIONS (Airy, Bessel, Laguerre, Legendre, Hermite, Fresnel	Combined lecture, use blackboard and	4 hours

hypergeometric, erf, gamma, etc.), Orthogonal polynomials, inverse functions, elliptic functions, Green functions Integration	visual aids	
6. CALCULUS, limits, differential calculus, Integral calculus, series, multivariable calculus, Fourier series	Combined lecture, use blackboard and visual aids	2 hours
7. Lists and Tables, list operations, Manipulating lists, approximating lists with funcions,	Combined lecture, use blackboard and visual aids	2 hours
8. MATRICES AND VECTORS, Nested lists, Basic Computations with Matrices and Vectors, Linear Systems of Equations, Eigenvalues and Eigenvectors, Linear Programming	Combined lecture, use blackboard and visual aids	2 hours
9. ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS, first-order, Second-order and Higher-order Linear Equations, System of Equations, Some important Partial Differential Equations	Combined lecture, use blackboard and visual aids	4 hours
10. PROGRAMMING IN MATHEMATICA, Procedural programming, Modules, Functional Programming, Rule-Based Programming	Combined lecture, use blackboard and visual aids	2 hours
11. APPLICATIONS, Solving equations : mechanics (waves), electrodynamics (dipole-radiation), hydrodynamic (fluid flow ec.de), quantum (one-dimensional problems, Clebsch-Gordan coefficients), plasma (dispersioneq., KDV equation-solitons, ec . Bessel equation for MHD waves), TRR (Christoffel coefficients), statistics (distributions, averages, etc..), atomic physics (orbitals)	Combined lecture, use blackboard and visual aids	4 hours

Bibliography

1. *The student's Introduction to Mathematica*, Cambridge University Press, 1999
2. *Mathematica in Actio*", S.Wagon, Springer, Telos, 2000
3. *Computing with Mathematic*", M.H.Hoft, Academic Press, New York, 2002
4. *Mathematica Book*, S. Wolfram, , Cambridge University Press, 2003
5. *Numerical and Analytical Methods for Scientists and Engeneering Using Mathematica*, D. Dubin, Wiley-Interscience, 2003
6. *Numerical Methods Mathematica Notebooks*, John H. Mathews,Department of Mathematics California State University Fullerton, 2006, **http://math.fullerton.edu/mathews/**
7. *Mathematica for Theoretical Physic*", Gerd Baumann, Springer, 2005
8. *Mathematica by Example*, M.L.Abell. J.P. Braselton, Elsevier, 2009
9. *A Brief Introduction to Mathematica*, C.Moretti, Department of Mathematics, Oklahoma State Univ., 2006
10. *The Theory of Equations*, W.S. Burnside and A.W. Panton, S. Chand & Co., 1972.
11. *Seminumerical Algorithms*, D.E. Knuth, Second Edition, Addison-Wesley, 1981.
12. *Tables of LaplaceTransforms*, F.Oberhettinger, L. BadiiNew York: Springer-Verlag, 1973.
13. *Numerical Mathematics: Theory and Computer Applications*, E. Froberg, Benjamin/ Cummings, 1985

14. *A First Course in Numerical Analysis*, A. Ralston & P. Rabinowitz, (2nd. ed.), McGraw-Hill, New York, 1978

15. *The Numerical Analysis of Ordinary Differential Equations: Runge-Kutta and General Linear Methods*, John C. Butcher: John Wiley &Sons, New York, 1987

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Running Mathematica, Numerical calculations, , numerical capabilities, basic numerical calculations, exact arithmetic, precision, clearing variables, iterators , symbolic computation, algebraic and trigonometric calculations, some intrinsic functions	heuristic conversation, individual and group topics, specific software packages	2 hours
2. Calculus, limits, differential calculus, Integral calculus, power series, multivariable calculus, matrices and vectors,complex arithmetic	heuristic conversation, individual and group topics, specific software packages	2 hours
3. Working with data, lists,manipulating lists, approximating lists with functions, tables, defining and evaluating functions, solving equations and linear system of equations, eigenvelues and eigenvectors	heuristic conversation, individual and group topics, specific software packages	2 hours
4. Graphics, simple plot, parametric plots, contour and density plots, 3D plots, animation, input and output control	heuristic conversation, individual and group topics, specific software packages	1 hours
5. Ordinary and partial differential equations, special functions (Airy, Bessel, Laguerre, Legendre, Hermite, Fresnel hypergeometric, erf, gamma, etc.), Fourier series and transforms	heuristic conversation, individual and group topics, specific software packages	2 hours
6. Loading Packages, Programming in mathematica, Procedural programming, Modules, Functional Programming, Rule-Based Programming,	heuristic conversation, individual and group topics, specific software packages	1 hours
7. Applications: Normal modes of a system of n masses (n=2,3,…,m), Gravitational fields, Electrostatics (potential of a ring, flat surface charge distribution), Magnetism (circular loop, current with general shape, solenoid, rotating charged spherical shell, rotating charged hollow cylinder), Fourier series (some applications), Nonlinear dynamical system (pendulum, time-independent Schrodinger equation, infinite potential well, finite potential well, harmonic oscillator, anharmonic oscillator), String dynamics: the wave equation (plucked string, traveling disturbances), Solution of the heat equation using separation of variables, Laplace equation in some separable geometries, etc	heuristic conversation, individual and group topics, specific software packages	4 hours

Bibliography

1. *Mathematica for Physics*, R.L. Zimmerman and F.I. Olness, Addison-Wesley, 2002 (2nd ed.)
2. *A Physicist's Guide to Mathematica* by P.T. Tam, Academic Press, 1997
3. Mathematica for Scientists and Engineers by R. Gass, Prentice Hall, 1998
4. *Mathematica by Example* by M.L. Abell and J.P. Braselton, Academic Press, 1997
5. ***Mastering Mathematica* by J.W. Gray, Academic Press, 1998 (2nd ed.)**

Useful links:

http://www.physics.umd.edu/courses/CourseWare/EssentialMathematica/

http://www.physics.umd.edu/courses/CourseWare/StatisticalPhysics/

http://www.physics.umd.edu/courses/CourseWare/MathematicalPhysics/

http://library.wolfram.com/

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- The course presents selected topics from the area of interest of the Masters degree candidates and emphasizes on applying the appropriate software packages. To this end, the course contains detailed usage instructions, explanations on linear approximations, interactive database manipulation, graphical representations, numerical calculus, etc. The Mathematica software is a technical programming environment, assuring means for numerical integration, symbolic calculation and graphics, thus being complementary to the conceptualizing of the problem. These concepts and means are gradually and systematically presented to the students in an interactive manner, allowing them to quickly solve problems in all natural sciences, e.g. physic, biology.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Research project	Oral examination	45%
	Continuous assessment	Tests (2)	30 %
10.5 Seminar/lab activities	Lab.Activity	Topics addressed, originality of the projects	25 %
10.6 Minimum performance standards			
➢ Using Mathematica to solve concrete theoretical physics applications and interdisciplinary issues ➢ Ability to develop a specific research master project			

Date ..... Signature of course coordinator . Lect.dr. Alexandru Marcu Signature of seminar coordinator .....

Date of approval .....

Signature of the head of department Prof.dr.Leontin David