SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	**Babeş-Bolyai University**
1.2 Faculty	**Faculty of Mathematics and Computer Science**
1.3 Department	**Department of Mathematics**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Master**
1.6 Study programme / Qualification	**High Performance Computing and Big Data Analysis**

2. Information regarding the discipline

2.1 Name of the discipline	**Statistical Computational Methods**						
2.2 Course coordinator	**Assoc. Prof. PhD. Habil. Sanda Micula**						
2.3 Seminar coordinator	**Assoc. Prof. PhD. Habil. Sanda Micula**						
2.4. Year of study	**2**	2.5 Semester	**3**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**Optional**

2.8 Course Code	MME8088	

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	41
Additional documentation (in libraries, on electronic platforms, field documentation)	15
Preparation for seminars/labs, homework, papers, portfolios and essays	35
Tutorship	19
Evaluations	23
Other activities:	-

3.7 Total individual study hours	133
3.8 Total hours per semester	175
3.9 Number of ECTS credits	7

4. Prerequisites (if necessary)

4.1. curriculum	• Probability and Statistics
4.2. competencies	• Logical thinking • Average logical programming skills

5. Conditions (if necessary)

5.1. for the course	• Lecture room with large blackboard and video projector, laptop, beamer
5.2. for the seminar /lab	• For seminar: Laboratory with computers having Matlab installed

6. Specific competencies acquired

Professional competencies	C4.3 Identifying the appropriate models and methods for solving real-life problems C4.4 Using simulations in order to study and elaborate models and evaluate their performance
Transversal competencies	CT1 Ability to conform to the requirements of organized and efficient work, to develop a responsible approach towards the academic and scientific fields, in order to make the most of one's own creative potential, while obeying the rules and principles of professional ethic CT3 Using efficient methods and techniques for learning, information, research and developing capabilities for using knowledge, for adapting to a dynamic society and for communicating in Romanian and in a worldwide spoken language

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

7.1 General objective of the discipline	• Acquire basic knowledge of Probability Theory and Mathematical Statistics applications and models
7.2 Specific objective of the discipline	• Ability to use Monte Carlo methods and simulations for solving real-life problems and perform statistical analysis of data • Become familiar and be able to work with various probabilistic and statistical models • Ability to use statistical features of various mathematical software

8. Content

8.1 **Course**	Teaching methods	Remarks
1. **Review of Probability and Statistics**. Probability space. Rules of probability. Conditional probability. Probabilistic models. Random variables and random vectors.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
2. Common discrete and continuous distributions. PDF and CDF. Examples, applications, properties.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
3. Random samples. Sample functions. Estimators. Confidence intervals. Hypothesis and significance testing.	• Interactive exposure • Explanation • Conversation	
4. **Computer simulations and Monte Carlo methods**. MC methods and random number generators. Discrete methods. Examples.	• Interactive exposure • Explanation • Conversation • Description	
5. Inverse transform and discrete inverse transform method. Rejection method. Special methods. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	

6. Accuracy of an MC study. Estimating probabilities, means, variances. Size of an MC study. Other applications of MC methods.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
7. **Stochastic processes**. Definitions, classifications. Markov processes and Markov chains. Transition probability matrix. Properties, examples.	• Interactive exposure • Explanation • Conversation • Description	
8. Steady-state distribution. Regular Markov chains. Periodic Markov chains. Simulation of Markov chains.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
9. Counting processes. Binomial and Poisson counting processes. Gamma-Poisson formula. Simulation of counting processes. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
10. **Queuing systems**. Basic notions, main components, Little's law. Bernoulli single-server QS. Systems with limited capacity.	• Interactive exposure • Explanation • Conversation	
11. M/M/1 QS. Evaluation of a system's performance. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
12. Multiserver QS's. Bernoulli k-server and M/M/k QS's. M/M/∞ QS's. Simulation of QS's.	• Interactive exposure • Explanation • Conversation	
13. **Statistical inference**. Nonparametric tests, Chi-square-tests, Wilcoxon tests. Bootstrapping. Applications, examples, simulations.	• Interactive exposure • Explanation • Conversation • Description	
14. Regression and correlation. Fitting models. Analysis of variance (ANOVA), prediction. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	

