Introduction to Networks, MATH1010A

Izabel Aguiar | Middlebury College Winter Term 2023

Syllabus

In this course we will explore the ubiquity of networks and the beautiful mathematics that helps us understand them. Together we will cover the basics of graph theory, introduce real-world social, informational, and biological networks, explore how information (or a virus) can diffuse or cascade through a network, and learn about popular social and graph phenomena like the six degrees of separation and the friendship paradox. We will utilize jupyter notebooks and python libraries to build a toolset for studying networks and you will have the opportunity to analyze an empirical network using the ideas and tools you develop over the course of this class. No previous coding or mathematical experience is necessary: we will cover all concepts together.

Welcome to *Introduction to Networks*, I'm excited for our month together. I hope by the end of this course you have found a new joy for mathematics and that you see your world a bit differently.

The Accessibility, Grading, Policies, Quizzes and Homeworks, and Final Project sections of this syllabus are final. The other sections (especially the Weekly Agenda), however, are subject to change throughout the term. If I change something on this syllabus you will be notified by email.

Learning Goals

By the end of this class you will be able to:

- Understand networks and introductory concepts from graph theory
- Have a working proficiency in using GitHub, Python, Jupyter notebooks, and the Python library `networkx`
- Learn about both foundational and modern concepts and findings in network science.
- Practice applying your skillset to a real-world network dataset.

Course Communication

We will be using a GitHub Repository as our primary course website `github.com/izabelaguiar/midd_networks`.
We will be guided by the weekly agenda below, which will be regularly updated on the course website. Important announcements will be sent to your Middlebury email address and will be posted on the course website.
If you have questions about the course, course material, math, or life in general, please feel free to email me at `iaguiar@middlebury.edu` or visit me during my Office Hours (listed below).

Course Readings

All readings are from Easley and Kleinberg, *Networks, Crowds, and Markets.* The complete textbook is available online at

`http://www.cs.cornell.edu/home/kleinber/networks-book/`

Any readings not from this textbook will be linked and a PDF will be uploaded to the course website.

The lectures are almost entirely dependent on the corresponding chapters in this book. **Reading is not required**, however the chapters in this book will also serve as your lecture notes if you missed something in class or need to refer to specific definitions. Please note that in the tentative Agenda below, entire chapters of this textbook are referenced. Depending on our schedule we may only cover some sections within each chapter[1]. After each class I will update the agenda with the specific sections we covered.

[1] For this reason, only read entire chapters at your own leisure and for your own benefit.

Office Hours

If you'd like to come chat about the course or anything else, I'll hold weekly office hours from **10am to 12pm on Mondays and Thursdays** in Warner Hall 215. Additional office hours by appointment.

Grading

Your final grade will be determined by the following components:

- Daily Quizzes (15%)[2]
- Weekly Homework (40%)[3]
- Final Project Presentation (20%)
- Final Project Writeup (25%)

[2] Each day's quiz is graded on participation and is worth 1% of your total grade. We'll only have 12 quiz days so this means everybody gets 3% for free. For this reason, you may not makeup any quizzes from days you were absent.

[3] Each of four homework assignments is worth 10% of your final grade.

Quizzes and Homeworks

There will be a daily quiz during the first 15 minutes of each class. The quizzes will be graded pass/fail[4] and will cover one concept from the previous class. If you are not in class (either as an absence or because you're late), you will not be able to makeup the quiz. See the grading breakdown above.

Weekly homework assignments will be uploaded to the course website on Tuesday mornings, and will be due by 1pm on the following Tuesday. If you like to typeset your solutions in LaTeXyou may email me your solutions as a pdf. Otherwise, you may bring a (legible) handwritten copy to turn in before class starts.

[4] You only fail if you are not in class.

Final Project

Our final project will give you the opportunity to apply the skills you've learned throughout this class to a real dataset. You (in a group of 2-3 students) have the option to analyze a readily available dataset, or to collect your own network data. Your group is expected to prepare a 10-15 minute presentation for the last day of class, and submit a final writeup (in the form of a jupyter notebook uploaded to GitHub) of your findings and the code that you used. We will discuss all details in class during which you will have the opportunity to ask clarifying questions.

