

Math 3322: Graph Theory

Spring 2020, Section 51

Instructor: Dr. Jennifer Vandenbussche

Meets: 9:05-9:55am MWF, Mathematics Building (D), Room 113

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Office Hours: 8:00-9:00am F, 10:05-11:05am MWF, 1:15-2:00pm M; Other times by appointment

Text: *A First Course in Graph Theory*, Chartrand and Zhang, ISBN 0-486-48368-1

Last day to withdraw with a grade of W: Wednesday, Feb. 26

Prerequisite: A grade of “C” or better in MATH 2345 or MATH 2390. **Please note: You WILL be required to write proofs.**

Catalog Course Description: This course serves as an introduction to the basic principles of graph theory. Topics include but are not limited to graph representations, isomorphisms, paths, cycles, colorings, trees, matchings, planarity, graph algorithms, and optimization.

A more detailed description: Graph theory as a relatively new and rapidly evolving area of mathematics. It has important applications in a variety of areas, including computer science, the social sciences, biology, chemistry, and logistics, to name just a few. We will just scratch the surface this semester. We will cover selected topics from chapters 1–6 and chapters 8–10 of Chartrand and Zhang’s book, including all of the topics in the catalog description and more. I will try to introduce you to applications as we go.

In addition to introducing you to the topic of graph theory, I will also be helping you to develop your logical thinking this semester, focusing on your mathematical communication and your proof-reading and proof-writing skills. This is a great course to help mathematics majors ease into higher-level mathematics courses, because it requires writing proofs, but the content is relatively visual and friendly - less abstract than some of the other courses in the major. It’s also an excellent course for students in computing disciplines who think they may want to pursue graduate work in the future, because in addition to the content being relevant to computer science, proof-writing skills are also essential for graduate school in computer science. Besides, whether you are a math major, a computer science major, or just a human being hoping to have an interesting job when you graduate, the ability to think logically and express yourself precisely will serve you well as you go forward.

Learning Outcomes: Upon completing this course, students should be able to:

- translate between formal, matrix, and visual representations of a graph
- determine when two graphs are either isomorphic or non-isomorphic
- apply algorithms on graphs
- identify non-planar graphs
- give proofs for the chromatic number of certain graphs

How can you be successful in the course? I’m going to be honest with you - this is a tough course. Because, well, math is tough! But if you have the right mindset and work ethic, and you

aren't afraid to come ask for help, you will be amazed at how much you can learn this semester. Here's what you should do:

1. *Come to class on time, and be prepared to learn and to participate.* I try to make the most of class time. I start right on time, and I keep our activities varied - some lecture, some individual practice, and some group practice. If you pay attention and work hard during the 50 minutes you are *in* class, it will help prepare you for the work you need to do *outside* of class. (And yes, you will need to do a lot of work outside of class!)
2. *Start your homework early, and try really hard to do all of it.* I cannot stress this enough. **You should expect each homework assignment to take you at least 10 (yes, TEN!!!) hours to complete.** Writing proofs is hard work! It takes preparation (you need to give yourself time to read about the topic and digest it), patience (you can rarely sit down and just write a correct proof the way you can just sit down and solve a calculus problem), and persistence. You'll have about two weeks to do each assignment, and you'll need both of those weeks!
3. *Learn how to read mathematics.* I'm going to teach you as much in class as I can, but there will probably be times when you don't completely understand something we went over. Your textbook has far more information in it than I have time to cover in class, and you can read it at your own pace. Remember, though: Mathematics should be read with paper and pencil at the ready. Reading an example requires you to set the book aside and try the example on your own so that you can learn more from it. Reading a proof requires you to fill in gaps when the writing isn't clear. (I'll give you some practice at this on your homework assignments.) The more you read, the better you will get at it, and the better you will become at learning new things yourself. (And after all, this is the goal of a college education!) However, you are still inexperienced, so sometimes reading may not be enough. In that case...
4. *Come get extra help when needed.* I really like having students in office hours - I *want* you to come see me! As soon as we hit a topic you are having trouble with, or a homework question you don't know how to start, stop by and I can point you in the right direction. There are very few students who will be able to complete every homework problem without help, and there is no shame in needing help!