Bibliography

1. Micula, S., Probability and Statistics for Computational Sciences, Cluj University Press, 2009.
2. Baron, M., Probability and Statistics for Computer Scientists, CRC Press, Taylor and Francis, Boca Raton, FL, 2014.
3. Milton, J.S., Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 3rd Edition. McGraw-Hill, New York, 1995.
4. Gentle, J. E., Elements of Computational Statistics, Springer-Verlag, New York, 2002.
5. Matloff, N., From Algorithms to Z-Scores: Probabilistic and Statistical Modelling in Computer Science, Orange Grove Texts Plus, Gainesville, FL, 2009.
6. Gentle, J. E., Hardle, W., Mori, Y., Handbook of Computational Statistics, Springer, Heidelberg, 2004.

8.2 **Seminar /Laboratory**	Teaching methods	Remarks
1. Random variables and applications.	• Interactive exposure • Explanation • Conversation	The seminar is structured as 2 hours per week, every other week
2. Computer simulations of discrete random variables. Discrete methods.	• Interactive exposure • Explanation	

	• Conversation • Individual and group work	
3. Computer simulations of random variables and Monte Carlo studies. Inverse transform method, rejection method, special methods.	• Interactive exposure • Conversation • Synthesis • Individual and group work	
4. Markov chains. Applications and simulations.	• Interactive exposure • Explanation • Conversation • Individual and group work	
5. Counting processes. Bernoulli and Poisson counting processes. Applications and simulations.	• Interactive exposure • Explanation • Conversation • Individual and group work	
6. Queuing systems. Examples and simulations.	• Interactive exposure • Explanation • Conversation • Individual and group work	
7. Statistical inference. Applications and simulations.	• Interactive exposure • Explanation • Conversation • Description • Individual and group work	

Bibliography

1. Baron, M., Probability and Statistics for Computer Scientists, CRC Press, Taylor and Francis, Boca Raton, FL, 2014.
2. Blaga, P., Statistica prin Matlab, Presa Universitara Clujeana, Cluj-Napoca, 2002.
3. Lisei, H., Micula, S., Soos, A., Probability Theory trough Problems and Applications, Cluj University Press, 2006.
4. Milton, J.S., Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 3rd Edition. McGraw-Hill, New York, 1995.
5. Gentle, J. E., Elements of Computational Statistics, Springer-Verlag, New York, 2002.
6. Matloff, N., From Algorithms to Z-Scores: Probabilistic and Statistical Modelling in Computer Science, Orange Grove Texts Plus, Gainesville, FL, 2009.

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 gives students solid statistical background for computational intelligence.
- The knowledge and skills acquired in this course give students a foundation for launching a career in scientific research.
- The statistical analysis abilities acquired in this course are useful in any career path students may choose.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	- acquire the basic principles in Computational Statistics, with emphasis on simulations and Monte Carlo studies; - be able to apply correctly the course concepts on various applications and problem solving	**Written exam** on problems only (a sheet with the main formulas is available)	60%
10.5 Seminar/Lab activities	- be able to apply course concepts and techniques on practical problems - be able to implement course concepts and algorithms in Matlab - be able to solve numerical statistical problems in Matlab	- participation in discussing, solving and implementing problems throughout the semester - individual presentation of solutions - **lab exam** (numerical statistical applications and simulations)	40%
10.7 Minimum performance standards			
➢ A grade of 5 or above (on a scale from 1 to 10) on **<u>each</u>** activity mentioned above (written test, seminar/lab evaluation)			

Date	Signature of course coordinator	Signature of seminar coordinator
11.04.2021	Assoc. Prof. PhD. Habil. Sanda Micula	Assoc. Prof. PhD. Habil. Sanda Micula

Date of approval

.....

Signature of the head of department

.....….....