I071	**Approximation algorithms**	L	P	S	ECTS
		2	2	0	6

Course objectives. Students will be introduced to fundamental and advanced principles in approximation algorithm design for combinatorial optimization problems for which no exact solution can be found efficiently. In this course, student will learn complexity analysis techniques for analysing problems and its approximability, i.e. how efficiently can one problem be approximated. Using linear and semidefinite programming theory students will develop methods for designing and analysing approximation algorithms. Several known combinatorial optimization problems and their approximation algorithms will be demonstrated.

Prerequisites. Undergraduate university study programme of mathematics and/or computer science.

Course content.

1. Introduction. Lower bound on optimal solution. Min-Max relations. Complexity theory overview.
2. Combinatorial algorithms. Greedy algorithm for set cover problem. Steiner tree problem and traveling salesman problem. The k-center problem. FPTAS for knapsack problem, packing problems and Euclidean TSP.
3. Machine jobs scheduling problem. Local search for facility location problem.
4. LP based algorithms. Introduction to LP duality. Min-max relations and LP duality. Set cover problem via dual fitting. Rounding and primal-dual scheme. Primal-dual scheme fir Facility location problem. The K median problem. Steiner forest problem.
5. Counting problems. Network reliability.
6. Hardness of approximation. Reductions and gaps. PCP theorem and hardness of set cover problem approximation.

LEARNING OUTCOMES

No.	LEARNING OUTCOMES
1.	Describe several well know results of approximation algorithms and examples of approximation.
2.	Apply basic design principles on developing approximation algorithms for simple problems.
3.	Argue an approximation guarantee for given algorithm with respect to design principles
4.	Argue hardness results using simple polynomial time reductions
5.	Describe basic concepts from complexity theory

RELATING THE LEARNING OUTCOMES, ORGANIZATION OF THE EDUCATIONAL PROCESS AND ASSESSMENT OF THE LEARNING OUTCOMES

TEACHING ACTIVITY	ECTS	LEARNING OUTCOME **	STUDENT ACTIVITY*	EVALUATION METHOD	POINTS	
					min	max
Attending lectures and exercises	1	1-5	Lecture attendance, discussion, teams work, independent work on given tasks and short written exams	Attendance lists, tracking activities, closed form exercises	0	0

Homework assignments	1	1-5	Independent work on given problems	Evaluation	0	20
Written exam (Mid-terms)	2	1-5	Preparing for written exam	Evaluation	25	40
Final exam	2	1-5	Revision	Oral exam	25	40
TOTAL	6				50	100

Teaching methods and student assessment. Lectures and exercises are obligatory. The exam consists of a written and an oral part. Upon completion of the course, students can take the exam. Successful midterm exam scores replace the written exam. Exercises are both auditory and laboratory. Laboratory exercises include the usage of computers. Students can improve their grades by writing homework assignments and seminars.

Can the course be taught in English: Yes

Basic literature:

1. V. Vazirani, Approximation Algorithms, Springer, 2011
2. D. P. Williamson, D.B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press, 2011

Recommended literature:

1. B. Gaertner, J. Matoušek, Approximation Algorithms and Semidefinite Programming, Springer, 2012
2. D. Hochbaum, Approximation Algorithms for NP-hard Problems, Course Technology, 1 Ed, 1996
3. B. Korte, J. Vygen, Combinatorial Optimization: Theory and Algorithms, Springer, 2018
4. C. H. Papadimitriou, K. Steiglitz, Combinatorial Optimization: Algorithms and Complexity, Dover publications, 1998