MATH 268, Spring 2022: Combinatorics and Graph Theory

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Class Meetings

Mondays, Wednesdays, Fridays: 9:40 AM - 10:40 AM in Olin 230

Office Hours

Drop-in times are *daily* 11am–noon. Other times are available by appointment (just email me!), and can be conducted in person or on Zoom.

About the Course

This course consists of two distinct though related concepts in discrete mathematics combinatorics and graph theory.

The first third of the course surveys main topics in combinatorics, which is the study of counting discrete structures. Combinatorics provides practice with precision in arguments, organizing information into an equation, and writing proofs.

The last two-thirds of the course surveys main topics in graph theory. These will include (but are not limited to) graph routes, trees, connectivity, matching, coloring, and planarity. Graphs provide practice with modeling a problem using a mathematical structure, organizing information so a solution can be found, and writing proper mathematical proofs.

Intended Learning Outcomes

By the end of this course, successful students will be able to construct valid proofs that proceed efficiently from hypothesis to conclusion; identify properties of graphs; analyze problems to construct appropriate graph theoretic models; analyze counting problems to identify appropriate solution techniques; and present solutions orally and in writing.

Required Materials

Online Resource: *Combinatorics* by Joy Morris
(available at http://www.cs.uleth.ca/~morris/Combinatorics/Combinatorics.pdf) Textbook:
Graph Theory: An introduction to Proofs, Algorithms, and Applications by
Karin Saoub (ISBN: 978-0-367-74375-8)
Other: basic calculator
All work should be completed neatly in pencil or typed.

Course Grades

The following table lists the weights for the various forms of assessment for this class.

Problems Sets	24%
Combinatorics Presentation	4%
Graph Theory Presentation	4%
Applications Presentation	8%
Tests (14% each)	42%
Final Exam	18%

A grade scale will be determined after final grades are computed, but will be no worse than the scale given below. Attendance and class participation will be considered when determining marginal grades.

		B+	87-89	C+	77-79	D+	67-69		
A	94-100	B	83-86	C	73-76	D	63-66	F	0-59
A-	90-93	B-	80-82	C-	70-72	D-	60-62		

Expected Work Hours

This course expects you to spend at least 12 hours of work each week inside and outside of class.

Academic Integrity

Students are expected to adhere to the Academic Integrity policies of Roanoke College. All work submitted for a grade is to be your own work! No collaboration is allowed on quizzes or tests. Unless otherwise stated, you many work together on the homework, but should write up your solutions separately.

Cell phones must be turned off prior to entering the classroom. Laptops may be used for note-taking during regular class sessions, if this seems useful to you, but you may not log on to the internet or to an email server unless specifically told to do so. The use of laptops and other electronic devices during an in-class exam is strictly prohibited. This includes tablets, smart phones, and iPods. Any use of such devices during a quiz or exam will be considered a breach of academic integrity. Note that looking at or using your cell phone during a test or quiz is considered a violation of Academic Integrity regardless of your purpose or intent in doing so.

Face Mask Policy

The College has issued a mask mandate for the start of the semester that requires masks to be worn in indoor common spaces such as our classroom. You must wear a mask over your nose and mouth in this class. If you arrive without a mask, you will not be allowed to stay and may lose credit for attendance or in-class work. The Bookstore sells masks if you need to make a quick purchase. If the mandate is extended, you will be required to continue to wear a mask.

Attendance & Make-Up Work

Attendance is critical to the understanding of the material in the course and some days include presentations and discussions that cannot be made-up. Repeated unexcused absences may result in lowering your overall course grade by up to 10 points; however, you should not attend class if you are ill.

If you have a temperature of 100.4 or higher or other coronavirus symptoms, don't come to class. Call Health Services IMMEDIATELY. Do not come to class or go to any public area on campus. Do keep up with all readings, assignments, and deadlines. In order for your absence to be excused, you must give Health Services permission to notify me that you have consulted them about coronavirus symptoms. If Health Services informs you that you should isolate and not attend class for multiple days or weeks, inform me so that we can make a plan to keep you current in the course. All absences caused by consultation with Health Services about coronavirus symptoms or isolation ordered by Health Services will be excused but you will need to do the work and graded assignments even if we extend a deadline for you.

