

Subject card

Subject name and code	Mathematical Methods in Economic Analysis, PG_00202535						
Field of study	Economics, International Economic Relations, International Business, Logistics and Mobility						
Date of commencement of studies	October 2025		Academic year of realisation of subject		2026/2027		
Education level	Master's studies		Subject group		Obligatory subject group in the field of study Optional subject group		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	2		Language of instruction		English		
Semester of study	4		ECTS credits		5.0		
Learning profile	academic		Assessment form		credit		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr Elżbieta Babula				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	0.0	30.0	0.0	0.0	0.0	30
	E-learning hours included: 0.0						
	eNauczanie source address: https://mdl.ug.edu.pl/course/view.php?id=13717						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	30		0.0		95.0	125
Subject objectives	The aim of this course is to develop students' advanced skills in formulating and analysing mathematical models in economics and finance. Rigorous mathematical analysis of theoretical models leads to a deeper understanding of economic problems. The course also aims to equip students with the ability to use computational tools for solving mathematical models and to apply their knowledge in practical economic modelling.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[LMMU2_W06] has an in-depth knowledge of statistical and econometric methods and tools for description and macro- and microeconomic modelling of logistics and mobility processes and systems	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[MSGGL3_U02] can assess economic and social phenomena occurring in an open economy, interpret necessary statistical data and economic indicators, as well as forecast economic phenomena and processes, using standard methods and tools applied in economic sciences	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task
	[EKONMU2_W06] knows in advanced stage statistical and econometric methods and tools for description and macro- and microeconomic modelling of economic structures and public institutions and processes occurring in them	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[IBMU2_U02] can interpret statistical data and economic indicators, and select and use quantitative and qualitative methods and tools developed by economic sciences, including advanced information and communication techniques	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task
	[EKONL3_K02] is aware of the level of knowledge in the field of economics and understands the need to deepen and update this knowledge throughout life	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work

	Course outcome	Subject outcome	Method of verification
	[MSG3_W10] knows selected methods and tools, including IT tools and data acquisition techniques, which make it possible to describe and analyse economic entities operating on the international market; knows the processes and phenomena occurring in them and between them, and processes supporting decision-making	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[MSGMU2_U02] can observe, evaluate and critically analyse the causes and course of processes and phenomena taking place in the open economy; can formulate his/her own opinions on the subject, interpret statistical data and economic indicators necessary in this respect, and also forecast economic processes and phenomena using advanced methods and tools applied in economic sciences	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task
	[IBL3_W03] knows and understands selected research methods and tools, including IT tools and data acquisition techniques, which are applicable to international business issues	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[EKONL3_W06] has an advanced knowledge of selected methods and tools, including statistical and econometric techniques, for describing economic agents and structures as well as social institutions and the processes taking place in them	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[MSG3_K02] critically assesses the level of his/her knowledge in the field of economics; is willing to deepen and update this knowledge throughout his/her life	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work
	[MSG3_U14] can interact and work in a team (including an international one), taking various roles within it	The student can cooperate in group to develop the solution for given task.	[SU8] observation of student's independent or team work

	Course outcome	Subject outcome	Method of verification
	[LMMU2_K02] is aware of the level of his/her knowledge in the field of logistics and mobility; understands the need to extend and update this knowledge throughout his/her life	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work
	[EKONMU2_U04] can forecast and model complex economic and social processes using quantitative and qualitative methods and tools developed by economic sciences (including statistics and econometrics)	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task
	[EKONMU2_K02] is aware of the level of their knowledge in the area of solving complex problems in economic.; understands the need to extend and update this knowledge throughout his/her life	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work
	[LMMU2_U04] can forecast and model complex economic and social processes, as well as logistics and mobility processes and systems using quantitative and qualitative methods and tools developed by economic sciences (including statistics and econometrics)	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task
	[IBMU2_W02] knows and understands in depth methods and tools for describing economic phenomena, including data acquisition techniques, which make it possible to describe and analyse business entities functioning on the international market as well as processes and phenomena occurring in them and between them	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[EKONL3_U15] is able to independently supplement and improve his acquired knowledge and skills in the field of economics, is open to new concepts and solutions, and demonstrates a willingness to engage in lifelong learning and to cooperate and exchange knowledge with other participants in the learning process.	The student can cooperate in group to develop the solution for given task. The student applies the computer tools to solve problems that require mathematical methods.	[SU5] implementation of a problem task [SU8] observation of student's independent or team work

