# ECE 442 - Network Science Analytics

## Syllabus - Spring 2025

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**Time:** Mondays and Wednesdays, 3:25 pm - 4:40 pm.
**Place:** Computer Studies Building (CSB) 601.
**Class website:** http://www.hajim.rochester.edu/ece/sites/gmateos/ECE442.html
**Make-up lectures:** Few selected Fridays, 3:25 pm - 4:40 pm in CSB 601.

**Instructor:** Gonzalo Mateos (gmateosb@ece.rochester.edu).
**Office hours:** Tuesdays 10:30 am in CSB 726.
**Teaching assistant:** Hamed Ajorlou (hajorlou@ur.rochester.edu).
**TA office hours:** Fridays 11 am in CSB 701.

**Bibliography:**

- Eric D. Kolaczyk, *"Statistical Analysis of Network Data: Methods and Models,"* Springer.

Available online from the University of Rochester library.

**Additional reading:**

- M. E. J. Newman, *"Networks: An Introduction,"* Oxford University Press.
- D. Easley and J. Kleinberg, *"Networks, Crowds, and Markets: Reasoning About a Highly Connected World,"* Cambridge University Press.
- W. L. Hamilton, *"Graph Representation Learning,"* Morgan and Claypool.
- Research papers provided by the instructor.

The books will be on reserve for the c50(and)-25se CSBLearary.

**Class description:** Network Science Analytics (ECE 442) is a graduate class about networks. The science of networks is an emerging discipline of great importance that combines graph theory, probability and statistics, and facets of engineering and the social sciences. Topics in this course will help answer intriguing questions such as: Where does "six degrees of separation" come from? How can we make sense of large graphs, ranging from social networks to the smart power grid? What are the underpinnings of Google's search engine and webpage ranking? What are good models for predicting popularity in Twitter? How can we estimate the size of the Internet?

**Class objectives:** This course will provide students with the mathematical tools and computational training to understand large-scale networks in the current era of Big Data. It will introduce basic network models and structural descriptors, network dynamics and prediction of processes evolving on graphs, modern algorithms for topology inference, community and anomaly detection, as well as fundamentals of social network analysis. All concepts and theories will be illustrated with numerous applications and hands-on case studies from technological, social, biological, and information networks.

**Topic outline:** Topics covered in ECE 442 will tentatively include

1) Introduction and overview. Why study networks?
2) Preliminaries: background on graphs, statistical inference, and optimization.
3) Descriptive network analysis: degrees, centrality, cohesion, and communities.
4) Sampling and estimation in network graphs.
5) Network models: random, small-world, preferential attachment.
6) Network topology inference: link prediction, tomographic inference.
7) Modeling and prediction for processes (evolving) over network graphs.
8) Graph signal processing and learning with graph neural networks.

Additional topics that will be left as optional readings

1) Mapping networks, visualization of large graphs.
2) Analysis of network flow data.

Visit the class website http://www.hajim.rochester.edu/ece/sites/gmateos/ECE442.html for a description of the course contents including a lecture-by-lecture schedule.

## Tentative class schedule - Spring 2025

| Date | Description | HW/Project |
|---|---|---|
| Wed. 01/22 | Introductions, class organization, networks, context, examples | |
| Fri. 01/24 | Graphs, digraphs, degrees, movement, strong and weak connectivity | |
| Mon. 01/27 | Families, algebraic graph theory, data structures and algorithms | |
| Wed. 01/29 | Inference, models, point and set estimates, hypothesis testing | |
| Mon. 02/03 | Tutorials on inference about a mean and linear regression | |