

Math 238a: 12:45pM - 2:05PM, T/F

Instructor: Yangyang Wang

Email: yangyangwang@brandeis.edu

Office Hours: T, F, 2:10-3:10 pm, Goldsmith 302

Class Time / Location: T, F 12:45pm-2:05pm, Goldsmith: 117

Main Textbooks:

- *A First Course in Network Science*, by Filippo Menczer, Santo Fortunato and Clayton A. Davis (includes Python code)
- *Networks: An Introduction*, by Mark Newman
- *Mathematical foundation of neuroscience*, by Bard Ermentrout & David Terman
- *Dynamical Systems on Networks*, by Mason Porter & James Gleeson

Topics
Mathematics of Networks
Introduction, Network Examples
Network representation, Adjacency matrix
Information networks, Bibliographic coupling, Acyclic networks
hypergraphs, bipartite graphs and projections, Multiplayer and dynamic networks
Degrees, Density and Sparsity; In-degree, Out-degree for directed networks
Walks and Paths, length, Shortest Path and the Small-World effect; Components, In- and Out-Component;
Independent paths, connectivity, Cut sets; Trees, Planar graphs
Breadth-first search: finding shortest paths, Social Distance
Graph diffusion equation Graph Laplacian, Properties Graph Partitioning; Network visualization
Random Walks on networks Resistor Networks
Measures and Metrics
Degree Centrality

Eigenvector Centrality Katz centrality PageRank
Hubs and authority Closeness Centrality Betweenness centrality
Transitivity and the Clustering Coefficients, Reciprocity Signed edges and structural balance Similarity
Python Lab: graphs and network analysis
https://cambridgeuniversitypress.github.io/FirstCourseNetworkScience/
Network Models
Random Network Models, The classic Erdos-Renyi model The configuration model, Preferential Attachment, Degree distributions, Power Laws and scale-free networks
Dynamical Processes on Networks
Epidemic spreading Social contagion Opinion dynamics
Mean-Field theories
Master stability Function Spectral of Networks Synchronization
Kuramoto Model Order Parameters
Phase reduction and weak coupling

Community Structure

Homophily and assortative mixing

Partitioning and spectral community detection
Clustering data and community definitions
Agglomerative and divisive algorithms
Modularity of a partition

Community Detection Methods based on statistical inference,
Stochastic Block Modeling

Bridge Removal, Label Propagation

Further topics

Coupled-cell networks - Symmetry & synchrony in networks

H/K theorem

Coloring balance