Policies

Absent Policy If you miss class you will miss the day's quiz. There are no options to retake the day's quiz (this is why quizzes are worth such a small amount of your grade).
Late Work Policy No late work will be accepted unless under approved circumstances. You must tell me why you need an extension at least one day (24h) before the deadline. Approval and extension length is at my discretion.
Collaboration policy You may discuss the assignments with other students in the class, but since the goal is to practice skills, the actual writing up of the solutions must be done separately. Your solution should not word-for-word resemble another student's.

Accessibility

Students who have Letters of Accommodation in this class are encouraged to contact me as early in the semester as possible to ensure that such accommodations are implemented in a timely fashion. For those without Letters of Accommodation, assistance is available to eligible students through the Disability Resource Center. Please contact ADA Coordinators Jodi Litchfield and Peter Ploegman in the DRC at `ada@middlebury.edu` for more information. All discussions will remain confidential.

Students also have access to Sensus Access, a web-based, self-service application that allows users to automatically convert documents into a range of alternate and accessible formats.

Weekly Agenda

[5] Mondays and Thursdays will consist of lectures with a 15 minute break in the middle. Tuesdays will be "Computer Lab"[6] days. **Please**

[5] This schedule is tentative and depends on our pace week-to-week.

[6] I don't know if Elementary School is still like this, but we used to have special days in the "Computer Lab" where we would practice typing and could play KidPix if we finished early.

bring your laptops on Computer Lab Tuesdays. We will go over a topic together and then will have an in-class activity to practice new skills.

Week One

Weekly Goals: *Getting to know each other, assessing your expectations and hopes for the class, networks in the wild, introduction to graphs.*

Reading: *Chapter 1, Chapter 2.1, Chapter 2.2,* `Graph_Types.pdf`

January 5

Introduction to {me; you; the course}. Introduction to graph theory.

Homework 0 Assigned Due Tuesday 1/10

Week Two

Weekly Goals: *Graph theory vocabulary and concepts, learn about different types of ties in social networks. Introduce the concepts of homophily, bipartite networks, and affiliation networks.*

Reading: *Chapter 2.3, Chapter 3.1, 3.2, 3.3, 3.4, 3.5, 3.6A, Chapter 4.1, 4.2,* `Adj_mats.pdf`, `Centrality_measures.pdf`

January 9

Finish introduction to graph theory, adjacency matrices, Strong and Weak Ties.

January 10

Class is asynchronous today with an optional in-person component from 3-4pm in our classroom. Introduction to python; set up jupyter notebooks; make a GitHub repository. **Important: There is still a quiz today. It will be online and you must complete it by 11:59pm today, 1/10.**

January 12

Betweenness and Graph Partitioning. Centrality measures, Homophily

Homework 1 Assigned Due Tuesday 1/17

HW0 due

Week Three

Weekly Goals: *Discuss the Friendship paradox and a modern example of social network science. Introduce some of the more well-known phenomena in network science: Power laws, rich-get-richer, and the small-world or six degrees of separation.*

Reading: Chapter 18, Chapter 20, *Friends You Can Count On. Super optional: Chetty et al. 2022, Social capital I*

January 16

No class in observation of Martin Luther King Jr. Day.

January 17

Adjacency matrices and numpy. Importing network data. Using `networkx` to visualize networks.

Homework 2 Assigned Due Tuesday 1/24

Project Proposal (Homework 3) Due Thursday 1/26

HW1 due

WiDs tonight!

January 19

Discuss final project options. Affiliation, the Friendship Paradox, Social Capital. Power Laws and Rich-Get-Richer. Small-World phenomenon.

Week Four

Weekly Goals: *Form project groups. Decide what you'd like to do for your final project. Learn about the web as a network and how search engines work. Introduction to information cascades, how news (or germs) travel through a network.*

Reading: *Chapter 13, Chapter 14, Chapter 16, Chapter 19, Chapter 21*

Final Project Writeups and Presentations Due Thursday 2/2

Project Proposal (Homework 3) Due Thursday 1/26

January 23

Project teams due January 23.

The structure of the web. Link analysis and web search. Page Rank and Page Rank activity.

January 24

HW2 due

Using `networkx` libraries to analyse real life networks.

January 26

Project Proposals due

Information Cascades and activity. Bayes' rule. Diffusion through a network. Epidemics

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Week Five

Weekly Goals: *Introduction to some more advanced applications of network science. Work on and finish final projects and presentations. Celebrate our time together.*

Reading: *None*

January 30

Example final project content and presentation. Modern applications of network science.

February 1

In-class final project workday.

February 2

Project Presentations and Writeups due

Final project due. Final project presentations; class celebration.