MATHEMATICS
2020-2021

Course title	ECTS	Degree	Course code	Prerequisites	Subject area
Linear Algebra	6	B	P120U519	School's mathematics.	Mathematics
Graph Theory	3	B	P110B202	School's mathematics	Mathematics
Mathematical Analysis	6	B	P130U518	School's mathematics.	Mathematics
Integrals in Rn Space	4	B	P130U520	Course *Differentiation in Rn* (or analogous).	Mathematics
Differentiating in Rn Space	4	B	P130U521	Mathematical analysis (one-variable functions).	Mathematics
Differential equations	5	B	P130B119	The basic knowledge of the mathematical analysis and the linear algebra.	Mathematics
Mathematic in economy	5	B	P001B122	Students must know the fundamental math course of the secondary school.	Mathematics
Probability Theory	6	B	P160B146	Knowledge of mathematical analysis.	Mathematics
Probability Theory and Mathematical Statistics	3	B	P160B171	Course of School Mathematics.	Mathematics
Theory of Complex Functions	4	B	P130B118	Courses of Mathematical Analysis, Geometry and Algebra.	Mathematics
Computer Statistics	6	B	P175B216	Courses of Probability Theory and Mathematical Statistics.	Mathematics

Subject area: Mathematics

Status	Course code: P120U519 Course title: **LINEAR ALGEBRA** Taught by: Assoc. Professor Dr. KANIŠAUSKIENĖ Karolina		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	6	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 32 h Seminar – 32 h Self-study – 96 h	10-point scale	School's mathematics.	Colloquium – 20 % Test – 40 % Individual Homework – 10 % Exam – 30 %

Subject content	Systems of linear equations. Vector spaces. Linear independence. Basis. Rank. Matrices and matrix operations. Determinants. Systems of linear inequalities.
Learning Outcomes	Knowledge and understanding of main concepts of algebra, ability to illustrate them with and examples. Ability to choose methods for solution of tasks of linear algebra. Ability to thinking analytically and deductionally, operate with abstract concepts.
Literature	1. S. Lipschutz. Linear algebra. McGraw-Hill Book Company, New York, London, 1974. 2. Lee W. Jonson, R. Dean Riess, J.T. Arnold. Introduction to Linear Algebra. Pearson Addison Wesley, 2001. 3. J. Valantinas, Lecture notes in linear algebra and differential calculus. Technologija, Kaunas, 2007. 4. J. Hefferon, Linear Algebra. *Comment:internet access http://joshua.smcvt.edu/linearalgebra* 5. http://planetmath.org 6. http://www.math-atlas.org

Subject area: Mathematics

Status	Course code: P110B202 Course title: **GRAPH THEORY** Taught by: Assoc. Professor Dr. KANIŠAUSKIENĖ Karolina		
Semester	**ECTS credits**	**Languages**	**Duration**

Autumn or Spring	3	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 24 h Seminar – 16 h Self-study – 40 h	10-point scale	The basic knowledge of the linear algebra.	Test – 40 % Individual Homework – 20 % Exam – 40 %

Subject content	Notion of graph, geometric interpretation. Directed, undirected, mixed, planar, isomorphic, homeomorphic graphs. Connected graphs. Matrixes of graphs and its applications. Metric characteristics. Operations with graphs. Eulerian and Hamiltonian cycles, applications to economy. Prime numbers in the graph theory. Tree graphs, their applications to practice.
Learning Outcomes	Will know and understand the concepts, definitions, theorems of the graph theory. Will be able to model real processes and situations and to apply the obtained results in practice. Will be able to think analytically and logically, solving practical tasks.
Literature	1. Basics of Graph Theory. *Comment:internet access https://www.ntu.edu.sg › home › guohua* 2. E. Bender. Lists, Decisions and Graphs. *Comment:internet access* https://cseweb.ucsd.edu/~gill/BWLectSite/Resources/LDGbookCOV.pdf 3. R. Diestel. Graph Theory. 2000. *Comment:internet access* http://www.esi2.us.es/~mbilbao/pdffiles/DiestelGT.pdf 4. Elements of Graph Theory. *Comment:internet access* https://courses.lumenlearning.com/waymakermath4libarts/chapter/graph-theory/