Cell phone policy: Please remember to silence your cell phones when you enter the room. There is **no texting** during class for any reason. (It's distracting to both you AND me!)

Calculator: Ha! Not needed. Not wanted.

Grading Policy:

1. *Participation:* (5 points) Attending class and making the most of your time there is very important to your progress in the course. You will earn two "participation credits" for each day you (1) come to class on time, (2) leave your cell phone in your pocket or your backpack, AND (3) fully participate in any individual or group work that takes place. One point is lost for coming late or for using your phone in class. (Not participating loses you both points, but it would just be silly to make the effort to come to class and then not participate once you are there!) You can start earning credits the second week of class, and there are 40 non-exam days on which you can earn credits.

- Earning 75 or more credits is worth all five participation points.
- Earning from 72 to 74 credits is worth four participation points.
- Earning from 69 to 71 credits is worth three participation points.
- Earning from 66 to 68 credits is worth two participation points.
- Earning from 63 to 65 credits is worth one participation point.

If you need to miss class for an excused reason (feeling ill, a school-sponsored event, a work-related conflict), you can earn your two participation points by reading through the posted notes from the day you missed and emailing me **before the next class day** with (1) your reason for missing class (no documentation needed, just be honest), and (2) a question about the notes from the day you missed. (This ensures that you come back to class with at least a minimal understanding of the material you missed, so you will be on track to understand what is happening!) Note that you can miss class twice for unexcused reasons (or forget to send the email on time, or be late five (!) times) and still get full participation credit. If you receive fewer than 63 participation credits, you will not receive any participation points for the semester.

2. *Homework*: (20 points) Your success in this course – and more importantly, your successful mastery of graph theory – will depend on you practicing the things we discuss in class. There will be six assignments, each worth four points. Your five highest scores will be added to obtain your total homework grade. The end of the syllabus contains more information about homework.
3. *Exams* (25 points each): There will be three exams. The exam dates will be:
 - Exam 1: Fri. Feb. 7 (during class)
 - Exam 2: Wed. March 18 (during class)
 - Exam 3: During finals week: Wed. April 29, 8:00am

In order to be excused from an exam, you must (1) notify me **before** the start of the exam (or as soon after as the circumstances allow), and (2) provide **official documentation** (a doctor's note, etc.) excusing your absence in a timely manner. If you meet both of these conditions, then I will give you a make-up exam. (In my efforts to make sure that the make-up exam is not easier than the original exam, it is likely I will make it more difficult than the original exam.) If you fail to meet either of the two conditions, you will receive a 0 on the exam. For the purpose of exams, “official documentation” means a note from a doctor, employer, or other responsible party who can verify the reason for your absence.

Although Exam 3 will be held during finals week, it will not be a “final exam” – it will not be cumulative.

4. *Exploration Assignments* (max of 12 points total): These will be extra-credit assignments worth between 1 and 3 points each. You may submit up to two exploration assignments during the first half of the semester (the deadline is Wednesday, Feb. 26) and up to two exploration assignments during the second half (the deadline is the last day of class). The more difficult the assignment is, the more points it is worth. More information can be found at the end of the syllabus.

Grade Scale: The grade scale will be the following:

A: 90 or more points; **B:** 80 - 89 points; **C:** 70-79 points; **D:** 60-69 points; **F:** below 60 points

Online Resource: All course announcements, notes from in class, course materials, and assignments will be posted on D2L. Please check the site frequently to view announcements. Grades for homeworks and exams will also be available on D2L.

Diversity statement: Kennesaw State University prides itself on offering a premiere, personalized educational experience for leadership and engagement within a diverse nation and world. This educational experience is achieved through recognition and appreciation of the differing backgrounds and experiences reflected within the University community. It is my intent that students from all diverse backgrounds and perspectives be well served by this course, that students' learning needs be addressed both in and out of class, and that the diversity that students bring to this class be viewed as a resource, strength and benefit. Your experience in this class is important to me. I (like many people) am still in the process of learning about diverse perspectives and identities. If something is said in class (by anyone) that makes you feel uncomfortable, please talk to me about it. Also, if at any point you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with me. I want to be a resource for you.

