SYLLABUS

Mathematical Statistics

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	Babeș-Bolyai University
1.2. Faculty	Mathematics and Computer Science
1.3. Department	Mathematics
1.4. Field of study	Mathematics
1.5. Study cycle	Bachelor
1.6. Study programme/Qualification	Mathematics and Computer Science
1.7. Form of education	Full-time

2. Information regarding the discipline

2.1. Name of the discipline	**Mathematical Statistics**					Discipline code	**MLE0030**
2.2. Course coordinator				Dr Oana-Andrea Lang			
2.3. Seminar coordinator				Dr Oana-Andrea Lang			
2.4. Year of study	3	2.5. Semester	5	2.6. Type of evaluation	E	2.7. Discipline regime	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)					19
Additional documentation (in libraries, on electronic platforms, field documentation)					17
Preparation for seminars/labs, homework, papers, portfolios and essays					15
Tutorship					8
Evaluations					10
Other activities:					-
3.7. Total individual study hours	**69**				
3.8. Total hours per semester	**125**				
3.9. Number of ECTS credits	**5**				

4. Prerequisites (if necessary)

4.1. curriculum	Probability Theory, Mathematical Analysis
4.2. competencies	Logical thinking, Average logical programming skills in Python

5. Conditions (if necessary)

5.1. for the course	Classroom with blackboard/video projector
5.2. for the seminar /lab activities	For seminar: room with large blackboard For lab: laboratory with computers having Python installed

6.1. Specific competencies acquired [1]

Professional/essential competencies	C1.1 Identifying basic concepts, describing theory and using specific language. C3.2 Interpretation of data and explaining the appropriate steps for solving problems by algorithms.
Transversal competencies	CT3 Using efficient methods and techniques for learning, information, research and developing capabilities for using knowledge, for adapting to a dynamic society.

6.2. Learning outcomes

Knowledge	The student knows: • fundamental notions related to Mathematical Statistics and methods of applying them to areas of science related to Mathematics, Mechanics and Engineering. • how to use at least a programming and editing environment to create attractive mathematical texts with formulas, diagrams and images.
Skills	The student is able to • ensure the formation of skills specific to the Mathematics-related disciplines needed to complete the assignments. • explore some mathematical content independently, drawing on ideas and tools from previous coursework to extend their understanding.
Responsibility and autonomy:	The student has the ability to work independently to • extend mathematical ideas and arguments from previous coursework to a mathematical topic not previously studied. • interpret articles or books from the mathematical literature and incorporate ideas and results from the literature in their written and oral presentations.

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

7.1 General objective of the discipline	• Acquire basic knowledge of Mathematical Statistics, with main focus on applications.
7.2 Specific objectives of the discipline	• Become familiar and be able to work with various statistical models and procedures. • Ability to perform statistical analysis of data. • Ability to use statistical features of various mathematical software.

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

8. Content

8.1 Course	Teaching methods	Remarks
1. Review of Probability Theory. 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. Descriptive Statistics. Data collection. Graphical display of data. Frequency distribution and histograms. Parameters of a statistical distribution. Measures of central tendency. Measures of variation.	Interactive exposure, explanation, conversation, didactical demonstration	
4. Correlation and regression. Correlation coefficient. Least squares estimation. Linear regression.	Interactive exposure, explanation, conversation, didactical demonstration	
5. Sample Theory. Samples. Sample functions: sample mean, sample variance, sample moments, sample distribution function, sample proportions, sample functions for two populations. Properties.	Interactive exposure, explanation, conversation, didactical demonstration	
6. Statistical Inference. Estimation theory, basic notions. Unbiased and minimum variance estimators. Standard error. Common unbiased estimators. Consistent estimators. Examples.	Interactive exposure, explanation, conversation, didactical demonstration	
7. Properties of point estimators. Likelihood function. Fisher's information. Absolutely correct estimators. Cramer-Raó Inequality. Efficiency and efficient estimators.	Interactive exposure, explanation, conversation, didactical demonstration	
8. Sufficient statistics, Raó-Blackwell Theorem. Complete statistics, Lehmann-Scheffé Theorem. Examples.	Interactive exposure, explanation, conversation, didactical demonstration	
9. Methods of estimation. The method of moments estimator, the method of maximum likelihood estimator. Examples.	Interactive exposure, explanation, conversation, didactical demonstration	
10. Confidence intervals. Basic concepts, general framework. Confidence intervals for estimating the population mean and the population variance. Confidence intervals for proportions. Selecting the sample size. Examples.	Interactive exposure, explanation, conversation, didactical demonstration	
11. Confidence intervals for comparing two population means and two population variances. Confidence intervals for comparing proportions. Examples.	Interactive exposure, explanation, conversation, didactical demonstration	
12. Hypothesis testing. Basic concepts, general framework. Rejection region. Type I errors. Significance testing and	Interactive exposure, explanation, conversation, didactical demonstration	