Subject area: Mathematics

Status	Course code: P130U518 Course title: **MATHEMATICAL ANALYSIS** Taught by: Professor Dr. ŠIAUČIŪNAS Darius		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	6	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 32 h Seminar – 48 h Self-study – 80 h	10-point scale	School's mathematics.	Colloquium – 15 % Test – 40 % Individual Homework – 15 % Exam – 30 %

Subject content	Elements of set theory. Limits of functions. Limit theory. Continuous and uniformly continuous functions. Properties of continuous functions. Derivatives and differentials of functions. Primitive functions. Definite and indefinite integrals. Integration methods.
Learning Outcomes	Will be able to know, to understand and to formulate main concepts and propositions of sets, limits, differential and integral calculus. Solving tasks, will know and will be able to select and adjust the methods of investigation of sets, limits, derivatives and integrals.
Literature	1. V.A. Zorich, Mathematical Analysis I. Springer-Verlag, Berlin, 2004. 2. V.A. Zorich, Mathematical Analysis II. Springer-Verlag, Berlin, 2004. 3. R. E. Larson, R. P. Hostetler. Calculus. D. C. Heat and Company, 1982. 4. J. Valantinas, Lecture notes in linear algebra and differential calculus. Technologija, Kaunas, 2007. 5. Jirí Lebl. Basic Analysis I. 2019. https://www.jirka.org/ra/realanal.pdf 6. http://www.math-atlas.org

Subject area: Mathematics

Status	Course code: P130U520 Course title: **INTEGRALS IN Rn SPACE** Taught by: Assoc. Professor Dr. GARBALIAUSKIENĖ Virginija		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	4	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 16 h Seminar – 32 h Self-study – 59 h	10-point scale	Course ,,Differentiation in Rn" (or analogous)	Test – 40 % Individual Homework – 20 % Exam – 40 %

Subject content	Continuous functions in several variables. Double and triple integrals, and applications. Multiple integrals. Manifolds in Rn, and their orientation. Curve and surface integrals.
Learning Outcomes	To know and understand the main concepts and propositions of integration of several variable functions. Ability to choose proper methods of integrations solving tasks. Ability to self-study and analyze new mathematical methods and apply them solving tasks.

Literature	1. V.A. Zorich. Mathematical Analysis I. Springer-Verlag, Berlin, 2004. 2. V.A. Zorich. Mathematical Analysis II. Springer-Verlag, Berlin, 2004. 3. https://www.math24.net/topics-calculus/ 4. https://mathinsight.org/double_integral_introduction

Subject area: Mathematics

Status	Course code: P130U521 Course title: **DIFFERENTIATING IN Rn SPACE** Taught by: Assoc. Professor Dr. GARBALIAUSKIENĖ Virginija		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	4	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 16 h Seminar – 32 h Self-study – 59 h	10-point scale	Mathematical analysis (one-variable functions).	Test – 50 % Individual Homework – 20 % Exam – 30 %

Subject content	Continuous functions in several variables and their differentiation. Total differentials. Derivatives and differentials of higher order. Implicit functions and their differentiation. Local extrema. Conditional extrema.
Learning Outcomes	To know and understand the main concepts and propositions of differentiation of several variable functions. Ability to choose proper methods of differentiation solving tasks. Ability to self-study and analyze new mathematical methods and apply them solving tasks.
Literature	1. V. A. Zorich. Mathematical Analysis I. Springer-Verlag, Berlin, 2004. 2. V.A. Zorich. Mathematical Analysis II. Springer-Verlag, Berlin,2004. 3. J. Valantinas. Lecture notes in linear algebra and differential calculus. Kaunas. Technologija, 2011. 4. https://www.math24.net/topics-calculus/ 5. http://tutorial.math.lamar.edu/ProblemsNS/CalcIII/CalcIII.aspx

Subject area: Mathematics

Status	Course code: P130B119 Course title: **DIFFERENTIAL EQUATIONS** Taught by: Lector Dr. KLOVIENĖ Neringa		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	5	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 16 h Seminar – 32 h consultation – 6 h Self-study – 79 h	10-point scale	The basic knowledge of the mathematical analysis and the linear algebra.	Test 1 – 30 % Test 2 – 30 % Individual Homework – 0 % Exam – 40 %

