SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeș-Bolyai University**
1.2 Faculty	**Faculty of Physics**
1.3 Department	**Department of Physics – Hungarian Line of Study**
1.4 Field of study	**Physics**
1.5 Study cycle	**Master**
1.6 Study programme / Qualification	**Computational physics / High Energy Physics**

2. Information regarding the discipline

2.1 Name of the discipline	**Methods of Stochastic Simulations in Statistical Physics. Interdisciplinary Applications / Monte Carlo Simulations in particle physics**						
2.2 Course coordinator	**Néda Zoltán**						
2.3 Seminar coordinator	**Lázár Zsolt**						
2.4. Year of study	1	2.5 Semester	2	2.6. Type of evaluation	E	2.7 Type of discipline	DF

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

3.1 Hours per week	5	Of which: 3.2 course	3	3.3 seminar/laboratory	2
3.4 Total hours in the curriculum	70	Of which: 3.5 course	42	3.6 seminar/laboratory	28

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	28
Additional documentation (in libraries, on electronic platforms, field documentation)	14
Preparation for seminars/labs, homework, papers, portfolios and essays	35
Tutorship	4
Evaluations	3
Other activities:	

3.7 Total individual study hours	84
3.8 Total hours per semester	154
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	
4.2. competencies	Statistical physics, C programming, elements of probability theory and mathematical statistics, logical thinking, interdisciplinary thinking, communication abilities in English, active participation at the courses and laboratories

5. Conditions (if necessary)

5.1. for the course	Video projector, blackboard
5.2. for the seminar /lab activities	Computers with Linux operating system, Video projector

6. Specific competencies acquired

Specific competences	C1. Capacities for analyzing and synthetizing physical data, capacities for modelling complex phenomena. C2. Working and mastering with software packages for analyzing and processing experimental data. Using C, Python and Mathematica software for modelling complex phenomena. Capacities for using information technologies in describing complex phenomena from physics, biology, chemistry and social sciences. Advanced programming techniques. C3. Trans- and Interdisciplinary thinking. C4. Planning and Performing computer experiments for validating physical models. Abilities for making high performance computations in physics. Capacities for writing computer codes and running them on modern supercomputers. C5. Communicating efficiently modern scientific ideas. Presenting in a professional manner results of a research or scientific projects. Capacities for writing scientific publications, to interact and have a scientific debate with Editors and Referees. Capacities for arguing and defending scientific views and ideas.
Transversal competences	CT1. To deal with professional duties efficiently and in a responsible manner, keeping in mind the laws and scientific ethics. Being responsible for the published scientific results and taking all actions for their proper use. CT2. Working in an Interdisciplinary environment respecting the professional hierarchy. Having initiative, new ideas and approaches to classical problems. Promoting the dialogue, cooperation and positive attitude in a group. Respecting multicultural environment and helping the others. CT3. Efficient use of information technology tools and presentation methods in English. Learning and applying auto evaluation methods, f or keeping the professional training up to date, in agreement with the demands of the market.

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

7.1 General objective of the discipline	• A rigorous introduction in MC simulation methods, oriented on interdisciplinary applications.
7.2 Specific objective of the discipline	• Mastering stochastic simulation methods and physical modelling. • Learning to approach modern problems in an interdisciplinary manner. • Using classical models of physics in approaching interdisciplinary problems. • Advance programming in C and C++. • An introduction to scientific research.

8. Content

8.1 Course	Teaching methods	Remarks
Computer simulation techniques – an overview Examples of MC simulations Random number generators Elements of Statistical Physics, Stochastic Processes and Critical Phenomena Brownian dynamics Monte Carlo The Ising model Metropolis and Glauber MC for the Ising The BKL or kinetic MC Cluster MC The histogram MC method and the microcanonical MC method Quantum Monte Carlo methods MC simulation of Frustrated Systems Interdisciplinary application of the MC methods	Problem formulation Presentation Demonstartations Software packages Discutions Movies	

Bibliography

1. Z. Neda: Stochastic simulations in physics with interdisciplinary applications, http://www.phys.ubbcluj.ro/~zneda/edu/mc.htm
2. Z. Ned: Stochasztikus szimulacios modszerek a fizikaban (Erdelyi Tankonyvtanacs, 1998), accesibil in numar mare la biblioteca Facultăţii de Fizică
3. H. Gould and J. Tobochnik Introduction to Computer Simulation Methods and applications in physics (Addison Wesley, 1996).
4. A. MacKinnon: Computational Physics online course http://b.sst.ph.ic.ac.uk/~angus/Lectures/compphys/compphys.html
5. F. Bagnoli: Introduction to Cellular Automata (cond-mat/9810012; arxiv.org, 1998)
6. David Landau and Kurt Binder: A guide to Monte Carlo Simulations in Statistical Physics, Cambridge Univ. Press, 2004

8.2 Laboratory	Teaching methods	Remarks
Organization aspects. The C programming language, some basic facts. Linux operational system, some basic facts	Explanations Presentations Discussions	
Research projects. Scientific papers that will be discussed. Computational study of the random walk.	Problem formulation	
Programming the projects and presentations. Computational study of phase transition in a two-state interacting systems.	Individual work	
Working of pseudo-random number generators. Testing the pseudo-random number generators.	Programming	
Generating random numbers with nonuniform distribution. Discussing novel scientific works related to Monte Carlo methods.		
Studying the Brownian dynamics. Studying stohastic resonance with molecular dynamics. Discussing novel scientific works related to Monte Carlo methods.		
The Monte Carlo integration with direct and importance sampling. Calculating the number PI with MC methods. Individual discussions with the students on their chosen research projects.		
Computational study of the 2D and 3D Ising model. Discussing novel scientific works related to Monte Carlo methods. Individual discussions with the students on their chosen research projects.		
Finite-size effects in the MC studies of the Ising model. Discussing novel scientific works related to Monte Carlo methods. Individual discussions with the students on their chosen research project.		
Simulating the Potts model with q states at low temperatures (the BKL Monte Carlo method). Simulationg the dynamics of atoms deposited on surfaces. Discussing novel scientific works related to Monte Carlo methods. Individual discussions with the students on their chosen research project.		
Studying 2D and 3D Ising models with the Swendsen and Wang and Wolf dynamics. Discussing novel scientific works related to Monte Carlo methods. Individual discussions with the students on their chosen research project.		
Studying 2D and 3D Ising problems with the histogram MC method. The microcanonical MC method. Discussing novel scientific works related to Monte Carlo methods. Individual discussions with the students on their chosen research project.		
Presentation of individual research projects.		

References

Z. Neda: Stochastic simulations in physics with interdisciplinary applications, http://www.phys.ubbcluj.ro/~zneda/edu/mc.htm

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 syllabus and the studied material agree with similar courses from other universities in Romania and abroad. For helping the integration with the demands of the work-force market, the syllabus was harmonized with the demands of the pre-university and university educations, of those of research institutes and the business sector.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	Knowledge, understanding and capacity of application of the thought material	Exam	55%
10.5 Seminar/lab activities	Homework, lab activity	Continuous evaluation	25%
	Realization degree and presentation of the research project	Oral presentation	20%
10.6 Minimum performance standards			
Understanding the methods presented at the course and laboratory. Addressing the laboratory requirements in proportion of at least 75%. Successful Developing a project of medium complexity.			

Date	Signature of course coordinator	Signature of laboratory coordinator
04.05.2023	prof. dr. Zoltán Néda	lect. dr. Zsolt-Iosif Lázár

Date of approval	Signature of the head of department
11.05.2023	conf. dr. Ferenc Járai-Szabó