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

**Name of subject in Polish Badania Operacyjne**
**Name of subject in English Operations Research**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): MODELLING, SIMULATION, OPTIMIZATION**
**Profile: academic / practical***
**Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide*~~**
**Subject code**
**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 | 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 classes (P) | 1 | | 3 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 3 | | | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic notions of linear algebra and logic.
2. Student knows basics of computer programming.

**SUBJECT OBJECTIVES**

C1 Learning of basic mathematical models supporting decision-making.
C2 Learning of basic algorithms used in operations research
C3 Acquisition of abilities in constructing mathematical models for real problems.
C4 Acquisition of abilities in implementing models in a mathematical modeling language
C5 Acquisition of abilities in presenting and interpreting solutions of the constructed models.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge the student:
PEU_W01 has in-depth knowledge of linear programming
PEU_W02 knows basic models and algorithms used in operations research.

relating to skills the student:
PEU_U01 can build mathematical models for real problems
PEU_U02 can implement mathematical models using a mathematical modeling language

relating to social competences the student:
PEU_K01 can present problem solutions to non-mathematicians in an understandable way.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours** |
| Lec1 | Introduction to operations research. Formulation of the linear programming problem | 2 |
| Lec2 | Building mathematical models (1) | 2 |
| Lec3 | Building mathematical models (2) | 2 |
| Lec4 | Building mathematical models (3) | 2 |
| Lec5 | The simplex algorithm for linear programming. | 2 |
| Lec6 | Duality and sensitivity analysis in linear programming | 2 |
| Lec7 | Algorithms for integer linear programming. | 2 |
| Lec8 | Minimum cost flow problem – applications and mathematical properties | 2 |
| Lec9 | Network simplex algorithm | 2 |
| Lec10 | The shortest (longest) path problem – applications and algorithms | 2 |
| Lec11 | The maximum flow problem – applications and algorithms | 2 |
| Lec12 | The assignment, minimum spanning tree and traveling salesperson problems – applications and algorithms | 2 |
| Lec13 | Elements of computational complexity, NP-hard combinatorial optimization problems and limitations of modern computational techniques. | 2 |
| Lec14 | Multiobjective programming | 2 |
| Lec15 | Written test | |
| | Total hours | **30** |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| La1 | Introduction to MathProg (AMPL) language | 2 |
| La2 | Building and implementing linear programming models for chosen problems | 4 |
| La3 | Building and implementing integer linear programming models for chosen problems | 8 |

| | | |
|---|---|---|
| La4 | Building and implementing models for the minimum cost flow problem and its variants | 4 |
| La5 | Building and implementing models for various variants of the traveling salesperson problem | 2 |
| La6 | Building and implementation models for chosen combinatorial optimization problems | 4 |
| La7 | Building and implementing models for chosen multiobjective problems | 4 |
| La8 | Written test | 2 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture – computer presentation and traditional method<br>N2. Laboratory – building models for chosen problems and implementation of the models using the AMPL language |

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1 | PEU_W01<br>PEU_W02 | Written test (lecture) |
| F2 | PEU_U01<br>PEU_U02<br>PEU_K01 | Written test (laboratory) |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] H. A. Taha. Operations research. An introduction. Pearson Eduction 2007.
[2] F.S. Hillier, G. J. Lieberman. Introduction to operations research. Mc. Graw Hill 2001.
[3] B. Kolman, R.E. Beck. Elementary linear programming with applications. Elsevier Science 1995.


**SECONDARY LITERATURE:**


[4] A. Shrijver. Theory of linear and integer programming. J. Wiley & Sons 1999.
[5] M.S. Bazaraa, J. J. Jarvis, H. D. Sherali. Linear programming and network flows. J. Wiley & Sons 2010.
[6] R. Ahuja, T. Magnanti, J. Orlin. Network flows. Theory algorithms and applications. Prentice Hall 1993.
[7] R. Fourer, D.M. Gay, B.W. Kernighan. AMPL. A modeling language for mathematical programming, free e-book: *http://ampl.com/resources/the-ampl-book/chapter-downloads/*


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


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