FACULTY OF PURE AND APPLIED MATHEMATICS
SUBJECT CARD

Name in Polish OPTYMALIZACJA NIELINIOWA
Name in English NONLINEAR OPTIMIZATION
Main field of study (if applicable):Applied Mathematics
Specialization (if applicable): Mathematics for Industry and Commerce
Level and form of studies: ~~1st/~~ 2nd* level, full-time ~~/ part-time*~~
Kind of subject: ~~obligatory /~~ optional ~~/ university-wide*~~
Subject code MAT1556
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*	Examination / crediting with grade*
For group of courses mark (X) final course	X				
Number of ECTS points	3		2		
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BK) classes	1.5		1.5		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student knows and he is able to use the classic concepts and theorems of algebra, mathematical analysis, the functional analysis and the probability theory.

SUBJECT OBJECTIVES

C1 Master of concepts and methods of mathematical programming.
C2 Knowing tasks of linear and square programming formulations.
C3 Understanding the basics convex analysis and its significance for mathematical programming.
C4 Acquisition of skills of analysis necessary and sufficient conditions for constrained optimization tasks.
C5 Mastering dynamic programming method.
C6 Application of acquired knowledge to create and analyze mathematical models to solve theoretical and practical problems in various fields of science and technology.

SUBJECT EDUCATIONAL EFFECTS

Relating to knowledge:

PEK_W01 knows formulate mathematical programming tasks

PEK_W02 has a basic knowledge about the usage and importance of mathematical programming tasks

PEK_W03 recognize situations requiring the application of optimization methods to solve practical problems

PEK_W04 knows the limits of the analytical methods and possibilities of optimization of numerical analysis

PEK_W05 known randomized methods for the analysis of mathematical programming tasks

Relating to skills:

PEK_U01 can formulate a mathematical programming task in a convenient form for analysis

PEK_U02 can apply the appropriate algorithm to solve the mathematical programming problems

PEK_U03 knows how to use optimization methods, analytical methods or numerical analysis, in order to solve practical problems

PEK_U04 can identify issues where appropriate optimization methods are based on the use of stochastic approach

Relating to social competences:

PEK_K01 can benefit from the scientific literature in English, including reaching the source materials and make them review

PEK_K02 can support the analysis of mathematical models of relevant Computer Science tools

PEK_K03 understands the need for systematic and independent work on mastery of course material

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours**
Lec 1	Introduction to mathematical programming. Linear and Quadratic programming. Formulation of programming problem. Wolfe algorithm.	2
Lec 2	Unconstrained optimization tasks. Optimality conditions. Gradient method - analysis of convergence. Newton's method and its variants.	2
Lec 3	Elements of convex analysis. Convex cone. Extreme points of a convex set. Convex functions. The tasks of optimizing the convex sets. Admissible directions and application of directions modification.	6
Lec 4	Nonlinear programming. Characterization of extremes: necessary and sufficient conditions. Examples of non-linear programming tasks.	4
Lec 5	The theory of Lagrange multipliers. The necessary conditions for extreme under in the equality form. Penalty function method. The method of elimination. The Lagrange function.	4
Lec 6	Constraints in the form of inequality. Optimality conditions of Karush-Kuhn-Tucker. Convex cost functional and linear	2

	constraints	
Lec 7	Dynamic programming.	2
Lec 8	Discrete time, deterministic control models.	2
Lec 9	Discrete time, stochastic control systems.	4
Lec 10	Summary	2
	Total hours	30

Form of classes - laboratory		**Number of hours**
Lab 1	Solving problems illustrating a lecture given theory using MATLAB, Mathematica and R	2
Lab 2	Illustration of the simplex method. Examples of quadratic programming tasks.	2
Lab 3	Issues illustrating properties of convex functions and convex sets.	2
Lab 4	Examples of the use of internal and external functions of punishment. Figure algorithms: Schmitt-Fox, Rosenbrock, Carroll. Methods of modified directions.	4
Lab 5	The concept of duality in convex programming. Coupled functions. Equilibrium points units in games and minimax theorem. Linear complementarity problem and the Lemke algorithm.	4
Lab 6	Methods of applying the inner and outer penalty function. Examples of algorithms: Schmitt-Fox, Rosenbrock, Carroll. Methods of modified directions.	4
Lab 7	Random extreme search methods. Direct Monte Carlo method. Random gradient method.	4
Lab 8	Examples of stochastic programming tasks - models and methods.	4
Lab 9	An example illustrating the dynamic programming method	2
Lab 10	Colloquium	2
	Total hours	30

