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 and Information Technology**
1.5 Study cycle	**Bachelor**
1.6 Study programme / Qualification	**Information Engineering**

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 DF**

2.8 Course Code	MLE0090	

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

3.1 Hours per week	4	Of which: 3.2 course	3	3.3 seminar/laboratory	1 LP
3.4 Total hours in the curriculum	56	Of which: 3.5 course	42	3.6 seminar/laboratory	14

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	22
Additional documentation (in libraries, on electronic platforms, field documentation)	18
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	• For lab: Laboratory with computers having Matlab installed

activities	

6. Specific competencies acquired

Professional competencies	C1.1 Recognizing and describing specific concepts to calculability, complexity, programming paradigms and modeling of computing and communication systems C1.2 Using specific theories and tools (algorithms, schemes, models, protocols, etc.) for explaining the structure and the functioning of hardware, software and communication systems C1.3 Building models for various components of computing systems C1.5 Providing theoretical background for the characteristics of the designed systems
Transversal competencies	CT1 Honorable, responsible, ethical behavior, in the spirit of the law, to ensure the professional reputation CT3 Demonstrating initiative and pro-active behavior for updating professional, economical and organizational culture knowledge

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 laws (Uniform, Normal, Gamma, Exponential, Chi-square, Student, Fisher). Independent random variables. Functions of continuous random variables.	• Interactive exposure • 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	
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. 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. Blaga, P., Statistica prin Matlab, Presa Universitara Clujeana, Cluj-Napoca, 2002.
6. Feller, W., An introduction to probability theory and its applications, Vol. 1, 3rd edition, WSE

Wiley, New York, 2008.
7. DeGroot, M. H., Schervish, M. J., Probability and Statistics, Addison-Wesley, Boston, 2012.

8.2 **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 Information Engineering students;

- 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 Theory and Mathematical Statistics; - be able to apply correctly the course concepts on various applications - be able to apply course concepts and techniques on practical problems - problem solving	Written exam on problems only - participation in discussing and solving problems throughout the semester - additional documentation - solving bonus problems	50% 25%
10.5 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 lab problems throughout the semester - lab test (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, participation, lab evaluation)			

Date	Signature of course coordinator	Signature of laboratory coordinator
14.05.2022	Assoc. Prof. PhD. Habil. Sanda Micula	Assoc. Prof. PhD. Habil. Sanda Micula

Date of approval

24.05.2022

Signature of the head of department