COURSE INFORMATON					
Course Title	*Code*	*Semester*	*L+P Hour*	*Credits*	*ECTS*
COMBINATORIAL OPTIMIZATION	**ESYE621**		**3+0**	**3**	**10**

Prerequisites	ISE222 or an equivalent introductory course in optimization

Language of Instruction	English
Course Level	Ph.D.
Course Type	Elective
Course Coordinator	
Instructors	Assist. Prof. Dilek Tüzün Aksu
Assistants	
Goals	This course is designed as an introduction to the fundamental concepts and methods used in combinatorial optimization. Particular emphasis will be given to complexity of combinatorial problems and the algorithms designed to solve them.
Content	Topics covered will include computational complexity and NP-completeness, matching, assignment, spanning tree, maximum flow, traveling salesman problems, integer programming, branch and bound and cutting plane algorithms, local search and approximation heuristics.

Course Learning Outcomes	**Program Learning Outcomes**	**Teaching Methods**	**Assessment Methods**
Defines combinatorial optimization problems and counts the basic properties of these problems.	1,2,3,4	1	A,D
Analyzes the computational complexity of combinatorial optimization problems.	1,3,4,5	1	A,D
Identifies the structures of combinatorial optimization problems such as minimum spanning tree, shortest path, matching, and assignment and analyzes the computational complexity of these problems.	3,5,7	1	A,D
Defines the complexity classes in the literature and categorizes combinatorial problems according to these classes.	3,5,7	1,2	A,D

Solves the combinatrial problems in class P using polynomial algorithms in the literature.	3,5,7,12	1,2	A,D
Solves problems in class NP using approaches such as cutting plane, branch and bound, branch and cut, column generation, and local search.	3,5,7,12	1,2	A,D

Teaching Methods:	1: Lecture, 2: Paper Discussion, 3: Lab, 4: Case-Study
Assessment Methods:	A: Testing, B:Paper Summary, C: Homework, D: Project

COURSE CONTENT

Week	Topics	Study Materials
1	INTRODUCTION TO COMBINATORIAL OPTIMIZATION	Textbook
2	MINIMUM SPANNING TREES	Textbook
3	SHORTEST PATHS	Textbook
4-5	MAXIMUM FLOW PROBLEMS	Textbook
6-7	MIN-COST FLOW PROBLEMS	Textbook
8	MIDTERM EXAM	Textbook
9	BI-PARTIDE MATCHING PROBLEMS	Textbook
10	GENERAL MATCHING PROBLEMS	Textbook
11	COMPUTATIONAL COMPLEXITY	Textbook, Article
12	NP-COMPLETENESS	Textbook, Article
13	THE TRAVELING SALESMAN PROBLEM (MATHEMATICAL PROGRAMMING BASED METHODS)	Textbook
14	THE TRAVELING SALESMAN PROBLEM (HEURISTICS)	Textbook

RECOMMENDED SOURCES	
Textbook	Combinatorial Optimization W.J. Cook, W.H. Cunningham, W. R. Pulleyblank, A. Schrijver Wiley-Interscience, 1997
Additional Resources	Combinatorial Optimization: Algorithms and Complexity C.H. Papadimitriou, K. Steiglitz, Dover, 1998. A First Course in Combinatorial Optimization J. Lee, Cambridge University Press, 2004. Integer and Combinatorial Optimization L.A. Wolsey, G.L. Nemhauser, Wiley-Interscience, 1999

MATERIAL SHARING	
Documents	Computational complexity article
Assignments	Homework 1-4
Exams	Midterm exam, final exam

ASSESSMENT		
IN-TERM STUDIES	**NUMBER**	**PERCENTAGE**
Mid-terms	1	38.5
Assignment	4	46.0
Attendance and participation	1	18.5
Total		**100**
CONTRIBUTION OF FINAL EXAMINATION TO OVERALL GRADE		35
CONTRIBUTION OF IN-TERM STUDIES TO OVERALL GRADE		65
Total		**100**

COURSE CATEGORY	Expertise/Field Courses

COURSE'S CONTRIBUTION TO PROGRAM							
No	Program Learning Outcomes	Contribution					
		1	2	3	4	5	
1	Ability to reach knowledge in breadth and depth through scientific research in Systems Engineering field; to have extensive knowledge about current techniques and procedures together with their constraints.			**X**			
2	Ability to complement and apply knowledge by scientific methods utilizing limited or missing data; to use knowledge in different disciplines effectively by blending them.			**X**			
3	Ability to formulate Systems Engineering problems; to develop novel and original ideas and procedures for their solutions and to use innovative procedures in solutions.					**X**	
4	Awareness of new and developing applications in Systems Engineering; ability to investigate and learn these applications when required.			**X**			
5	Ability to design and apply analytical, and modeling and experimental based research; to solve and interpret complex situations encountered in this process.					**X**	
6	Ability to lead multi-disciplinary teams; to develop solution approaches in complicated situations and to take responsibility.						
7	Ability to develop novel and/or original ideas and methods; to develop innovative solutions for the design of systems, parts or the processes.					**X**	
8	Ability to communicate orally or in writing the process and the results of Systems Engineering studies systematically and openly in national or international platforms.						
9	Ability to master a foreign language (English) at the European Language Portfolio B2 General Level to communicate orally or in writing.						
10	Ability to recognize social, scientific and ethical values in the process of collection, interpretation and publishing of data, and in all professional activities.						
11	Ability to visualize social and environmental dimensions of Systems Engineering applications and to observe these dimensions in professional practice.						
12	Ability to develop appropriate methodology and procedures for the modeling, improvement, control and design of complex systems for a specified target.					**X**	

ECTS ALLOCATED BASED ON STUDENT WORKLOAD BY THE COURSE DESCRIPTION			
Activities	Quantity	Duration (Hour)	Total Workload (Hour)
Course Duration (Including the exam weeks: 14x Total course hours)	14	3	42
Hours for off-the-classroom study (midterms)	1	35	35
Hours for off-the-classroom study (final)	1	40	40
Midterm examination	1	2	2
Homework	4	35	140
Final examination	1	2	2
Total Work Load			261
Total Work Load / 25 (h)			10,44
ECTS Credit of the Course			10