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 Computer Science**
1.4 Field of study	**Computer Science**
1.5 Study cycle	**Bachelor**
1.6 Study programme / Qualification	**Computer Science**

2. Information regarding the discipline

2.1 Name of the discipline	**Probability Theory and Statistics**						
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	**Compulsory**

2.8 Course Code	MLE0031	

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

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	1 sem + 1 lab
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	25
Additional documentation (in libraries, on electronic platforms, field documentation)	15
Preparation for seminars/labs, homework, papers, portfolios and essays	25
Tutorship	9
Evaluations	20
Other activities:	-

3.7 Total individual study hours	94
3.8 Total hours per semester	150
3.9 Number of ECTS credits	6

4. Prerequisites (if necessary)

4.1. curriculum	• Mathematical Analysis • Algebra
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

5.2. for the seminar /lab activities	• For seminar: room with large blackboard • For lab: Laboratory with computers having Matlab installed

6. Specific competencies acquired

Professional competencies	C4.1 Defining basic concepts, theory and mathematical models C4.2 Interpretation of mathematical models C4.3 Identifying the appropriate models and methods for solving real-life problems C4.5 Embedding formal models in applications from various areas
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, with main focus on applications
7.2 Specific objective of the discipline	• Become familiar and be able to work with various probabilistic and statistical models • Ability to perform statistical analysis of data • Ability to use statistical features of various mathematical software

8. Content

8.1 **Course**	Teaching methods	Remarks
1. Experiments, events, field of events, operations with events. Axiomatic definition of probability. Poincaré's formula. Classical definition of probability.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
2. Conditional probability. Independent events. Total probability formula. Classical probabilistic models (Binomial, Hypergeometric, Poisson, Pascal, Geometric).	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
3. Random variables and random vectors. Discrete random variables. Probability distribution function. Cumulative distribution function. Properties, examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
4. Discrete probability laws (Bernoulli, Binomial, Hypergeometric, Poisson, Negative Binomial, Geometric). Discrete random vectors. Operations with discrete random variables.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
5. Continuous random variables. Probability density function. Continuous probability	• Interactive exposure	

laws (Uniform, Normal, Gamma, Exponential, Chi-square, Student, Fisher). Independent random variables. Functions of continuous random variables.	• Explanation • Conversation • Didactical demonstration	
6. Numerical characteristics of random variables. Expectation. Variance. Moments (initial, central, absolute). Covariance and correlation coefficient. Quantile, median, quartiles. Inequalities (Markov, Chebyshev).	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
7. Stochastic processes. Markov chains. Transition probability matrix. Steady-state distribution. Regular Markov chains. Periodic Markov chains. Examples	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
8. Descriptive statistics. Data collection. Graphical display of data. Frequency distribution and histograms. Parameters of a statistical distribution. Measures of central tendency. Measures of variation. Correlation and regression. Linear regression.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	Video projector presentation
9. Sample theory. Samples. Sample functions (sample mean, sample variance, sample moments). Confidence intervals for estimating the population mean and the population variance. Confidence intervals for comparing two population means and two population variances.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
10. Estimation theory. Properties of point estimators. Unbiased and minimum variance estimators. Standard error. Likelihood function. Fisher's information. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
11. Absolutely correct estimators. The Rao-Cramer inequality. Efficient estimators. Methods of estimation. The method of moments estimator, the method of maximum likelihood estimator. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demosntration	
12. Hypothesis testing. Rejection region. Type I errors. Significance testing and P-values. The Z-test for the mean. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
13. The T (Student)-test for the mean. The Chi-square-test for the variance. The F-test for the ratio of variances. Tests for the difference of means. Examples. Robust tests.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
14. Type II errors and the power of a test. Most powerful tests and the Neyman-Pearson lemma. Uniformly most powerful tests. 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. Blaga, P., Calculul probabilitatilor si statistica matematica. Vol. II. Curs si culegere de probleme, Universitatea "Babes-Bolyai" Cluj-Napoca, 1994.
5. Feller, W., An introduction to probability theory and its applications, Vol. 1, 3rd edition, WSE Wiley, New York, 2008.
6. DeGroot, M. H., Schervish, M. J., Probability and Statistics, Addison-Wesley, Boston, 2012.