TEACHING TOOLS USED
N1. Lecture - traditional method N2. Computer laboratory N3. Individual consultation N4. Student's own work - to prepare for the lab

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEK_W01 PEK_W02 PEK_W03 PEK_W04 PEK_W05 PEK_K01 PEK_K02	test
F2	PEK_W01 PEK_W02 PEK_W03 PEK_W04 PEK_W05 PEK_U01 PEK_U02 PEK_U03 PEK_U04 PEK_K01 PEK_K02 PEK_K03	verbal responses, short tests, tests, reports
C=0.4*F1+0.6*F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Dimitri P. Bertsekas:Nonlinear Programming, Athena Scientific, Belmont, MA: 1999.
[2] Bertsekas, Dimitri P. and Nedic, Angelia and Ozdaglar, Asuman E., Convex Analysis and Optimization, Athena Scientific, Belmont, MA: 2003.
[3] Bela Martos, Programowanie nieliniowe, Warszawa: Państwowe Wydawnictwo Naukowe, 1983.
[4] Andrzej Ruszczyński, Nonlinear optimization, Princeton University Press, Princeton, NJ, 2006.
[5] R. Dautray, J. L. Lions, Mathematical Analysis and Numerical Methods for Science and Technology, Springer, Berlin 1988-1993.

SECONDARY LITERATURE:

[1] K. Atkinson, W. Han, Theoretical Numerical Analysis – A Functional Analysis Framework, Springer, 2001.
[2] A. Bjork, G. Dahlquist, Metody numeryczne, PWN, Warszawa 1987.
[3] B. P. Flannery, W. H. Press, S. A. Teukolsky, W. T. Vetterling, Numerical Receipes in C, Cambridge 1992.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
OPTYMALIZACJA NIELINIOWA MAPMAT1556
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Applied Mathematics**
AND SPECIALIZATION **Mathematics for Industry and Commerce**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**	Subject objectives***	Programme content***	Teaching tool number***
PEK_W01 (knowledge)	K2MIC_W01,K2MIC_W02, K2MIC_W03,K2MIC_W06, K2MIC_W07,K2MIC_W08, K2MIC_W10	C1—C3	Lec 1—Lec 3	1,3,4
PEK_W02	K2MIC_W01,K2MIC_W02, K2MIC_W03,K2MIC_W06, K2MIC_W07,K2MIC_W08, K2MIC_W10	C2—C4	Lec2-Lec5	1, 3, 4
PEK_W03	K2MIC_W01,K2MIC_W02, K2MIC_W03,K2MIC_W06, K2MIC_W07,K2MIC_W08, K2MIC_W10	C2—C4	Lec 4—Lec 8	1,3,4
PEK_W04	K2MIC_W01,K2MIC_W02, K2MIC_W03,K2MIC_W06, K2MIC_W07,K2MIC_W08, K2MIC_W10	C4—C6	Lec 8—Lec 9	1,3,4
PEK_W05	K2MIC_W01,K2MIC_W02, K2MIC_W03,K2MIC_W06, K2MIC_W07,K2MIC_W08, K2MIC_W10	C4—C6	Lec 8—Lec 10	1,3,4
PEK_U01 (skills)	K1MIC_U01, K1MIC_U11, K1MIC_U25, K1MIC_U29	C1—C3	La1-La9	2,3,4
PEK_U02	K1MIC_U01, K1MIC_U11, K1MIC_U25, K1MIC_U29	C1—C3	La1-La9	2,3,4
PEK_U03	K1MIC_U01, K1MIC_U11, K1MIC_U25, K1MIC_U29	C2—C5	La1-La9	2,3,4
PEK_U04	K1MIC_W05, K1MIC_W06, K1MIC_W07, K1MIC_W08, K1MIC_W09, K1MIC_W10, K1MIC_W11, K1MIC_W16, K1MIC_W17	C4—C6	La1-La9	2,3,4
PEK_K01 (competences)	K1MIC_K01, K1MIC_K02, K1MIC_K06, K1MIC_K07	C1—C6	Lec1-Lec10, La1-La9	1, 2, 3, 4
PEK_K02	K2MIC_K01,K2MIC_K02, K2MIC_K03,K2MIC_K04, K2MIC_K05,K2MIC_K06 K2MIC_K07	C1—C6	Lec1-Lec10, La1-La9	1, 2, 3, 4
PEK_K03	K2MIC_K01,K2MIC_K02, K2MIC_K03,K2MIC_K04, K2MIC_K05,K2MIC_K06 K2MIC_K07	C1—C6	Lec1-Lec10,	1, 2, 3, 4

** - z tabeli powyżej