**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

Name in Polish: **Teoria optymalizacji**
**Name in English: Optimization Theory**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable):**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: obligatory ~~/ optional / university-wide*~~**
**Subject code MAT001588**
**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) | 180 | | | | |
| 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 | 6 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| 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 has basic knowledge of calculus and algebra.

**SUBJECT OBJECTIVES**

C1 Student is understanding the concepts and methods of mathematical programming.
C2 He knows and understands the formulation of the linear and quadratic programming.
C3 He has knowledge of the theoretical background of mathematical programming.
C4 He knows the computer methods of mathematical programming.
C5 He is able to apply the acquired knowledge to create and analyze mathematical models to solve theoretical and practical study in various fields of science and technology.

**SUBJECT EDUCATIONAL EFFECTS**

*The scope of the student's knowledge*:
PEK_W01: Student knows the formulation of mathematical programming problems.
PEK_W02: He has a basic knowledge about the usage and importance of mathematical programming methods.
PEK_W03: He knows the limitations of analytical methods and the possibility of numerical analysis of optimization problems.

*The scope of the student's skills*:
PEK_U01. Student is able to formulate mathematical programming problem in a

convenient form for analysis.
PEK_U02. He can use the appropriate algorithm to solve tasks in the mathematical programming.
PEK_U03. He can apply optimization methods, and analytical methods or numerical analysis, in order to solve practical problems.

*The scope of the student's social skills*:
PEK_K01 The student is able to find and use the recommended literature course and independently acquire knowledge
PEK_K02 The student is able to use the basic tools for the analysis of mathematical models
PEK_K03 The student understands the need for systematic and independent work on mastery of course material.

## Course content

| Form of activities - lectures | | Hours load |
|---|---|---|
| Wy1 | Introduction to mathematical programming. Optimization without constraints. Global and local extremes. Optimality conditions. | 2 |
| Wy2 | Gradient methods. Steepest descent method. Newton's method and its variants. Analysis of convergence. | 6 |
| Wy3 | Linear programming. Geometric interpretation. Simplex algorithm. | 4 |
| Wy4 | Dual problem. Duality theory for linear programming. Sensitivity analysis. | 2 |
| Wy5 | Integer programming. Linear programming relaxation. Branch and bound method. | 2 |
| Wy6 | The theory of Lagrange multipliers. The necessary and sufficient conditions for extreme for constraints in the equality form. Lagrange multipliers in sensitivity analysis. | 4 |
| Wy7 | Constraints in the form of inequality. Optimality conditions of Karush-Kuhn-Tucker. | 2 |
| Wy8 | Quadratic programming. Wolfe's algorithm. | 2 |
| Wy9 | Elements of convex analysis. Projection theorem. Supporting hyperplane theorem. Separating hyperplane theorem. | 2 |
| Wy10 | Optimization on a convex set. Frank-Wolfe's method. Gradient projection method. | 2 |
| Wy11 | Convex programming. Duality for convex programming. Subgradient. Subgradient methods. | 2 |
| | **Total load (in hours)** | **30** |

| Form of activities: classes, practice | | Number of hours |
|---|---|---|
| Ćw1. | Necessary and sufficient optimality conditions. | 2 |
| Ćw2. | Properties of convex functions and convex sets. | 2 |
| Ćw3. | Illustration of gradient methods. | 4 |
| Ćw4. | Simplex method. Practical applications of linear programming. Sensitivity | 8 |

| | | |
|---|---|---|
| | analysis. | |
| Ćw5. | Applications of Lagrange multiplier theory in practical optimization problems. | 6 |
| Ćw6. | Quadratic programming problems. | 4 |
| Ćw7. | Applications of convex analysis in solving optimization problems. | 2 |
| Ćw8. | Test. | 2 |
| | Total hours | **30** |

| **TOOLS FOR TEACHING** |
|---|
| 1 Lecture - traditional method.<br>2 Exercise and accounting problems - the traditional method.<br>3 Consultation.<br>4 Student's own work - preparing to exercise and test. |

**OCENA OSIĄGNIĘCIA EFEKTÓW KSZTAŁCENIA**

| **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_K01, PEK_K02 | oral presentations, quizzes, tests |
| F2 | PEK_W01, PEK_W02, PEK_W03, PEK_U01, PEK_U02, PEK_U03, PEK_K01, PEK_K02, PEK_K03 | exam |
| P=0,4*F1+0,6*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] S.P. Bradley, A.C. Hax, T.L. Magnanti, Applied Mathematical Programming, Addison-Wesley Publishing Company, 1977
[2] D.P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, MA: 1999.
[3] I. Nykowski, Programowanie liniowe, PWE Warszawa 1980.
[4] W. Grabowski, Programowanie matematyczne, PWE Warszawa 1980.
[5] R.S. Garfinkel, G.L. Nemhauser, Programowanie całkowitoliczbowe, PWN, 1978.
[6] B. Martos, Programowanie nieliniowe, Warszawa: PWN, 1983.


**SECONDARY LITERATURE:**


[7] D.P. Bertsekas, A. Nedic, A.E. Ozdaglar, Convex Analysis and Optimization, Athena Scientific, Belmont, MA: 2003.
[8] A. Ruszczyński, Nonlinear optimization, Princeton University Press, Princeton, NJ, 2006.
[9] R. Dautray, J. L. Lions, Mathematical Analysis and Numerical Methods for Science and Technology, Springer, Berlin 1988-1993.
[10] S. Boyd, L. Vanderberghe, Convex Optimization, Cambridge University Press,

| |
|---|
| 2004 |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| Dr hab. inż. Anna Jaśkiewicz (anna.jaskiewicz@pwr.edu.pl)<br>Dr inż. Piotr Więcek (Piotr.wiecek@pwr.edu.pl) |

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **OPTIMIZATION METHODS MAT001588** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MODELLING, SIMULATION, OPTIMIZATION**

| **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)** | K2MST_W01<br>K2MST _W06<br>K2MST_W10<br>K2MST_mso_W01 | C1—C2 | Wy1—Wy11 | 1,3,4 |
| PEK_W02 | K2MST _W02<br>K2MST _W07<br>K2MST_W15<br>K2MST_mso_W02 | C5 | Wy1—Wy6 | 1,3,4 |
| PEK_W03 | K2MST _W03<br>K2MST _W08<br>K2MST_mso_W03 | C3—C4 | Wy1—Wy11 | 1,3,4 |
| PEK_U01 **(skills)** | K2MST_U01<br>K2MST_U11<br>K2MST_mso_U01 | C1—C2, C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_U02 | K2MST_U19<br>K2MST_U24<br>K2MST_mso_U02 | C4—C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_U03 | K2MST_U25<br>K2MST_U29<br>K2MST_mso_U03 | C1—C2,<br>C4—C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_K01 **(competences, social skills)** | K2MST_K01<br>K2MST_K04<br>K2MST_mso_K01 | C1, C2, C3, C4, C5 | Wy1-Wy11, Ćw1-Ćw9 | 1, 2, 3, 4 |
| PEK_K02 | K2MST_K02<br>K2MST_K05<br>K2MST_mso_K02 | C1—C5 | Wy1-Wy11, Ćw1-Ćw9 | 1, 2, 3, 4 |
| PEK_K03 | K2MST_K03<br>K2MST_K06<br>K2MST_K07 | C1—C5 | Wy1-Wy11, Ćw1-Ćw9 | 1, 2, 3, 4 |

** - from table above