INDUSTRIAL ENGINEERING DEPARTMENT

IE 456
Graph Algorithms and Applications
Fall 2020

Type:	IE elective
Credits/ECTS:	3 Credits / 6 ECTS (Letter Grade)
Class/Laboratory/PS:	Monday 11:00-11:50 (Online) Regular class Thursday 9:00-10:50 (Online) Regular class
Instructor:	Tınaz Ekim (tinaz.ekim@boun.edu.tr) Office Hours: TBA
Assistant:	TBA
Prerequisite(s):	None

Important notes for online teaching: Live Zoom sessions for regular class hours will be recorded and videos will be shared via Moodle. Students will follow the lecture notes written on the board/paper via a document camera. There will be interactive games or problem solving sessions during some lecture hours. Interactive tools and popular scientific papers related to networks will be assigned via Moodle and discussed during online/offline forums. Participation to discussions will be highly encouraged. Midterm is replaced with a group project that will be evaluated with a written report and short presentation. Office hours will be held via zoom upon booking during the given time period.

Course Description:
This course is an introduction to graph theory as a tool for modeling and solving several industrial engineering problems related to network science. After providing some basic notions on graphs, solution methods for some classical graph 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. A project based on a paper will be assigned. It will consist in reading and understanding the paper and the related literature, implementing some algorithms described in the paper, writing a detailed report and giving a short presentation.

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: https://www.iro.umontreal.ca/~hahn/IFT3545/GTWA.pdf
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), Simple Heuristics for graph coloring

Grading:

Homeworks: 7,5% each (Assigned weeks 3, 8)

Quizzes: 12,5% each (Weeks 5, 12 – During live zoom sessions)

Project: 25% (Groups of 2-3 students, Report and short presentation)

Final Exam: 35 % (In-class final exam expected)