Warsaw University of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-00000BC-0032	Name of the course	Polish	Metody optymalizacji	
			English	**Optimization Methods (**OPME)	
Type of the course	General courses				
Course coordinator	dr hab. inż. Artur Tomaszewski, prof. uczelni				
Implementing unit	WEiTI	Scientific discipline / disciplines*			
Level of education	Doctoral studies	Semester	Winter		
Language of the course	English				
Type of assessment:	Graded credit	Number of hours in a semester	60	ECTS credits	5
Minimum number of participants	6	Maximum number of participants	24	Available for students (BSc, MSc)	Yes/~~No~~

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	1	1	1	1	0
	in a semester	30		15	15	0

* does not apply to the Researcher's Workshop

1. Prerequisites

Fundamentals of programming and algorithms, basic notions of calculus, algebra, set theory, discrete mathematics.

2. Course objectives

Introduce the subject, making students familiar with concepts, theory, methods and tools of linear and integer programming, and of combinatorial optimization, and their application in operations research related to diverse domains: computer, road, railway and utility networks; transportation and logistics; resource, system and process management; job scheduling and crew assignment, etc. A particular area of application is optimisation of intelligent complex systems SoS (System-of-Systems) – autonomous interacting technology-intensive systems, communicating and interacting with the environment, involved in real-time decision-making – computer networks, mobile networks, sensor networks (potentially utility networks as well), and systems providing services and applications in those networks – in particular, 5G and Internet of Things services, targeting problems of design, management and real-time control of systems related to structure optimisation, resource allocation, job scheduling, etc.

3. Course content (separate for each type of classes)

Lecture

Optimization problem. Application examples of linear and integer programming.
Elements of convex analysis; separation theorem.
Linear Programming (LP) problem; formulation, feasible set, basic solutions, solution approaches. Applications. Problem modelling and formulation examples. Simplex algorithm and its variants. Linear programming duality. Constraint generation. Column generation algorithm; restricted master and pricing problems.
Elements of complexity theory; NP-completeness.
Integer Programming (IP) problem: formulation, characteristics. Applications. Problem modelling and formulation examples. Strong formulations and relaxations. Cutting plane method. Branch and bound algorithm and its variants. Lagrangean relaxation method.

Laboratory

Mathematical modeling language AMPL and its environment. Problem formulation, and declarative and procedural programming in AMPL. Problem solving and problem management in the AMPL environment.
Linear and integer programming solvers – CPLEX and GUROBI. Solver configuration and AMPL problem solving. Programming environments and native libraries of the solver. Basic linear and integer programming with solvers. Advanvced integer programming with solvers – management of constraints, cuts, solutions.

4. Learning outcomes			
	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
K01	Ma wiedzę z zakresu podstaw teoretycznych optymalizacji liniowej.	SD_W2, SD_W3	active participation during classes, homework, written test
K02	Ma wiedzę na temat metod i algorytmów obliczeniowych optymalizacji liniowej oraz ich skuteczności.	SD_W2, SD_W3	active participation during classes, homework, written test
K03	Ma wiedzę z zakresu podstaw teoretycznych optymalizacji całkowitoliczbowej.	SD_W2, SD_W3	active participation during classes, homework, written test
K04	Ma wiedzę na temat metod i algorytmów obliczeniowych optymalizacji całkowitoliczbowej oraz ich skuteczności.	SD_W2, SD_W3	active participation during classes, homework, written test
Skills			
S01	Potrafi formułować zagadnienia projektowania systemów i procesów jako zadania optymalizacyjne i komunikować się na ich temat.	SD_U1, SD_U4, SD_U6	active participation during classes, homework, written test, report evaluation
S02	Potrafi wykorzystywać języki, środowiska i narzędzia modelowania i rozwiązywania problemów optymalizacyjnych (liniowych, całkowitoliczbowych, kombinatorycznych) i komunikować się na ich temat.	SD_U1, SD_U4, SD_U6	active participation during classes, homework, written test, report evaluation
Social competences			
SC01	Rozumie rolę badań operacyjnych w optymalizacji systemów i procesów różnych dziedzin oraz ma świadomość znaczenia i zakresu stosowania metod optymalizacji (liniowej, całkowiitoliczbowej, kombinatorycznej) w tym zakresie.	SD_K2	active participation during classes

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
Results of the written test, homeworks, laboratories and project will produce the final grade.

6. Literature
Basic References: [1] S. Bradley, A. Hax, T. Magnanti, “Applied Mathematical Programming”, Addison-Wesley, 1977 [2] L. Wolsey, “Integer Programming”, Wiley, New York, 1998

[3] R. Fourer, D. Gay, B. Kernighan, “AMPL: A Mathematical Programming Language”, Management Science 36 (1990), 519–554
Additional references:
[1] A. Schrijver, “Theory of Linear and Integer Programming”, Wiley, New York, 1998
[2] G. Nemhauser, L. Wolsey, “Integer and Combinatorial Optimization”, Wiley, New York, 1998

7. PhD student’s workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	60
2	Hours of consultations with the academic teacher, exams, tests, etc.	5
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	70
4	Amount of time devoted to the preparation for exams, test, assessments	5
	Total number of hours	**140**
	ECTS credits	**5**

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)