MATH 6312: Combinatorics and Graph Theory

Term: Fall 2024
Time and Place: TR 1:00pm – 2:15pm in SLC 1.204.
Instructor: Nathan Williams
Office: FO 2.402C
Office hours: TR 9:00am – 10:00am, or by appointment.
E-mail: Nathan.Williams1@utdallas.edu

Textbook: N.A. Loehr. Combinatorics (Second Edition). CRC Press, New York, *Discrete Mathematics and its Applications* (2018).

Additional Resource:

- R.P. Stanley. Enumerative Combinatorics, Volume 1 (Second Edition). *Cambridge Studies in Advanced Mathematics* (2011).
- J. Morris. Combinatorics, 2022. Available at https://www.cs.uleth.ca/~morris/Combinatorics/Combinatorics.pdf
- H. Adams, K. Emmrich, M. Gillespie, S. Golden, and R. Pries. *Counting Rocks! An Introduction to Combinatorics*, 2021. Available at arXiv:2108.04902

Pre-requisites: Theoretical Concepts of Calculus and Abstract Algebra I is required or instructor consent.

Course description: This course covers theory and applications of combinatorics and graphs, topics from basic counting principles, principle of inclusion and exclusion, permutation statistics, ordinary and exponential generating functions, composition of integers, integer partitions, Stirling numbers of the first kind, q-analogs of binomial and multinomial coefficients, Euler's formula, Hamilton paths, planar graphs, chromatic and Tutte polynomials, and algorithms on networks.

Learning Outcomes:

1. Students will be able to articulate basic definitions and theorems in enumerative combinatorics and graph theory.
2. Students will be able to apply definitions/theorems to solve problems involving application of counting principles in many counting situations.
3. Students will be able to apply graph theoretical techniques and algorithms for solving typical graph problems.

Instructional Mode: Traditional, subject to university guidance. Please visit https://www.utdallas.edu/covid/students-families-info/ for further details.

Expectations: Besides attending lectures, students should regularly and actively participate in the course by giving feedback and asking questions during class, office hours, email, or message boards.

Homework: Homework assignments will be posted on eLearning. Every assignment should be completed independently by each student; however, students are encouraged to collaborate in thinking through the homework assignments, so long as they provide the names of their collaborators. Homework will account for 25% of the course grade.

Exams: There will be two midterms and a final exam. All exams are closed-book and closed-notes.

Grading: Students must show all details of their work to receive full credit.

- Homework: 25%
- Two Exams (Exam I & Exam II): 25% each
- Final: 25%

Important dates:

Monday, August 19: Classes begin
Monday, November 25 – Sunday, December 1: University closed; Fall Break
Thursday, December 5: Classes end

Comet Creed This creed was voted on by the UT Dallas student body in 2014. It is a standard that Comets choose to live by and encourage others to do the same:

"As a Comet, I pledge honesty, integrity, and service in all that I do"

Academic Support Resources The information contained in the following link lists the University's academic support resources for all students. Please go to Academic Support Resources webpage for these policies.

UT Dallas Syllabus Policies and Procedures The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus. Please go to UT Dallas Syllabus Policies webpage for these policies.

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.

Tentative Academic Calendar

Tuesday	Thursday
Aug 20th **1** **1.1-1.5.** Sets, permutations, binomial coefficients.	22nd **2** **1.1-1.5.** Sets, permutations, binomial coefficients.
27th **3** **5.1.** Generating functions **Homework 1 due.**	29th **4** **1.6-1.9.** Probability.
Sep 3rd **5** **1.10-1.11.** Counting functions, bijections. **Homework 2 due.**	5th **6** **1.12-1.14, 5.3.** Multisets, compositions, lattice paths.
10th **7** **2.1-2.5, 5.3.** Combinatorial identities. **Homework 3 due.**	12th **8** **2.6-2.9, 5.5.** Identities and recursion.
17th **9** **Midterm I.**	19th **10** **2.10.** Catalan objects and recursions.
24th **11** **2.10.** More Catalan objects and recursions. **Homework 4 due.**	26th **12** **2.11, 5.15–5.17.** Integer partitions.

Tuesday		Thursday	
Oct 1st	**13**	3rd	**14**
2.12-2.15. Set partitions and equivalence relations, Bell and Stirling numbers **Homework 5 due.**		**2.16, 5.5.** Solving recursions.	
8th	**15**	10th	**16**
4.1–4.5. Inclusion-exclusion. **Homework 6 due.**		**4.6–4.7.** Involutions.	
15th	**17**	17th	**18**
4.9–4.12. Posets and Möbius inversion. **Homework 7 due.**		**3.1–3.3.** Graphs, digraphs, adjacency matrices, walks.	
22nd	**19**	24th	**20**
Midterm II.		**3.4–3.7.** Rooted trees.	
29th	**21**	31st	**22**
3.8–3.10. Connectedness, forests, trees. **Homework 8 due.**		**3.11–3.12.** Counting trees.	
Nov 5th	**23**	7th	**24**
3.13–3.15. Matching theorems. **Homework 9 due.**		**3.16.** Graph coloring.	
12th	**25**	14th	**26**
3.17–3.18. Spanning trees and the matrix-tree theorem. **Homework 10 due.**		**3.19.** Eulerian tours.	
19th	**27**	21st	**28**
Chapter 7. Algebraic combinatorics. **Homework 11 due.**		**Chapter 7.** Algebraic combinatorics.	
26th	**29**	28th	**30**
Fall Break		**Fall Break**	
Dec 3rd	**31**	5th	**32**
Final Exam		**Chapter 7.** Algebraic combinatorics.	