INDUSTRIAL ENGINEERING DEPARTMENT

IE 456
Graph Theory and Applications
Fall 2016

Type:	IE elective
Credits/ECTS:	3 Credits / 6 ECTS
Class/Laboratory/PS schedule:	Tuesday 9:00-10:50 (M2281) Regular class
	Thursday 11:00-11:50 (M2180) Regular class
Instructor:	Tınaz Ekim (tinaz.ekim@boun.edu.tr)
	Office Hours: T 11.00-12:00, Th 9:00-11:00
Assistant:	Oylum Şeker (oylum.seker@boun.edu.tr)
Prerequisite(s):	None

Course Description:
This course introduces graph theory as a new tool for modeling and solving several industrial engineering problems of combinatorial nature. After providing some basic notions on graphs, solution methods for some classical graph theoretical problems such as maximum matching, maximum flow and minimum coloring will be covered. A wide range of applications that can be modeled using these problems will be addressed.

References:
The following textbooks may help to a better understanding of some chapters:
1. R. Gould, Graph Theory, 1988. Online at: http://www.mathcs.emory.edu/_rg/m531.html and http://www.mathcs.emory.edu/_rg/m532.html
2. J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, 1976. Online at: http://www.ecp6.jussieu.fr/pageperso/bondy/books/gtwa/gtwa.html
3. J. Clark, D.A. Holton, A First Look at Graph Theory, World Scientific Publishing Company, 1991.
4. D. West, Introduction to Graph Theory, 2001.

Course objectives (and program outcomes):
The primary objective of this course is to provide necessary tools of graph theory in order to handle various engineering problems. Students are expected to acquire the ability of modeling real-life problems as graph theory problems and expressing their ideas using graph theory terminology. Besides their power for modeling real-life problems, graphs are also very important for their underlying mathematical theory. Consequently, the second objective is to provide students with rigorous mathematical thinking skills using graphs.
This course addresses mainly the following Student Outcomes (SOs) of the Industrial Engineering undergraduate program:

- SO (A): An ability to apply knowledge of mathematics, science, and engineering.
- SO (E): Ability to identify, model, formulate and solve industrial engineering problems.
- SO (I): A recognition of the need for, and an ability to engage in life-long learning.

- SO (K): An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice.

Topics covered:

1. BASIC NOTIONS IN GRAPHS

Definitions, graph representations, modeling using graphs, graph search (BFS, DFS), shortest paths (Dijkstra algorithm, Bellman algorithm), minimum weight spanning tree (Kruskal's algorithm, Prim's algorithm)

2. EULERIAN AND HAMILTONIAN GRAPHS

Eulerian graphs, Fleury's algorithm, Chinese Postman Problem, Hamiltonian cycles, Traveling Salesman Problem, a very short introduction to Complexity Theory

3. NETWORK FLOWS

Definitions, Maximum Flow Problem, Ford-Fulkerson Algorithm, Min Cut - Max Flow Theorem, Maximum Flow of Minimum Cost, Feasible Flows, Menger's theorem, Transshipment problem

4. MATCHING THEORY

Maximum matching, augmenting path, Edmond's algorithm, maximum matching and minimum vertex cover in bipartite graphs, König's Min-Max theorem, Min Cost bipartite matching, Assignment Problem, Hungarian Method, Stable Marriage, Gale-Shapley Algorithm, Minimum path cover

5. COLORING PROBLEMS

Edge coloring and its applications to timetabling and sport scheduling, Vizing's Theorem, König's bipartite graph edge coloring theorem, stable sets and cliques, vertex coloring and its applications to frequency assignment and aircraft scheduling, Bounds on the chromatic number (Mycielski graphs, Perfect graphs, Planar graphs and 4-color theorem, Brook's Theorem), Heuristics for graph coloring (Largest first and Smallest last sequential colorings, Brelaz's DSATUR algorithm, Tabu search)

Grading: (tentative program)
Homeworks: 7,5% each (Assigned weeks 3, 7)
Quizzes: 7,5% each (Weeks 5, 12)
Midterm: 30% (Week 9, November 16 or 17, 2016)
Final Exam: 40 %

Eligibility for the Final Exam:
In order to be eligible to take the final exam, the students are required to

- take the midterm,
- hand in the two homeworks,
- take the two quizzes,
- get at least 20% as weighted average before the final exam:
  $0.30(\text{Midterm}) + 0.075(\text{HW1}) + 0.075(\text{HW2}) + 0.075(\text{Q1}) + 0.075(\text{Q2}) > 20$ pts