When absent, excused or unexcused, you are responsible for all material covered in class. You will not be allowed to make up any work missed due to an unexcused absence.

No late work will be accepted unless you have contacted me prior to the due date and obtained permission to turn in late work. Permission will be granted only for rare circumstances outside your control, such as illness. Do not wait until the last minute to submit work that is due online.

Reading and Participation

The key to learning a topic in mathematics is participation. We will strive to have an active, rather than passive, classroom environment. The last page of the syllabus is a day by day outline of the sections that will be discussed in class (this is subject to change as needed). You are fully expected to have read the upcoming section **before** the class meeting!

Problem Sets

A problem set will be due each week (excluding week 11) as shown on the schedule on the last page. These will be assigned the previous week and each are worth a total of 25 points. There are three parts to each problem set. The first part is worth 7 points and will be graded based on effort and completeness. This part consists of the three daily homework assignments for the previous three class periods. Daily homework will include more computational type problems and you are welcome to ask questions about them at the beginning of class. The second part of each problem set is worth 16 points and will be graded based on correctness and presentation. Each week you will complete 4 problems, worth 4 points each, which will be carefully graded for correctness and completion of the solution. The third part of the problem set, worth 2 points, is for presentation of the problems.

When you turn in your problem sets, make sure the four problems graded for correctness are on top and then below are your three daily assignments. Your homework should be neat, organized, and stapled. You can collaborate on problem sets but you must write up your own solution. If you are looking at another person's work when you are writing up your problem set, then you are in violation of the academic integrity policy of Roanoke College.

If you will be absent, turn in your homework before the class period it is due, or have a friend turn it in for you. Late homework will only be accepted within 2 days of the original due date and will automatically lose the completion points.

Presentations

You will be responsible for presenting some of the material in this class. You should not start on the presentation the night before it is due! These will focus on more in-depth proofs, interesting problems, or puzzles not previously introduced to the class. Students will be in small groups (around 3 students per group). There will be two different types of presentations: topic based and application based.

For the topic based presentations, groups will give 5-8 minute presentations closely related to the material we have been studying recently. The first round of presentations will be combinatorics based and occur at the end of the combinatorics portion of the course. The second round of presentations will be split amongst various days in the graph theory portion of the course, and will provide additional insight into topics recently covered in class.

For the application based presentation, each group will present on an application of graph theory. These presentations should outline not only the way in which graph theory is used to answer a question, but also provide an example of its use. These will be 10-15 minutes in length and encompass two days of class time at the end of the semester. A presentation proposal will be due April 8.

Tests

Three in-class tests will be given, roughly according to the schedule on page 5. Each test will focus on material from the most recent chapters studied. However, as with most mathematics classes, each test will require you to understand and remember things from the past.

Final Exam

The Final Exam is cumulative (covering both Combinatorics and Graph Theory) and will be more proof heavy than the in-class exams. Specific instructions will be given with the final exam regarding outside help. The Final Exam will be distributed at the end of Test 3 and is due by 11AM on Thursday April 28th.

The Final Exams must be turned in on-time; a late-penalty (after grading) of $33\frac{1}{3}\%$ will be assessed per 24 hours late (rounded up); no exceptions.

Co-Curricular Engagement

The MCSP Department offers a series of talks (MCSP Conversation Series) that appeal to a broad range of interests related to these fields of study. These co-curricular sessions engage the community to think about ongoing research, novel applications and other issues that face our discipline.

Members of this class are invited be involved with all of these meetings; however participation in **at least two** of these sessions is mandatory. After attending, students will submit a one page paper reflecting on the discussion to Inquire *within one week of the presentation*. This should **not** be a regurgitation of the content, but rather a personal contemplation of the experience.

Failure to submit a reaction paper will result in a 1% reduction in your final grade. Additional events may be attended, and subsequent reflection papers may be submitted for extra credit, with .5% added to your course average for each additional attended, up to 2% total. In addition, individually you may request that other appropriate events count.