8.2 **Seminar**	Teaching methods	Remarks
1. Euler's Functions; Properties. Counting, Outcomes, Events.	• Interactive exposure • Explanation • Conversation	The seminar is structured as 2 hours per week, every other week
2. Classical Probability; Rules of Probability; Conditional Probability; Independent Events.	• Interactive exposure • Explanation • Conversation • Individual and group work	
3. Probabilistic models.	• Interactive exposure • Conversation • Synthesis • Individual and group work	
4. Discrete random variables and discrete random vectors.	• Interactive exposure • Explanation • Conversation • Individual and group work	
5. Continuous random variables and continuous random vectors.	• Interactive exposure • Explanation • Conversation • Didactical demonstration • Individual and group work	
6. Numerical characteristics of random variables.	• Interactive exposure • Explanation • Conversation • Didactical demonstration • Individual and group work	
7. Inequalities; Central Limit Theorem; Markov Chains; Point Estimators.	• Interactive exposure • Explanation • Conversation • Didactical demonstration • Individual and group work	
8.3 **Laboratory**	Teaching methods	Remarks
1. Introduction to Matlab.	• Interactive exposure • Explanation • Conversation • Individual and group work	The lab is structured as 2 hours per week, every other week
2. Discrete random variables; Probability distribution function; Command PDF in Matlab.	• Interactive exposure • Explanation • Conversation	

	• Individual and group work	
3. Continuous random variables; Probability density function; CDF and Inverse CDF.	• Interactive exposure • Explanation • Conversation • Individual and group work	
4. Numerical characteristics of random variables; Random number generators (command RND in Matlab); Computer simulations of discrete random variables.	• Interactive exposure • Synthesis • Conversation • Individual and group work	
5. Descriptive Statistics; Statistical measures; Correlation and regression; Confidence intervals for means and variances.	• Interactive exposure • Explanation • Conversation • Individual and group work	
6. Hypothesis and significance testing for means and variances.	• Interactive exposure • Explanation • Conversation • Individual and group work	
7. Overview of statistical methods.	• Interactive exposure • Explanation • Conversation • Individual work	

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. Blaga, P., Statistica prin Matlab, Presa Universitara Clujeana, Cluj-Napoca, 2002.
4. Lisei, H., Micula, S., Soos, A., Probability Theory trough Problems and Applications, Cluj University Press, 2006.
5. 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.

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 follows the ACM and IEEE Curriculum Recommendations for Computer Science majors;
- The course exists in the studying program of all major universities in Romania and abroad;
- 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 Probability	Written exam on problems only (a sheet with the main	50%

	Theory and Mathematical Statistics; - be able to apply correctly the course concepts on various applications - problem solving	probabilistic and statistical formulas is available)	
10.5 Seminar activities	- be able to apply course concepts and techniques on practical problems - be able to choose and apply the right probabilistic or statistical model to various practical problems - problem solving	- participation in discussing and solving problems throughout the semester - additional documentation - individual presentation of solutions - solving bonus problems	25%
10.6 Lab activities	- be able to implement course concepts and algorithms in Matlab - be able to solve numerical statistical problems in Matlab	- participation in discussing and solving problems throughout the semester - lab exam (numerical statistical applications)	25%
10.7 Minimum performance standards			
➢ A grade of 5 or above (on a scale from 1 to 10) on **each** of the three activities mentioned above (written test, seminar evaluation, lab evaluation)			

Date	Signature of course coordinator	Signature of seminar coordinator
14.04.2022	Assoc. Prof. PhD. Habil. Sanda Micula	Assoc. Prof. PhD. Habil. Sanda Micula

Date of approval

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Signature of the head of department

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