Subject content	The course consists of the preliminaries of the ordinary differential equations theory: the main concepts of differential equations, various first-order differential equations and their solving, the solutions and the existence and the uniqueness theorems, various higher order differential equations and their solving, the fundamental solutions and the analysis of the differential equations systems, real physical models described by differential equations or systems.
Learning Outcomes	The knowledge of the differential equations theory concepts, definitions, theorems and proofs. Knowledge of the differential equations solving methods and abilities to apply these methods for solving theoretical and practical problems. Ability to choose and apply the reasonable methods of differential equations theory for modeling and solving the physical problems. Ability to think logically and analytically using differential equations theory concepts and symbols. Ability to find the relationship between different parts of the task, to create and to motivate the algorithm of the solving, to evaluate different approaches of the analysis and to choose the most reasonable.
Literature	1. Garrett B., Rot G. C, Ordinary Differential equations. Waltham (Mass.): Blaisdell Publishing Company, 1969. 2. Brauer F., Nohel J. A., Problems and solutions in ordinary differential equations. New York: W. A. Benjamin, 1968. 3. Adkins W., Davidson M. G., Ordinary Differential Equations. Springer, 2012. 4. Teshl G. Ordinary Differential Equations and Dynamic Systems. AMS, Providence, 2012. http://www4.ncsu.edu/~schecter/ma_732_sp13/teschl_ode.pdf 5. Hirsch Morris W., Differential equations, dynamical systems, and an introduction to chaos. 2013. http://www.sciencedirect.com/science/book/9780123820105 6. Shapiro B. E., Lecture Notes in Differential Equations. California State University, Northridge, 2011. http://bruce-shapiro.net/math351/ODE.pdf

Subject area: Mathematics

Status	Course code: P001B122 Course title: **MATHEMATIC IN ECONOMY** Taught by: Lector Dr. KLOVIENĖ Neringa		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	5	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 16 h Seminar – 16 h Lab. Work – 101 h	10-point scale	Students must know the fundamental math course of the secondary school.	Test – 40 % Individual Homework – 30 % Exam – 30 %

Subject content	The subject is devoted to the students of the social sciences seeking to absorb the theory of functions and sets, the knowledge of calculating derivatives, functions, integrals, determinants, to solve differential equations, to create and solve linear equations and inequalities systems. Explaining of the subject the methods of explanatory narration and engaging lecture are used. Assessing the skills of students is used written survey and individual activities assessments.
Learning Outcomes	Will learn mathematical concepts, theorems and algorithms used in economic problems. Will be able to apply mathematical knowledge solving real economic problems. Will receive individual and group work skills in solving mathematical tasks.
Literature	1. Ummer E.K. (2012). Basic mathematics for economics, business, and finance, London; New York, NY :Routledge. 2. Bradley T., Patton P. (2002). Essential mathematics for economics and business, New York: John Wiley & Sons. 3. Simon, C., Blume, L. (2010). Mathematics for Economists, W. W. Norton & Co. 4. Jacques, I. (2009). Mathematics for Economics and Business. Financial Times/ Prentice Hall. 5. Chiang, A. C., Wainwright, K. (2005). Fundamental Methods of Mathematical Economics. McGraw-HillHigher Education. 6. Renshaw, G. (2005). Math for Economics. OUP Oxford. 7. Anthony, M., Biggs, N. (2003). Mathematics for Economics and finance (Methods and Modelling). Cembridge University Press. 8. Klein, M. W. (2002). Mathematical Methods for Economics, Addison-Wesley.

