MATH-949 Combinatorics

Credit Hours: 3-0

Prerequisites: None

Course Objectives: This course is for the students in MS/ PhD Mathematics program. The main objective of this course is to understand countable discrete structures. The main educational objectivesof this course are:

To introduce the discrete structures and discrete mathematical models

To model, analyze, and to solve combinatorial and discrete mathematical problems.

It is also aimed to develop the ability in students to apply these techniques for solving the practical problems in optimization, computer science and engineering as well as to apply combinatorial techniques in other disciplines of mathematics like algebra, graph theory and geometry etc.

Core Contents: Classical Techniques, Generating functions, Recurrence relation, Combinatorial Numbers, Partition of Integers, Inclusion-Exclusion Principal and applications, Polya's enumeration theory, Chromatic Polynomials of graphs

Detailed Course Contents: Classical Techniques: Two Basic counting principals, Binomial, Multinomial numbers and multinomial formula, combinations with or without repetitions, Permutations and permutation with forbidden positions; Brief Introduction to graphs/discrete structures. Generating Functions: Generating Function Models, Calculating Coefficients of Generating Functions, Exponential Generation Functions. Partition of Integers: Partitions of integers (their properties, recurrence relations, generating functions). Recurrence Relation: Recurrence Relation Models, Divide-and-Conquer Relations, Solution of Linear Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solution with Generating Functions. Inclusion-Exclusion Principals: Counting with Venn diagrams, Inclusion, Inclusionformula and its forms, Applications of Inclusion-Exclusion. Combinatorial Numbers: Stirling, Bell, Fibonacci and Catalan numbers (their recurrence relations, generating functions and applications to enumeration problems in graph theory and geometry). Polya enumeration theory: Equivalence and symmetry groups, Burnside's Theorem. Chromatic Polynomials: Fundamental Reduction Theorem, Chromatic Equivalence, Chromatic Uniqueness

Course Outcomes: This course is specially designed for students who want to choose pure mathematics as their specialty in general and more specifically who want to opt discrete mathematics as their research area. On successful completion of this course, students will be able

- To understand the fundamental structures and techniques of combinatorial mathematics and importance of combinatorial techniques in comparison with other techniques
- To explore the logical structure of mathematical problems,
- To develop problem solving skills in combinatorial related problems and their applications.

Text Book: Alan Tucker, Applied Combinatorics (4th Edition, 2002) John Wiley and Sons.

Reference Books:

1. John M. Harris, Jeffry L. Hirst, Micheal J. Mossinghoff, Combinatorics and Graph Theory, Springer, 2nd Edition, 2008.
2. V. Krishnamurthy, Combinatorics, theory and applications, Ellis Horwood Publ.,C
3. R . A. Brualdi, Introductory Combinatorics (5th Edition), 2010, Prentice Hall.

ASSESSMENT SYSTEM

Nature of assessment	Frequency	Weightage (%age)
Quizzes	Minimum 3	10-15
Assignments	-	5-10
Midterm	1	25-35
End Semester Examination	1	40-50
Project(s)	-	10-20

Weekly Breakdown		
Week	***Section***	***Topics***
1	5.1, 5.2, 5.5	Two Basic Counting Principles, Simple Arrangements and Selections, Binomial Coefficients and Binomial formula, Multinomial

		formula
2	5.3, 5.4, 5.5	Arrangements and Selections with Repetitions, Multinomial Coefficients and multinomial formula, The Pigeonhole Principle, Distributions, Binomials Identities
3	6.1, 6.2, 6.3	Generating Functions Models, Calculating Coefficients of Generating functions and applications, Exponential Generating Functions
4	7.1, 7.2	Recurrence Relation Models, Divide-and-Conquer relations
5	7.3,7.4	Solutions of Linear Recurrence Relations, Solution of Inhomogeneous Recurrence Relations
6	7.5	Solutions with Generating Functions
7	8.2	Counting with Venn Diagrams, Inclusion-Exclusion principle and applications
8	8.3	Permutations with forbidden positions
9	**Mid Semester Exam**	
10	2.6.4, 2.6.6	Stirling numbers (First kind and second kind) and Bell numbers (their recurrence relations, generating functions), applications of these numbers to enumeration problems in graph theory and geometry
11	2.8.2, 2.8.3	Fibonacci and Catalan numbers (recurrence relations,
12	9.1, 9.2	generating functions) and applications
13	9.3	Equivalence and symmetry groups, Burnside's Theorem,
14	6.3	Partitions of integers (their properties, recurrence relations, generating functions)
15	9.4	Polya’s Theorem and applications
16	J. M. Harris 1.6.4	Chromatic polynomials in graph colorings (properties and the fundamental reduction theorem), Chromatic Equivalence and chromatic Uniqueness
17	-	Review
18	**End semester Exam**	