Accommodations Statement: Any student with a documented disability or medical condition needing academic accommodations of class-related activities or schedules must contact the instructor immediately. Written verification from the KSU Student Disability Services is required. No requirements exist that accommodations be made prior to completion of this approved University documentation. All discussions will remain confidential.

Academic Integrity:

- From the university: Every KSU student is responsible for upholding the provisions of the Student code of Conduct, as published in the Undergraduate and Graduate catalogs. The Student Code of Conduct addresses the University's policy on academic honesty, including provisions regarding plagiarism and cheating, unauthorized access to University materials, misrepresentation/falsification of University records or academic malicious/intentional misuses of computer facilities and/or services, and misuse of student identification cards. Incidents of alleged academic misconduct will be handled through the established procedures of the Student Conduct and Academic Integrity department, which includes either an "Informal" resolution by a faculty member, resulting in a grade adjustment, or a formal hearing procedure, which may subject a student to the Code of Conduct's minimum one semester suspension requirement.
- From me: **I value academic integrity very highly.** I promise you that I will do whatever I can to help you to be successful in this course, and I take a personal interest in every student's success. For this reason, I also take it very personally when students do not show integrity in my course. Read my lips, tell your friends, shout it from the rooftops: **If I catch you cheating in my course, I WILL report you to the Department of Student Conduct and Academic Integrity, you WILL get a mark on your record, and NEITHER of us will be happy.** So please, don't cheat. Better to fail and have another chance at learning than demean yourself and the integrity of the institution by cheating.

Important Note About Course Withdrawal: Students are solely responsible for managing their enrollment status in a class; nonattendance does not constitute a withdrawal. However, per

university policy, I will assign a grade of WF to all students who do not complete the semester, where “not completing the semester” is defined as **ceasing to attend class and take exams prior to the last two weeks of the semester**. I am also required to report a “last attended” date for those of you that do not complete the semester. **Please note that my compliance with this policy may affect your financial aid.** The safest way to avoid problems is to either participate in the course until the end of the semester (please!), or to officially withdraw prior to the withdrawal deadline (in which case you will receive a W, rather than a WF).

If at any time you have a question or a concern about the course or your progress in it, please feel free to e-mail me, stop by office hours, or make an appointment to come see me.

Homework Information

Graph Theory is *very very cool*. Proving things in graph theory is often a lot like solving brain teasers - you’re looking for that little clever trick that makes everything fall into place. Of course, the way to get better at that (and improve your ability to think creatively and rationally at the same time while you’re at it) is to practice. A lot. So as a service to you, my students, I will assign plenty of practice problems. (Don’t rush out and get me a present all at once, now...)

The Details

The homework assignment will consist of two parts: Basic skills problems, and what I will (affectionately) call “the fun problems”. You should expect that each assignment will take at least 10 hours, so start the assignments early. The basic skills problems should not give you too much trouble if you are following what we do in class - they will just be checking your basic understanding of definitions, algorithms, and concepts. They will generally be short answer, and for full credit you must show your work or explain your answer where appropriate. I would encourage you to work with your classmates on these, but note that if you copy the answers to these problems from your classmates, you will probably not understand the material well enough to tackle...

...the “fun problems”! The “fun problems” will be more challenging. You will generally have a choice of which problems you want to submit. Most of the fun problems will involve writing a proof. In order to receive full credit on these problems, your work must be written in complete sentences with correct grammar and spelling. Usage of symbols must be consistent with standard mathematical writing (see me if you want more information on that). *Complete justification for all steps must be included*. If you have limited experience writing proofs, you should plan to come see me early and often this semester to get help. We will spend some time reviewing proof writing in class, and I will post some supplemental materials to help you, as well. **Note that you will not be able to pass this course without being able to write proofs.** (Ask students who have taken the course with me before. Just doing the non-proof questions does not collect enough points to pass.)

