King Fahd University of Petroleum and Minerals

Department of Mathematics

Syllabus MATH 645- AY: 2025-2026 (T252)

Prof. Dr. Othman Echi (Office: 403-Building 5)

Title: Combinatorics

Textbook: Sagan, Bruce E. Combinatorics: the art of counting. Graduate Studies in Mathematics 210. Providence, RI: American Mathematical Society (AMS), 2020.

Description: Basic Counting Principles. Arrangements and Derangements. Generating Functions. Exponential generating functions. Recurrence Relations. The Sieve Formula. The Möbius inversion formula in partially ordered sets. Group Actions: Burnside and Polya-Redfield Counting theorems.

Office Hours: Every Monday from 08:30 to 10:00 AM (or by appointment via e-mail)

Week	Topics
1-2	**Preliminaries:** Review of set theory, partially ordered sets, lattices, chains and antichains; operations on posets, Dilworth's theorem and Sperners's theorem.
3- 4	**Basic Counting:** The sum and product rules for sets; permutations and words; combinations and subsets; set partitions; permutations by cycle structure; integer partitions; compositions; lattice paths; pattern avoidance.
5- 6	**Counting with Signs:** The principle of inclusion–exclusion; sign-reversing involutions; the Reflection Principle.
7-8	**Counting with Ordinary Generating Functions:** The algebra of formal power series; the sum and product rules for OGFs; revisiting integer partitions; recurrence relations and generating functions; rational generating functions; linear recursions.
9-10	**Counting with Exponential Generating Functions:** Generating functions for Eulerian polynomials; labeled structures; the sum and product rules for EGFs; the exponential formula.
11-12	**Counting with Partially Ordered Sets:** The Möbius function of a poset; the Möbius inversion theorem; quotients of posets; computing the Möbius function; binomial posets.
13-15	**Counting with Group Actions:** Groups acting on sets; Burnside's lemma; the cycle index; the Redfield–Pólya theorem.

Course Learning Outcomes

Code	CLOs	Teaching Strategies	Assessment Methods
1	**Knowledge and Understanding**		
1.1	Recall the fundamental principles of enumerative combinatorics, including counting principles, the pigeonhole principle, permutations, combinations, and binomial coefficients	Lecturing, reading, projects and assignments	Homework, project reports, presentations, exams
2	**Skills**		
2.1	Use generating functions to solve counting problems	Lecturing, reading, projects and assignments	Homework, project reports, presentations, exams
2.2	Apply the concepts of group actions, Burnside's Lemma, and Polya's Enumeration Theorem to count objects up to symmetry	Lecturing, reading, projects and assignments	Homework, project reports, presentations, exams
2.3	Derive and prove combinatorial identities using bijective proofs, algebraic methods, and various combinatorial techniques	Lecturing, reading, projects and assignments	Homework, project reports, presentations, exams
2.4	Use recurrence relations to model and address complex counting problems	Lecturing, reading, projects and assignments	Homework, project reports, presentations, exams
2.5	Employ advanced counting techniques, such as the inclusion-exclusion principle and Möbius inversion in partially ordered sets	Lecturing, reading, projects and assignments	Homework, project reports, presentations, exams

Schedule of Assessment Tasks for Students

Assessment Task*	Week Due	Proportion of Total Assessment Score
Homework	Weekly	7% (HW (2%)+ Attendance (5%))
Exam1	Week 7	20%
Exam 2	Week 11	20%
Projects/Presentations	Week 14	18%
Final exam	Week 16	35%

MATH645-03,

UT	1230-1345	63-135

Please change the room to building 4 (a small room, the number of registered students is 8)

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UT	12:30-13:45	63-135