# *SYST420*
## *Network Analysis /Network Modeling*
## George Mason University
## Systems Engineering and Operations Research Department

**Professor Karla Hoffman**
**Classroom: 1108 Nguyen Engineering Building**
**Time:** Fridays: 1:30-4:10pm
**Office:** 2207 Nguyen Engineering Building
**Phone:** 703-993-1679 (Direct) 703-993-1670 (Office)

All lecture notes, homework assignments, the posting of grades, etc. will appear at: http://mymason.gmu.edu

To access these lecture notes you will need to have registered for the course and have an active email account at GMU.

**Office hours:** Fridays: 10:00-11:00am and Thursdays 3:00-4:00pm
Warning: On the following Fridays, I will not have office hours because of the SEOR Department meetings: 9/2, 9/23, 10/28, 11/4, 12/2.

I am usually on campus Tuesdays, Thursdays and Fridays from 10:30am-6:30pm. I can also be available after class on Fridays but you must make an appointment if you want to meet with me anytime other than office hours.

**Text:** *Network Flows: Theory, Algorithms and Applications* by Ravindra K. Ahuja, Thomas L. Magnanti and James B. Orlin. Published by Prentice Hall, 1993.

**Course Description:** This course is about modeling, solving and understanding problems that can be modeled as networks, and network problems with additional side constraints. It is primarily an optimization course that also teaches some computer science concepts regarding how one measures the complexity of algorithms.

Network problems arise naturally in many disciplines such as telecommunications, electronic circuitry, water distribution, and transportation. In addition, there are problems that can be solved using network algorithms where the network structure might not be immediately obvious. There are three general topic areas covered in the course:

(1) modeling and understanding network application areas,
(2) algorithmic development of network algorithms including proofs of correctness and
(3) computational measures of goodness for such algorithms.

We will also examine network problems that fall into the class of combinatorial optimization problems because of side-constraints whereby the problem no longer can be thought of as “pure network”.

**Software:** You will be expected to use both a general purpose optimization package, (such as CPLEX or GUROBI), a optimization modeling language (MPL, AMPL, OPL Studio, or AIMMS). You will also be expected to be able to code in Python. All software is available to students free-of-charge. Instructions about how to obtain them and their general use will be provided within the class.

**Main goals:**

1. *Modeling:* Enable one to formulate optimization problems as networks and graphs (i.e. as a collection of nodes and arcs with information about any restriction on flow, any side constraints, and other data-related issues) and be able to specify an appropriate objective function.
2. *Graph Theory and Network Algorithms:* Learn the terminology of graph theory and cover the fundamental algorithm ideas for solving the main categories of network flow algorithms
3. *Data Structures, Basic Computer Algorithms and Computational efficiency* Understand simple computer science algorithms that will be used within a network algorithm, such as sorting, searching, topological ordering and decomposing flows. Identify what makes an algorithm computationally efficient and be able to measure the efficiency of specific implementations of an algorithm.
4. *Solution Techniques* Be able to solve efficiently shortest path, maximum flow, minimum cost flow, minimal spanning tree, assignment and matching algorithms. Be able to use these algorithms in more complicated combinatorial problems that have network sub-structures.

**Homework and grading:**
Homework problems will be assigned each week. Some or all of the assignments will be collected and graded.
There will be one in-class midterm exam and an in-class final. All exams are open book and open notes.

Grades will be computed as follows:

- 30% homework
- 30% midterm
- 35% final
- 5% class participation

Grading Scale:
90 -100 A; 80–89 B; 70 –79 C; 60 –69 D, 0-59 F;

**Fundamental rules:**

1. Makeup exams will only be given for extreme situations, and only if I am contacted before the exam is given and full arrangements are established.
2. The schedule of topics and exam dates are tentative and it is the student’s responsibility to keep abreast of changes.
3. Homework must be legible. Each graded homework will count 10 points. The lowest homework grade will be dropped and the other grades averaged to obtain the grade for the

homework component of the overall grade. There is a 10% penalty of the homework grade for each day that the homework is late.

4. All students must adhere to the George Mason University Honor Code

Grading Scale:
90 -100 A; 80–89 B; 70 –79 C; 60 –69 D, 0-59 F;

**Course Outline**:

The course will include all or part of the following chapters from the Network Flow text, covered in the indicated sequence. The exact scheduling will depend upon the interests of the class, which will determine the amount of time that will be devoted to each topic.

There will be two Midterm Exams. Each exam is likely to take only half of the period and then we will continue on with course work.

| WEEK | CHAPTER(S) | Topic |
|---|---|---|
| Week One | Chapters 1 and 2 | Introduction to Network Models |
| Week Two | Chapter 2 | Graph Terminology, Data Structures |
| Week Three | Chapter 3 | Some Complexity Theory and Graph Search Algorithms |
| Week | | |
| Week Four | Chapter 4 | Shortest Paths, Label-setting algorithms |
| Week Five | Chapter 5 | Shortest Paths, Heap Searches and Label-correcting Algorithms |
| Week Six | First Midterm Exam | |
| Week Seven | Chapter 6 | Basic Algorithms for Max Flow |
| Week Eight | Chapter 6 (Continued) | Combinatorial Applications of Maximum Flow Problems |
| Week Nine | Chapter 7 | Preflow Push Algorithm and Global Minimum Cut |
| Week Ten | Chapter 9 | Minimum Cost Flow Algorithm |
| Week Eleven | Second Midterm Exam | |
| Week Twelve | Chapter 11 | Network Simplex Algorithm |
| Week Thirteen | Chapter 13 | Minimum Spanning Trees |
| Week Fourteen | Review for Final Exam | |
| Week Fifteen | Final Exam | |