	Course outcome	Subject outcome	Method of verification
	[IBL3_U02] can formulate and solve complex and nonstandard issues in international business by employing quantitative and qualitative research methods and tools, as well as advanced communication and information techniques applicable in the field of international business, economics and finance	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task
	[IBMU2_K01] Is ready to recognise the importance of knowledge of international business in the process of identifying and solving business problems and the need to consult experts in cases of complex issues	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work
	[MSG3_U08] uses methods and computer programmes as well as marketing techniques and tools to acquire and analyse data necessary in his/her professional work to diagnose economic processes and make adequate economic decisions	The student applies the computer tools to solve problems that require mathematical methods.	[SU5] implementation of a problem task
	[IBL3_U09] is able to work individually and within teams, also of interdisciplinary character; can plan and organize own tasks and the works of teams	The student can cooperate in group to develop the solution for given task.	[SU8] observation of student's independent or team work
	[EKONMU2_U08] can independently analyse economic and social phenomena and processes, and can perform a theoretically deepened assessment of such phenomena, using appropriately selected research method	The student applies the computer tools to solve problems that require mathematical methods.	[SU5] implementation of a problem task
	[MSGMU2_K01] is ready to recognise the importance of knowledge of economics in the process of identifying and solving problems in the area of international economic relations and to consult experts in case of difficulties in solving them independently	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work
	[EKONL3_U02] is able to use the knowledge of theory and data to analyse concrete economic and social processes and phenomena and to analyse these phenomena using methods developed in economics, finance and management sciences	The student classifies the systems of linear equations and solves the systems if possible; identifies the basic types of differential equations and applies the correct solution method; solves constraint optimization problems and interprets the solution; analyzes and interprets the qualitative solutions of basic dynamic problems; solves and analyzes optimal control problems; applies matrix methods to discuss properties of Markov chains; can find the invariant measure of Markov chain. The student recognizes the areas of application for the methods in economics and finance.	[SU2] presentation/project/paper/report [SU4] test/exam - oral or written [SU5] implementation of a problem task

	Course outcome	Subject outcome	Method of verification
	[MSGMU2_W13] knows and understands methods and tools for describing economic phenomena, including data acquisition techniques, which make it possible to describe and analyse economic entities functioning on the international market as well as processes and phenomena occurring in them and between them, and also those supporting decision-making processes	The student knows and understands the conditions for the existence of the solution of a linear system of equations; knows the types of constraint optimization problems and understands the solution methods; understands the qualitative solutions of basic dynamic problems; characterizes the dynamic programming and optimal control problems and knows its solution methods; understands the basic characteristics of Markov chains. The student knows the computer tools to support mathematical analysis.	[SW2] presentation/project/paper/report [SW5] implementation of a problem task
	[IBL3_K02] is ready to critically assess own knowledge in the field of international business, economics and finance and complementary disciplines	The student individually as well as in cooperation within group expands his or her awareness of possibilities and boundaries of applying mathematics to a better understanding of economic problems.	[SK1] oral statement/conversation/discussion [SK5] implementation of a problem task [SK8] observation of student's independent or team work
Subject contents	1. Review of basic linear algebra: determinants and matrix inverses; Cramers rule; rank of matrix; linear systems of equations; degrees of freedom. All tasks in this topic are conducted in a computer laboratory. 2. Linear programming: basic properties and examples of linear programs; basic solutions; the fundamental theorem of linear programming; the simplex method; dual linear programs. This topic is conducted with computer laboratory support. 3. Non-linear programming: constrained optimization with equality constraints (Lagrange problem) and with inequality constraints (Kuhn-Tucker problem). 4. Differential equations: constant coefficient linear differential equations; qualitative solution: phase portrait diagrams; nonlinear systems; fixed points; linearization of dynamic system in the plane. This topic is conducted with computer laboratory support. 5. Optimal control: maximum principle; transversality conditions. 6. Dynamic programming: dynamic programming problems; the principle of optimality. 7. Stochastic processes: Markov chains; stationary distributions. This topic is conducted with computer laboratory support.		
Prerequisites and co-requisites	Completed Mathematical applications in economics and management course or other undergraduate mathematics course. The course requires basic knowledge of: differential calculus (derivatives and integrals of elementary functions with basic rules of differentiation and integration); matrix algebra.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Group work in-class activities	51.0%	60.0%
	Assignments: tasks to be solved individually outside of class within given deadline	51.0%	30.0%
	Quizzes and tests online at fixed dates outside the class	51.0%	10.0%
Recommended reading	Basic literature	K. Sydsater, P. Hammond, A. Seierstad, A. Strom, Further mathematics for economic analysis, Prentice Hall, 2005.	
	Supplementary literature	1. Chiang A., Elements of dynamic optimization, McGraw-Hill 1992. 2. Chiang A., Fundamental methods of mathematical economics, McGraw-Hill 1967. 3. Brzeźniak Z., Zastawiak T., Basic stochastic processes, Springer 2003.	
	eResources addresses		
Example issues/ example questions/ tasks being completed			
Work placement	Not applicable		

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