Each homework assignment will be worth four points: 1 point for your scratch work (more information in a minute), 1 point for the basic skills problems, and 2 points for your write-up of the fun problems. There will be six assignments over the course of the semester, and your five highest scores will be added for a total of 20 homework points available. (Particularly impressive homework

assignments may earn you a bonus point.) On days when homework is due, it must be turned in by 9:05am sharp if you bring it to class, or 8:45am if you wish to slide it under my office door or email it to me instead. If you miss class for an excused reason on a day when homework is due, you can hand it in on the following class day instead for full credit, but you must email me **before class** (or as soon as you are reasonably able) to be excused. Other late homeworks will be accepted up until the following class day for **half credit**.

What is this scratch work? When you did your calculus homework, you (for the most part) probably sat down and powered through the problems, perhaps erasing something here and there, but generally going from beginning to end without much trouble. *That's not how higher-level math works!* When you solve a challenging mathematics problem or write a proof, there are definitions you write down to remind yourself what you are trying to prove. There are starts that turn out to be incorrect. There are examples you look at to get the idea. There are rough drafts of proofs that have the main idea correct but lots of garbled details, and there are final proofs that are polished and clean. I want to see that scratch work - it helps me to diagnose where (if anywhere) you are going wrong, if you are approaching your assignment correctly, if you are thinking good thoughts that just don't quite turn out to be helpful... It gives me a lot of insight into where you stand. Since homework is meant to be a learning experience, it helps me help YOU to learn.

So when you turn in your assignment, there should be two parts: The finished, pretty version (that is worth 3 points total, 1 for the basic skills and 2 for the proofs), and the scrap work (1 point). Your scrap work can be as big a mess as you like - no need to cross off wrong things, or make it easy to follow, or anything like that. Just staple it all together and label it by question at the top of each page. Sometimes, it might be 10 pages. Sometimes, it might only be a page. But if you don't have any scrap work (you only have a "pretty" version), then chances are either (1) your pretty version could be prettier, or (2) you copied your pretty version from somewhere (which of course you will not do). Note that this means that even if you aren't able to actually write any complete proofs, but you have scrap work showing me that you tried every question - wrote down relevant definitions, looked at some examples, etc. - you can get a point for that. Essentially, it's a point just for effort! *I will show you some examples of what scratch work looks like when we work through problems in class.*

Academic Integrity - What help is allowed on homework?

Important: Use your homework as a learning opportunity. Do not cheat on it.

- For those of you that are in this class to learn (which hopefully is all of you!): Ninety percent of the learning in this course comes through struggling through the homework. (And yes, it will be a struggle sometimes!) Learning how to take the tools and ideas you have seen and apply them in new ways takes practice and a LOT of patience, but it will pay off if you are persistent. You will see your ability to reason mathematically and express yourself precisely improve over the semester, and it is very rewarding. And it is *completely fine* if you have to turn in some homework problems unfinished. The collection of mathematical proofs I have left unfinished in my life would fill several books. Just keep practicing, keep getting help, and keep giving yourself permission to not be perfect. Don't fall back on the internet or copying a friend's work, because then you rob yourself of the opportunity to learn.
- For those of you who are just in this class to pass it (which I hope is none of you): Even if you get a perfect score on the homework, most of your grade comes from the exams. If you don't

really work to understand the homework problems, you won't be able to pass the exams, and you won't pass the course. Cheating your way to a perfect homework score is not a winning strategy for success.

- For all of you: Go back and read the academic integrity statement above. **I value academic integrity very highly.** I turned in ONE THIRD of the class for academic violations last time I taught this course, and I was miserable along with the students I turned in.

In summary: Please, don't cheat.

So... What constitutes "cheating", and what collaboration is allowed?

