Math 4800 Syllabus, Spring 2017

January 8, 2017

1 General Information

• **Course:** Graph Theory (Math 4800, Section 001).

• **Description:** This course, intended for mathematics and computer science majors, is an introduction to graph theory as well as an introduction to research. It will be run as a seminar. The first nine weeks will feature student presentations of the material in the textbook. The remainder of the course will be focused on individual research projects.

• **Prerequisites:** My permission is required for enrollment. Basic familiarity with the language of mathematical proofs is assumed.

• **Instructor:** Thomas Goller. You can call me “Thomas”.

• **Course Webpage:** Google my name and follow the links. I will occasionally post materials on the course webpage.

• **Time and Place:** MW 4:35 – 5:55 PM in LCB 219.

• **Textbook:** *A First Course in Graph Theory*; by Gary Chartrand and Ping Zhang; ISBN: 978-0486483689.

• **Participation:** I expect you to be actively involved in the course!

• **Presentations:** Two 30-minute presentations based on material in the textbook (before spring break).

• **Project:** You will be working on a research project after spring break. You will give shorter presentations on your progress and write up your work in a final paper.

• **Quizzes, problem sets, final exam:** None.

• **Grading:** Based on participation, presentations, and the project. The two presentations on textbook material and the project write-up are mandatory for passing the course.
• **Missing a presentation:** Let me know several days in advance so I can cover for you! You will have to give a presentation on a later date.

• **Office Hours:** You can always talk to me before or after class or e-mail me to set up an appointment. You can also just drop by my office, JWB 307, at the risk that I might be busy right at that moment.

• **ADA Statement:** The Americans with Disabilities Act requires that reasonable accommodations be provided for students with physical, cognitive, systemic learning, and psychiatric disabilities. Please contact me at the beginning of the semester to discuss any such accommodations that you may require for this course.

• **Disclaimer:** Please remember that things on this syllabus can change! I will hold you accountable for information that is communicated in class or posted on the course webpage. Be sure to check the course webpage frequently throughout the semester.

# 2 Course Details

## Main Course Objectives

- Acquire a broad understanding of the basics of graph theory.
- Practice presenting and discussing mathematics.
- Practice bolstering geometric intuition with mathematical precision.
- Explore a topic on your own without the rigidity of problem sets and exams: this is what research is like.

## Reading the Textbook

I expect you to be familiar with every section of the textbook, including those that are not covered by the presentations. You don’t need to go through all the proofs in detail, but try to understand the key concepts and statements of theorems. The first step toward understanding a concept or theorem is being able to give examples, so focus on the examples provided in the book and think of your own examples!

Explore those topics that seem particularly interesting to you using other resources (such as the internet and other books). I hope that some of the material in the book will catch your interest and lead to a research topic. The “Excursion” and “Exploration” sections are especially valuable sources of possible research topics, so do not skip them!

## Presentations

Each class runs from 4:35 to 5:55 PM. We will have a 30-minute presentation from 4:35-5:05, followed by a 20-minute discussion and break, and then a second 30-minute presentation from 5:25-5:55.
When you present a section from the book, your main goal should be to describe the key definitions and theorems using rigorous mathematical language and also in a more intuitive way (provide examples and try to explain your intuition using words and pictures!). Try to include each of the following components in your presentation:

(a) Intuitive descriptions of key definitions and theorems

(b) Rigorous statements of key definitions and theorems

(c) Examples and pictures

(d) At least one careful proof

(e) A statement of an open problem that could lead to a research topic

(f) A relevant algorithm (if applicable)

Since 30 minutes are over quickly, you will need to condense the material in the book and streamline your presentation. Keep it as simple as possible while still presenting the highlights of the section.

Practice your presentation by yourself or with a friend (in an empty classroom or on a pad of paper). Time yourself! If you (like me) get nervous and have trouble thinking clearly at the board, then practicing your presentation once or twice will boost your confidence. If you have trouble putting your ideas into words, then practicing your explanations (ideally with another person) will greatly improve your presentation. If are struggling to construct a presentation or just want another opinion, talk to me or to other students in the class. My job is to help you, so please make use of me!

While you are preparing your first presentation, I would like you to meet with me to practice parts of your talk or at the very least show me an outline of what you are planning to talk about. The success of the first nine weeks of class depends on the quality of these presentations, so please take them seriously!

A bit of perspective: when you are presenting a section, think of yourself more as a discussion-leader than as an expert on the material. Your job is to make the material appetizing for the rest of us, and if people are engaged then you are probably doing a great job (especially if they are asking questions!). It is absolutely fine if you can’t answer a particular question; just direct the question back to the class and maybe someone can help.

**Getting Help**

Since there are no problem sets or exams, it is entirely your responsibility to keep up with the material. If you don’t understand something in the textbook, be brave and ask me or another student for help. If you want to deepen your understanding of a concept, work on some of the exercises in the book or explore other resources. In any case, you can always come to me: my job is to help you!
Projects

The first nine weeks of the course are designed to give you a broad background in graph theory and many ideas for research topics, which I will compile in a list for your convenience. The presentations and your supplementary reading should help you find a topic to pursue.

Once you have a research topic, you should read more specialized materials and start thinking about examples. Playing with examples can be a good way to come up with conjectures or algorithms. A computer program can be useful for studying numerous or complicated examples that would be too tedious to do by hand. Many of the big open problems in graph theory are extremely difficult in general (that’s why they are open!) but could be vulnerable in special cases (e.g. for special classes of graphs).

Ultimately, your goal is to make substantial progress on a conjecture or develop and study an algorithm. But this is just a class project, not a PhD thesis! The purpose of working on a project is to give you practice exploring a topic for an extended period of time and thinking creatively without the constraints of a textbook or a problem set. If you are willing to struggle, are honest with yourself, and seek out help when you are stuck, you will have something interesting to write up by the end of the course.

Programming

I highly recommend that you learn enough programming to run simple algorithms on graphs. An easy place to start is SageMath, which is free to download, allows you to store results in a worksheet, and has a huge library of graph algorithms and plenty of online documentation. For example, the code

```python
G = Graph( {0:[1,2,3], 1:[2]} )
A = G.adjacency_matrix()
print(A)
print(G.spectrum())
plot(G)
```

creates a graph with four vertices labeled 0, 1, 2, 3 and four edges 01, 02, 03, 12, prints the adjacency matrix of the graph, prints the eigenvalues of the adjacency matrix, and displays a drawing of the graph. (Hint: when learning to write simple code, the internet is your best friend. If you don’t know how to do something, google it!)

Typesetting

I highly recommend that you learn basic \LaTeX for typesetting your research paper.

Feedback

Please let me know if you have any suggestions for improving the course. I am trying to structure the course to be as engaging for you as possible, and I would be grateful if you would let me know when something is not working for you.