Subject area: Mathematics

Status	Course code: P160B146 Course title: **PROBABILITY THEORY** Taught by: Assoc. Professor Dr. KANIŠAUSKAS Vaidotas		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	6	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 48 h Seminar – 48 h Self-study – 64 h	10-point scale	Knowledge of mathematical analysis.	Colloquium – 25 % Test – 50 % Exam – 25 %

Subject content	Object of the theory of probabilities. Random events. Space of elementary events. Classical definition of probability. Operations with events. Probabilistic schemes. Formulas for calculation of probabilities. Random values. Distribution functions. Density. Numerical characteristics of random values. Two-dimensional random values. Probabilistic convergence methods. Characteristics functions. Law of large numbers. Central limit theorem.
Learning Outcomes	Learns to create a probabilistic model, to define the probabilities, to make actions with events and to calculate their he probabilities. Knowledge of the theory of random variables, ability to recognize the distribution of random variables, the discreteness or continuity of it, find their distribution functions, densities and the characteristic functions. Knowledge of numerical characteristics of random variables and ability to find them; learn to find covariance and correlation functions of random variables and investigate their independence using various criteria; knowledge of the theory of random vectors. Knowledge of convergence types to random sequences and ability to apply them.
Literature	1. Robert B. Ash, BASIC PROBABILITY THEORY. http://www.math.uiuc.edu/~r-ash/BPT/BPT.pdf 2. Charles M. Grinstead, J. Laurie Snell. INTRODUCTION TO PROBABILITY. http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/amsbook.mac.pdf 3. Oliver Knill. PROBABILITY THEORY AND STOCHASTIC PROCESSES WITH APPLICATIONS. http://www.math.harvard.edu/~knill/books/KnillProbability.pdf 4. Leif Mejlbro. INTRODUCTION TO PROBABILITY PROBABILITY EXAMPLES C-1. http://bookboon.com/en/introduction- to-probability-ebook 5. V. Krokhman. Introductory Probability and the Central Limit Theorem . 2011. http://www.math.uchicago.edu/~may/VIGRE/VIGRE2011/REUPapers/Krokhmal.pdf

Subject area: Mathematics

Status	Course code: P160B171 Course title: **PROBABILITY THEORY AND MATHEMATICAL STATISTICS** Taught by: Professor Dr. MACAITIENĖ Renata		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	3	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 8 h Seminar – 16 h Lab. Work – 8 h Self-study – 48 h	10-point scale	Course of School Mathematics.	Tests – 50 % Laboratory works – 30 % Exam – 20 %

Subject content	The course is intended for the students of Electrical Engineering, Electronic Engineering, Civil Engineering, Informatics Engineering and Mechanical Engineering Study Programmes. During the studies, the students familiarize with the fundamental theories and models of random events, random variables and mathematical statistics (the calculations of descriptive statistics, and the correlation and regression analyses are performed, parametric hypotheses are verified); the methods of tasks solving and the software tools of data processing, also the principles of interpretations of results and assumptions are discussed.
Learning Outcomes	Knowledge, understanding and ability to define the main notions and propositions of probability theory and mathematical statistics' theory as well as the methods and principles; to illustrate them with the examples. Ability to apply the acquired knowledge in solving classical tasks. Ability to model and perform the elementary statistical research, to select and apply appropriate mathematical methods and specialized software packages, to present and reasonably interpret the results.
Literature	1. E. T. Berkman, S. P. Reise, Conceptual guide to statistics using SPSS. Los Angeles, London: Sage, 2012. 2. Fundamentals of probability. http://www.statlect.com/fndprb.htm 3. Fundamentals of statistics. http://www.statlect.com/fundamentals_of_statistics.htm 4. Introductory Statistics. https://openstax.org/details/books/introductory-statistics 5. Probability and Random Variables. https://web.stanford.edu/class/archive/ee/ee278/ee278.1176/lectures_EE178/lect01-2_Abbas.pdf 6. J. Gravner. Lecture Notes for Introductory Probability. https://www.stat.berkeley.edu/~aldous/134/gravner.pdf 7. P. Sahoo. Probability and Mathematical Statistics http://www.iiserpune.ac.in/~ayan/MTH201/Sahoo_textbook.pdf 8. S. Landau, B. S. Everitt, A Handbook of Statistical Analysis using SPSS. http://www.fao.org/tempref/AG/Reserved/PPLPF/ftpOUT/Gianluca/stats/Statistics%20-%20A%20Handbook%20of%20Statistical%20Analyses%20using%20SPSS%20-%20Excellent%20!!!.pdf

