William Paterson University of New Jersey
College of Science and Health
Department of Mathematics
Course Outlines

1) Title of Course and Credits:

Math 4110 - Advanced Discrete Mathematics 3 credits

2) Description of Course:

This is a course in combinatorics and graph theory with emphasis on applications. Topics to be covered include: Elements of graph theory, graph isomorphism, covering circuits and graph coloring, trees and search algorithms, enumeration of selections and arrangements, recurrence relations, generating functions, and Polya's enumeration formula.

3) Course Prerequisites:

Math 2020 Linear Algebra or CS 2600 Discrete Structures.

4) Course Objectives:

In this course, students will be introduced to fundamental techniques in combinatorics and graph theory ranging from basic principles of counting, whose simplicity masks both the power and the ease with which they can be misused, to more advanced techniques of counting, such as Polya's enumeration theorems. Students will also be introduced to elements of graph theory and learn how graphs are used in solving problems from diverse areas of natural and social sciences.

5) Student Learning Outcomes:

Up on completion of this course students will be able to

a) Formulate and solve problems from diverse areas using application specific analysis and/or generating function and graph models. This will be assessed through assignments and exams.
b) Work effectively in groups on problems that require an understanding and use of combinatorial analysis and graph theory methods, and provide answers to these problems in clear, coherent, and convincing manner. This will be assessed through assignments, exams, and projects.
c) Locate and use information on combinatorics, graph theory and their applications. This will be assessed through writing assignments and projects.

6) Topical Outline of the Course Content:

PART I: Graph Theory

Chapter 1: Elements of Graph Theory
- 1.1 Graph Models
- 1.2 graph Isomorphism
- 1.3 Edge Counting
- 1.4 Planar Graphs

Chapter 2: Covering Circuits and Graph Coloring
- 2.1 Euler Circuits
- 2.2 Hamilton Circuits
- 2.3 Graph Coloring

Chapter 3: Trees and Searching
- 3.1 Properties of Trees
- 3.3 Spanning Trees

PART II : Enumeration

Chapter 5: Counting Methods for Selections and Arrangements
- 5.1 Two Basic Counting Principles
- 5.2 Simple Arrangements and Selections
- 5.3 Arrangements and Selections with Repetition
- 5.4 Distributions
- 5.5 Binomial Identities

Chapter 6: Generating Functions
- 6.1 Generating Function Models
- 6.2 Calculating Coefficients of Generating Functions
- 6.3 Partitions

Chapter 7: Recurrence Relations
- 7.1 Recurrence Relation Models
- 7.3 Solution of Linear and Non-Linear Recurrence Relations
- 7.5 Solutions with Generating Functions

Chapter 9: Polya's Enumeration Formula
- 9.1 Equivalence and Symmetry Groups
- 9.2 Burnside's Lemma
- 9.3 The Cycle Index
- 9.4 Polya's Formula

7) <u>Guidelines/Suggestions for Teaching Methods and Student Learning Activities:</u>

This course is taught as a combination of lectures, computer demonstrations and student presentations on selected topics. Strong emphasis will be given to understanding the use of combinatorial techniques to solve enumeration problems. Computer algebra systems such as Mathematica® will be used to confirm computations throughout the course.

8) <u>Guidelines/Suggestions for Methods of Student Assessment</u>

- Through quizzes, tests, and final examination.
- Project: Project in which each student is to prepare a topic for presentation to the class. Topics on application problems will be provided.
- Homework: Homework will be assigned regularly and students should submit their work along with computer printouts. Problems which are not routine and of considerable length will be examined by the instructor.
- Classroom Participation: This is an advanced course in discrete mathematics and student participation in classroom discussions is desirable for the instructor to effectively communicate basic concepts and techniques.

9) <u>Suggested Reading, Texts and Objects of Study:</u>

Tucker, A., Applied Combinatorics, 6th Edition, John Wiley & Sons Inc., 2012.

10) <u>Bibliography of Supportive Texts and Other Materials:</u>

1. Bona, M., *A Walk Through Combinatorics*, 4th Edition, World Scientific Publishing Company, River Edge, New Jersey, 2016.
2. Wilf, H. S.; *Generatingfunctionology*, Second Edition, Academic Press, San Diego, CA 1994.
3. Graham, R.L., Knuth, D.E., and Patashnik, O., *Concrete Mathematics*, Addison-Wesley Publishing Company, 1989.
4. Lando, S. K., *Lectures on Generating Functions*, American Mathematical Society – Student Mathematical Library Series, Providence, Rhode Island, 2003.
5. Pemmaraju, S. and Skiena, S., *Computational Discrete Mathematics – Combinatorics and Graph Theory with Mathematica®*, Cambridge University Press, Cambridge, 2003.
6. Van Lint, J.H. and Wilson, R.M., *A Course in Combinatorics*, Cambridge University Press, Cambridge, 1992.

11) <u>Preparer's Name and Date:</u>

Prof. Melkamu Zeleke, Revised for BA/BS in Mathematics in Fall 2006

12) Department Approval Date:

Approved for Revised BA/BS Program in Mathematics in Spring 2008.