Please, please, please - work together on the homework! Talking about definitions and examples is a great way to make sure you understand them. Discussing proofs with others can help you learn to detect flaws in proofs and to learn to explain yourself more precisely. However, **write-ups of homework must be completed alone, and you must understand what you have written.** Let me try to be as clear as possible:

What IS allowed:

- Discussing homework problems with other students and other mathematicians.
- Using **the course textbook** and **the course notes** to find ideas of how to solve the problems.
- Having a classmate read and critique your write-ups.
- Getting help from me. (By all means! I love talking about graph theory!)

What is NOT allowed:

- **Looking for solutions to homework or quiz problems in other textbooks, solutions manuals, or online. No "GOOGLING" for solutions!** (If you accidentally stumble upon a solution, be sure to cite the source when you turn your work in. However, this should be rare, because **under no circumstances should you be googling solutions to the problems.**)
- Sitting next to another mathematician (this includes students in the class and anyone else who knows anything about writing proofs) when you write down your solutions in the format you intend to submit. If you find yourself asking your classmates questions like, "How did you explain in your proof how to get from step A to step B?" then you're not putting the solutions in your own words.
- **Copying verbatim (or with superficial words changed) anything from anywhere.** This includes other students, online sources, textbooks, and solutions manuals.
- Submitting a proof that you do not understand. (For example, if you work with another student, and you find yourself writing down something that doesn't really make sense to you because your friend wrote it, that's not OK. Maybe it's not OK because it's incorrect, or maybe it's not OK because you are submitting something you don't understand. But in either case, it's not OK.)

I am an academic honesty stickler. **Every semester I teach an upper-level mathematics course, I end up referring students for disciplinary action. I do not want that to happen this semester!!!** I expect everyone to abide by the rules above (and the spirit of these rules). If you are unsure of whether or not something is allowed, **ask!** “I didn’t know that wasn’t allowed,” will not be a valid defense. Note that the homework isn’t worth enough points to make cheating worthwhile! Use it for its intended purpose: To help you learn.

Exploration Assignments

You may complete up to four exploration assignments (think “bonus homework assignments” or “make-up participation points”) over the course of the semester. Two must be completed by midway through the semester (Feb. 26), and two must be completed during the second half of the semester (due the last day of class). I will not accept more than two after Feb. 26, so if you would like to receive the maximum amount of extra credit available, you must complete two by mid semester. (FYI: Last time I taught the course, almost *everyone* wished they had turned in exploration assignments before the first deadline.)

Important note: Usually, the punishment for violating the academic integrity policy, if it is your first offense, is a 0 on the relevant assignment. However, I find the idea of cheating on extra credit assignments so offensive that **any student caught cheating on exploration assignments will have their course grade reduced by a full letter grade**, in addition to being referred to the Department of Student Conduct and Academic Integrity.

Another important note: I’m happy to help you with these assignments! If you submit your assignment *at least one week before the deadline*, I can give you feedback and allow you to resubmit it. If you come to office hours, I will talk to you about the exploration assignments. Even though these are “extra credit”, I’m happy to help you use them as a learning opportunity!

Below is a partial list of available assignments, to give you an idea of what they will look like. I will add more as the semester progresses.

- *Section 2.5 - up to 2 points.* Read section 2.5. For one point, complete exercises 2.42, 2.44, and 2.46. For an additional point, complete exercise 2.48 (a formal proof). (Note that most assignments I add later will have this flavor.)
- *Attend a research talk on graph theory - 1 point each.* The university will be hosting several such seminars over the course of the semester; I will announce them in class. In order to receive the point, you must attend the seminar and write something about what you learned. If you do additional research after the seminar to enhance your write-up (be sure to cite your sources), I may give you an additional point.
- *Connect graph theory to your life - 1 point.* Write a 1-page summary of where you have encountered graph theory in a meaningful way in either another course or in some other aspect of your life. If you do research that includes some significant mathematical content to enhance your write-up, then I may give you an additional point.
- *Other - ??? points.* If you have a suggestion for an additional activity you might complete that would enhance your learning in graph theory, feel free to discuss with me the possibility of earning extra credit for it.