Description of course	
Code of course	**1160-TR000-MSA-0102**
Name of course	**Mathematical Methods in Transport**
Version of course	2021/22
A. Place of the course in system of studies	
Level of education	Second-degree studies
Form and mode of studies	Full-time studies
Field of studies	Transport
Profile of studies	General academic profile
Specialisation	Transport systems engineering and management
Place of teaching of course	Warsaw University of Technology, Faculty of Transport, Air Transport Engineering Department
Place of realization of course	Not applicable
Coordinator of course	prof. Jacek Skorupski, PhD, DSc, Air Transport Engineering Department, Warsaw University of Technology, Faculty of Transport
B. General characteristic of the course	
Block of courses	General
Level of course	Intermediate level
Status of course	Mandatory course
Language of course	English
Nominal semester	1
Location of the subject in the academic year	Winter semester
Preliminary requirements	none
Limit of students	-
C. Effects of education and manner of teaching	
Purpose of course	Introduction to the problems and mastering the basic knowledge and skills in the use of selected mathematical methods in transport.

Effects of education with reference to the learning outcomes for the area and field of study

No. Effect	***Description of the effect***	***Reference to the characteristics of learning outcomes***	***Reference to the learning outcomes in the program***
	Assumed learning outcomes in terms of knowledge		
W01	He/she knows the basic concepts of modeling, optimization, system analysis - in relation to broadly understood transport issues. Knows the basic models of inventory theory, knows the basic concepts of fuzzy sets, knows the definitions, elements and rules of modeling with the use of Petri nets, knows the basic concepts of game theory and decision theory, knows the methods of analyzing and determining the characteristics of mass service systems	Tr2A_W01	I.P7S_WGo
	Assumed learning outcomes in terms of skills		
U01	He/she can formally define a decision task based on a verbal description of a decision situation. Can, on the basis of a formal formulation of a decision task in transport, determine which mathematical methods are appropriate to search for optimal solutions	Tr2A_U11	I.P7S_UWo III.P7S_UW.2
	Assumed learning outcomes in the field of social competences		
KS01	He/she understands the need to look at the real tasks faced by a transport engineer as decision problems, he/she notices the need to look for solutions that are better than intuitive. He recognizes the need to formalize tasks, understands that the optimization of solutions brings ec onomic and social benefits, and at the same time can critically evaluate the solutions obtained.	Tr2A_K02	I.P7S_KK

Form of didactic studies and number of hours	Lecture	Exercise	Laboratory	Project	Other
On a weekly plan	1	1	0	0	0
Throughout the semester	30	15	0	0	0

Contents of education	Lecture: General introduction to the subject (presentation of typical, real decision-making problems in transport, demonstrating the need to use mathematical methods, demonstrating the need for systematic and comprehensive problem analysis, modeling process, the concept of optimization, optimization task, general overview of optimization tasks and methods). Inventory theory (general definitions, deterministic economic batch size models, deterministic dynamic models, probabilistic inventory models, formulating a decision problem as a task of inventory theory and choosing the right model). Application of game theory in transport issues (basic definitions and concepts, theory of non-cooperative games, formulation of the decision problem as game theory tasks, methods of solving matrix games, multiplayer games, the bargaining problem and methods of its solution). Decision theory (games with nature - transport examples, formulation of a decision problem as tasks of decision theory, decision making under uncertainty, analysis of the possibility of reducing the scope of uncertainty). Queuing theory (basic definitions, types and classification of mass service systems, random reporting and service processes, determination of system characteristics - equilibrium conditions, Little's theorem, system utilization factor) Multi-criteria analysis (general definitions, transport examples, formulation of a decision problem as a multi-criteria analysis task, solution methods - normalization, lexicographic method, distance method, two-reference interactive procedure, supercriterion - weighted utility function, ranking methods). Fuzzy sets (basic concepts - fuzzy set, membership function, formulation of decision problems in transport as tasks of fuzzy sets theory). Petri nets (basic definitions, elements of Petri nets - places, transitions, arcs, markers, general principles of Petri nets construction, network dynamics, modeling of traffic processes using Petri nets). Classes: Solving tasks formulated as a verbal description of simple transport problems - formalization to a form that allows the use of one of the mathematical methods, selection of the appropriate method and its variant (e.g. model defined in the literature), performing calculations using the selected method.
Teaching methods	Lecture: A multimedia presentation supported by practical examples. Exercises: Solving problems preceded by a discussion aimed at searching for an appropriate method to solve the presented simple transport problem.

Methods of verification of effects of education

No. Effect	Methods of verification
Assumed learning outcomes in terms of knowledge	
W01	Part of the exam including 6 open questions, for which you can get up to 12 points. It is required to obtain a minimum of 6 points.
Assumed learning outcomes in terms of knowledge	
U01	The part of the exam includes 4 open questions for which up to 8 points can be obtained. It is required to obtain a minimum of 5 points.
Assumed learning outcomes in the field of social competences	
KS01	Active participation in discussions during exercises. At least 3 in-depth discussions are required.

Methods of evaluation	Written exam. Active participation in discussions during exercises.
Exam	Yes
Literature	Basic literature: 1. F.S. Hillier, G.J. Lieberman, Introduction to Operations Research, McGrow-Hill, 2010. 2. J. Zappone, Inventory Theory, 2006. 3. Joseph G. Ecker, Michael Kupferschmid, Introduction to Operations Research, John Wiley and Sons, New York, 1988. 4. J. von Neumann, O. Morgenstern, Theory of games and economic behavior, 2004. 5. R.D. Luce, H. Raiffa, Decisions Theory, 1964. 6. R. Cooper, Introduction to Queuing theory, North Holland, 1977. 7. Communities, Multi-criteria analysis: a manual, London, 2009. 8. H.J. Zimmermann, Fuzzy Set Theory and Its Applications, Springer, 2001. 9. G. Chen, T.T. Pham, Introduction to Fuzzy Sets, Fuzzy Logic and Fuzzy Control Systems, CRC Press, 2001. 10. J.L. Peterson, Petri net theory and the modeling of systems, Prentice-Hall, 1981.
Website of the course	None
D. Student's activity	
Number of credits ECTS	3
Number of hours of student's job for achievement of education's effect (description):	120 hours, including: work at lectures 30 hours, work on exercises 15 hours, study of literature on the subject 30 hours, consultations 1 hour, ongoing preparation for exercises 14 hours, preparation for the exam 30 hours
Number of credits ECTS on the course with direct participation of academic teacher	1.5 ECTS points (46 hours, including: work at lectures and classes: 45 hours., consultations 1 hour
Number of credits ECTS on practical activities on the course	0
E. Additional information	
Notes	As long as it does not cause changes in the relationship of a given subject with the directional effects in the content of education, changes may be introduced on an ongoing basis, taking into account the latest scientific achievements.
Date of last edition	2021-08-20