SYLLABUS

Probability and Statistics

University year 2025-2026

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**
1.7 Form of education	**Full-Time**

2. Information regarding the discipline

2.1 Name of the discipline	**Probability and Statistics**			Discipline code		**MLE0031**	
2.2 Course coordinator	**Prof. Sanda Micula, PhD. Habil.**						
2.3 Seminar coordinator	**Prof. Sanda Micula, PhD. Habil.**						
2.4. Year of study	**2**	2.5 Semester	**3**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**DF Compulsory**

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 for individual study (ID) and self-study activities (SA)					hours
Learning using manual, course support, bibliography, course notes (SA)					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 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 and standard deviation. Median. Moments (initial, central, absolute).	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
7. Quantiles. Covariance and correlation coefficient. Inequalities (Markov, Chebyshev). Central limit theorem.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
8. Descriptive statistics. Data collection. Graphical display of data. Frequency distribution, histograms, stem-and-leaf plots. Parameters of a statistical distribution. Measures of central tendency.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
9. Measures of variation. Correlation and regression. Linear regression, least squares estimation.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
10. Statistical inference. Sample theory. Samples. Sample functions (sample mean, sample variance, sample moments). Estimation theory, basic notions. Confidence intervals for estimating the population mean and the population variance.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
11. Confidence intervals for comparing two population means and two population variances. Hypothesis testing, basic notions. Rejection region. Type I errors. Significance testing and P-values.	• Interactive exposure • Explanation • Conversation • Didactical demosntration	
12. Tests for the parameters of one population Tests for comparing the parameters of two populations. Examples. Robust tests. Summary of hypothesis testing.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
13. Properties of point estimators. Unbiased and minimum variance estimators. Fisher's information. Absolutely correct estimators. The Rao-Cramer inequality. Efficient estimators. Methods of estimation (method of moments, method of maximum likelihood). Examples.	• 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, 3rd edition, CRC Press, Taylor and Francis, Boca Raton, FL, 2019.
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. 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. Estimating probability by computer simulations.	• Interactive exposure • Explanation • Conversation • Individual and group work	
3. Discrete random variables. PDF and CDF.	• Interactive exposure • Explanation • Conversation • Individual and group work	
4. Continuous random variables. PDF, CDF and Inverse CDF.	• Interactive exposure • Synthesis • Conversation • Individual and group work	
5. Descriptive Statistics. Statistical measures. Correlation and regression.	• Interactive exposure • Explanation • Conversation • Individual and group work	

6. Confidence intervals and tests for the mean and variance.	• Interactive exposure • Explanation • Conversation • Individual and group work	
7. Confidence intervals and tests for the difference of means and ratio of variances.	• 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, 3rd edition, CRC Press, Taylor and Francis, Boca Raton, FL, 2019.
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 Theory and Mathematical Statistics; - be able to apply correctly the course concepts on various applications	**Written exam**	**70%**
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	- participation in discussing and solving problems throughout the semester - additional documentation - individual presentation of solutions - solving bonus problems	**15%**
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 - individual presentation of solutions	**15%**
10.7 Minimum performance standards			
➢ A grade of 5 or above (on a scale from 1 to 10) on **<u>each</u>** of the three activities mentioned above (written test, seminar evaluation, lab evaluation)			

11. Labels ODD (Sustainable Development Goals)[1]

	General label for Sustainable Development							
								

Date	Signature of course coordinator	Signature of seminar coordinator
29.04.2025	Prof. Sanda Micula, PhD. Habil.	Prof. Sanda Micula, PhD. Habil.

Date of approval

Signature of the head of department

Prof. dr. Andrei Mărcuș

[1] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable.*".