Study Room

The MCSP Study Room, Trexler 271, can be used by you and your friends to meet up so that you can work on homework together or prepare for tests. It is open virtually 24 hours a day, 7 days a week (very occasionally there are meetings in that room). Your student ID card should grant you access to Trexler Hall any time of day if the doors happen to be locked (use the card access point located by the first floor entrance facing the parking lot). Take advantage of this area and time, especially during weekdays when I am around (which is generally a lot)!

Accessible Education Services

AES located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library. AES provides reasonable accommodations to students with documented disabilities. To register for services, students must self-identify to AES, complete the registration process, and provide current documentation of a disability along with recommendations from the qualified specialist. Please contact Becky Harman, Assistant Director of Academic Services for Accessible Education, at 540-375-2247 or by e-mail at aes@roanoke.edu to schedule an appointment. If you have registered with AES in the past and would like to receive academic accommodations for this semester, please contact Becky Harman at your earliest convenience to schedule an appointment and/or obtain your accommodation letter for the current semester.

Classroom Etiquette

I consider this classroom to be a place where you will be treated with respect, and I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability – and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records.

Tentative	Date	Section	Topic	Assignment

	Mon	Jan 17		**No Class** (Martin Luther King Jr. Day)	
1	Wed	Jan 19	2	Introduction & Product/Sum Rule	
	Fri	Jan 21	3	Permutations & Combinations	PS 1
	Mon	Jan 24	3	Binomial Theorem	
2	Wed	Jan 26	4	Bijections	
	Fri	Jan 28	4	Combinatorial Proofs	PS 2
	Mon	Jan 31	5	Repetitions	
3	Wed	Feb 2	5	Arrangements	
	Fri	Feb 4	10	Pigeonhole Principle	PS 3
	Mon	Feb 7	10	Inclusion-Exclusion	
4	Wed	Feb 9	1.1, 1.2	Introduction to Graph Theory	
	Fri	Feb 11	*Combinatorics Presentations: All groups*		PS 4
	Mon	Feb 14		**Review**	
5	Wed	Feb 16		**Test 1**	
	Fri	Feb 18	1.2, 1.4	Graph Terminology and Matrices	PS 5
	Mon	Feb 21	1.3, 1.5	Isomorphisms and proofs	
6	Wed	Feb 23	2.1	Eulerian Graphs	
	Fri	Feb 25	2.2	Hamiltonian Graphs *Graph Theory Presentation: Group A, B & C*	PS 6
	Mon	Feb 28	2.2	Hamiltonian Graphs	
7	Wed	Mar 2	3.1	Spanning Trees	
	Fri	Mar 4	3.2	Tree Properties	PS 7
				Spring Break	
	Mon	Mar 14	3.3	Rooted Trees	
8	Wed	Mar 16	4.1	Connectivity *Graph Theory Presentation: Group D & E*	PS 8
	Fri	Mar 18	4.2	Menger's Theorem	
	Mon	Mar 21	4.3	Network Flow	
9	Wed	Mar 23	5.1	Matching	PS 9
	Fri	Mar 25		**Test 2**	
	Mon	Mar 28	5.2	Augmenting Paths	
10	Wed	Mar 30	5.3	Stable Matching	
	Fri	Apr 1	5.4	Factors	PS 10
	Mon	Apr 4	6.1	Graph Coloring	

Course Schedule

11				*Graph Theory Presentation: Group F*	
	Wed	Apr 6	6.2	Graph Coloring	
	Fri	Apr 8	6.4	On-line Coloring/Brooks' Theorem	*Proposal due*
	Mon	Apr 11	7.1	Planarity	PS 11
12				*Graph Theory Presentation: Group G*	
	Wed	Apr 13	7.1	Kuratowski's Theorem	
	Fri	Apr 15		**No Class** (Good Friday)	
	Mon	Apr 18	7.2	Graph Coloring Revisited	
13	Wed	Apr 20		Graph Theory Summary	PS 12
	Fri	Apr 22		**Test 3**	
	Mon	Apr 25		*Applications Presentations: Groups A, B, C, & D*	
14	Tue	Apr 26		*Applications Presentations: Groups E, F, & G*	
	Wed	Apr 27		*Reading Day*	
	Thu	Apr 28		**Final Exam due by 11:00 AM**	