P-values. The Z-test for the mean. Selecting the sample size. Examples.		
13. The T (Student)-test for the mean. Tests for proportions. The Chi-square-test for the variance. The F-test for the ratio of variances. Tests for the difference of means. Paired data tests. 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. Overview of statistical procedures.	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.

8.2 Seminar	**Teaching methods**	**Remarks**
1. Euler's Functions. Properties. Computation of moments of continuous random variables.	Interactive exposure, explanation, conversation, individual and group work	
2. Rules of probability, random variables. Applications.	Interactive exposure, explanation, conversation, individual and group work	
3. Descriptive Statistics. Measures of central tendency and measures of variation.	Interactive exposure, explanation, conversation, individual and group work	
4. Correlation and regression. Correlation coefficient, lines of regression.	Interactive exposure, explanation, conversation, individual and group work	
5. Sample functions. Properties.	Interactive exposure, explanation, conversation, individual and group work	
6. Unbiased, consistent and minimum variance estimators.	Interactive exposure, explanation, conversation, individual and group work	
7. Fisher's information. Absolutely correct and efficient estimators.	Interactive exposure, explanation, conversation, individual and group work	
8. Sufficient and complete statistics. Lehmann-Scheffé Theorem. Minimum variance unbiased estimators.	Interactive exposure, explanation, conversation, individual and group work	
9. Method of moments.	Interactive exposure, explanation, conversation, individual and group work	
10. Maximum likelihood method.	Interactive exposure, explanation, conversation, individual and group work	
11. Confidence intervals for the mean, the variance and proportions. Selecting the sample size.	Interactive exposure, explanation, conversation, individual and group work	
12. Confidence intervals for comparing the parameters of two populations.	Interactive exposure, explanation, conversation, individual and group work	

13. Hypothesis and significance testing for the mean, the variance and proportions. Selecting the sample size.	Interactive exposure, explanation, conversation, individual and group work	
14. Hypothesis and significance testing for comparing the parameters of two populations. Most powerful tests.	Interactive exposure, explanation, conversation, individual and group work	
8.3 Laboratory	**Teaching methods**	**Remarks**
1. Review of Python features. Statistics and machine learning toolbox.	Interactive exposure, synthesis, conversation, individual/group work	The lab is structured as 2 hours per week, every other week
2. Random number generators. Simulations of random variables. Samples, statistical measures.	Interactive exposure, synthesis, conversation, individual/group work	
3. Descriptive Statistics. Histograms, frequency polygons, boxplots.	Interactive exposure, synthesis, conversation, individual/group work	
4. Correlation and regression. Best fit of data.	Interactive exposure, synthesis, conversation, individual/group work	
5. Confidence intervals for means, variances and proportions.	Interactive exposure, synthesis, conversation, individual/group work	
6. Confidence intervals for comparing two populations. Hypothesis and significance testing for the parameters of one population.	Interactive exposure, synthesis, conversation, individual/group work	
7. Hypothesis and significance testing for comparing two populations and for paired data.	Interactive exposure, synthesis, conversation, individual/group 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 Mathematics and Computer Science majors;
- The course exists in the studying program of all major universities in Romania and abroad;
- The statistical analysis abilities acquired in this course are useful in any career path students may choose.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	• to acquire the basic principles from	• Written exam • Coursework	70% 30%

	Mathematical Statistics • to be able to apply correctly the course concepts on various applications • problem-solving		
10.5 Seminar/laboratory	• to be able to apply the course concepts to solve problems • choose and apply the appropriate statistical procedure to various practical problems	• participation in discussing and solving problems in seminar and lab throughout the semester • individual presentation of solutions	Extra 10% possible
10.6 Minimum standard of performance			
• At least 50% overall.			

11. Labels ODD (Sustainable Development Goals)[2]

	General label for Sustainable Development							
								

Date:
11.04.2025

Signature of course coordinator

O Lang

Signature of seminar coordinator

O Lang

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuș

[2] 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*.".