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	**Mathematics**
1.5 Study cycle	**Bachelor**
1.6 Study programme / Qualification	**Mathematics Computer Science**

2. Information regarding the discipline

2.1 Name of the discipline	**Mathematical 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	**3**	2.5 Semester	**5**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**Compulsory**

2.8 Course Code	MLE0030	

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

3.1 Hours per week	5	Of which: 3.2 course	2	3.3 seminar/laboratory	2 sem + 1 lab
3.4 Total hours in the curriculum	70	Of which: 3.5 course	28	3.6 seminar/laboratory	42

Time allotment:	hours
Learning using manual, course support, bibliography, course notes	10
Additional documentation (in libraries, on electronic platforms, field documentation)	7
Preparation for seminars/labs, homework, papers, portfolios and essays	5
Tutorship	3
Evaluations	5
Other activities:	-

3.7 Total individual study hours	30
3.8 Total hours per semester	100
3.9 Number of ECTS credits	4

4. Prerequisites (if necessary)

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

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	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

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 objective 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

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	Video projector presentation
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	• Interactive exposure • Explanation • Conversation	

function, sample proportions, sample functions for two populations. Properties.	• 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 P-values. The Z-test for the mean. Selecting the sample size. Examples.	• Interactive exposure • Explanation • Conversation • Didactical demonstration	
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, 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. Computation of moments of continuous random variables.	• Interactive exposure • Explanation • Conversation	
2. Rules of probability, random variables. Applications.	• Interactive exposure • Explanation • Conversation • Individual/group work	
3. Descriptive Statistics. Measures of central tendency and measures of variation.	• Interactive exposure • Explanation • Conversation • Individual/group work	
4. Correlation and regression. Correlation coefficient, lines of regression.	• Interactive exposure • Explanation • Conversation • Individual/group work	
5. Sample functions. Properties.	• Interactive exposure • Explanation • Conversation • Individual/group work	
6. Unbiased, consistent and minimum variance estimators.	• Interactive exposure • Explanation • Conversation • Individual/group work	
7. Fisher's information. Absolutely correct and efficient estimators.	• Interactive exposure • Conversation • Synthesis • Individual/group work	
8. Sufficient and complete statistics. Lehmann-Scheffé Theorem. Minimum variance unbiased estimators.	• Interactive exposure • Explanation • Conversation • Individual/group work	
9. Method of moments.	• Interactive exposure • Explanation • Conversation • Didactical demonstration • Individual/group work	
10. Method of maximum likelihood.	• Interactive exposure • Explanation • Conversation • Individual/group work	
11. Confidence intervals for the mean, the variance and proportions. Selecting the sample size.	• Interactive exposure • Explanation • Conversation • Individual/group work	
12. Confidence intervals for comparing the parameters of two populations.	• Interactive exposure • Explanation • Conversation • Individual/group work	

13. Hypothesis and significance testing for the mean, the variance and proportions. Selecting the sample size.	• Interactive exposure • Explanation • Conversation • Individual/group work	
14. Hypothesis and significance testing for comparing the parameters of two populations. Most powerful tests.	• Interactive exposure • Explanation • Conversation • Individual/group work	
8.3 **Laboratory**	Teaching methods	Remarks
1. Review of Matlab features. Statistics and machine learning toolbox.	• Interactive exposure • Explanation • 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 • Explanation • Conversation • Individual/group work	
3. Descriptive Statistics. Histograms, frequency polygons, boxplots.	• Interactive exposure • Explanation • 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 • Explanation • Conversation • Individual/group work	
6. Confidence intervals for comparing two populations. Hypothesis and significance testing for the parameters of one population.	• Interactive exposure • Explanation • Conversation • Individual/group work	
7. Hypothesis and significance testing for comparing two populations and for paired data.	• Interactive exposure • Explanation • 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, 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 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

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 Mathematical Statistics; - be able to apply correctly the course concepts on various applications	Written exam on problems only (a sheet with the main statistical formulas is available)	60%
10.5 Seminar/Lab activities	- apply course concepts and techniques on practical problems - choose and apply the appropriate statistical procedure to various practical problems - implement course concepts and algorithms in Matlab - to solve numerical statistical problems in Matlab	- participation in discussing and solving problems in seminar and lab throughout the semester - solving numerical statistical applications - additional documentation - individual presentation of solutions	40%
10.7 Minimum performance standards			
➢ A grade of 5 or above (on a scale from 1 to 10) on **each** of the activities mentioned above (written test, seminar/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	Signature of the head of department
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