Subject area: Mathematics

Status	Course code: P130B118 Course title: **THEORY OF COMPLEX FUNCTIONS** Taught by: Professor Dr. MACAITIENĖ Renata		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	4	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 32 h Seminar – 32 h Self-study – 43 h	10-point scale	Courses of Mathematical Analysis, Geometry and Algebra.	Tests – 75 % Exam – 25 %

Subject content	During the studies, the knowledge of mathematical analysis is expanded to the complex plane: the students familiarize with the set of complex numbers, sequences and series, functions of complex variable (analytical, harmonic functions, elementary mappings); the differential (Cauchy and Riemann conditions, differentiation rules) and integral (integral by smooth curve, the basic integral theorems, application of Cauchy integral formula) computing is studied; the convergence of functions series, the expression by power and Laurent series are studied as well; the students are provided with the basics of Residue theory and its application for integrals‘ calculation.
Learning Outcomes	Knowledge, understanding and ability to explain the main notions and propositions of differentiation and integration of complex functions, series of functions, the theories of residues as well as the methods and principles of analysis, to illustrate them with the examples. Ability to formulate and prove the main propositions of the theory of complex functions, to find and explain the connections and functional relations. Ability to apply the acquired knowledge in solving classical tasks.
Literature	1. Basics of Complex Numbers. https://portal.uea.ac.uk/documents/6207125/8203725/other+essential+skills+basics+of+complex+numbers.pdf 2. C. Berg. Complex Analysis, 2012. http://web.math.ku.dk/noter/filer/koman-12.pdf 3. K. Houston, Complex Analysis, 2005. https://www.zuj.edu.jo/download/complex-analysis-k-houston-pdf/. 4. S. G. Krantz. A guide to Complex Variables, 2007. http://www.math.wustl.edu/~sk/books/guide.pdf. 5. W. Chen, Introduction to complex analysis. http://williamchen-mathematics.info/lnicafolder/lnica.html 6. Complex Functions and the Cauchy-Riemann Equations. http://www.math.columbia.edu/~rf/complex2.pdf.

Subject area: Mathematics

Status	Course code: P175B216 Course title: **COMPUTER STATISTICS** Taught by: Professor Dr. MACAITIENĖ Renata		
Semester	**ECTS credits**	**Languages**	**Duration**
Autumn or Spring	6	English	1 semester
Study hours	**Assessment**	**Prerequisites**	**Examination**
Lectures – 32 h Lab. Work – 32 h Self-study – 96 h	10-point scale	Courses of Probability Theory and Mathematical Statistics.	Laboratory works – 75 % Exam –25 %

Subject content	During the studies, the students familiarize with the software tools of data processing; the calculations of descriptive statistics and estimations of parameters are performed, parametric and nonparametric hypotheses are verified, the correlation, regression, factor analysis and other multidimensional statistical methods are used, the principles of interpretations of results and assumptions are discussed.
Learning Outcomes	Knowledge and understanding of the methods and principles of data collection, systemization and processing. Ability to select and apply appropriate mathematical methods and specialized software to statistical calculations and data analysis, to present the obtained results and conclusions. Ability to model and perform the statistical research, to present and reasonably interpret the results.
Literature	1. E. T. Berkman, S. P. Reise, Conceptual guide to statistics using SPSS, Los Angeles, London: Sage, 2012. 2. T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd ed., Springer, 2009. http://www-stat.stanford.edu/~tibs/ElemStatLearn. 3. Introductory Statistics. https://openstax.org/details/books/introductory-statistics 4. S. Landau, B. S. Everitt, A Handbook of Statistical Analysis using SPSS. http://www.fao.org/tempref/AG/Reserved/PPLPF/ftpOUT/Gianluca/stats/Statistics%20-%20A%20Handbook%20of%20Statistical%20Analyses%20using%20SPSS%20-%20Excellent%20!!!.pdf 5. SPSS for the Classroom: the Basics. https://www.ssc.wisc.edu/sscc/pubs/spss/classintro/spss_students1.html 6. SPSS Tutorials: Home. https://libguides.library.kent.edu/SPSS/home