Southern Connecticut State University
Mathematics 378 – Discrete Mathematics

I. Description. Rigorous introduction to the basic elements of discrete mathematics: recursion, combinatorics, and graph theory.

II. Credit.
  A. MAT 378 carries three semester-hours of credit.
  B. MAT 378 does not satisfy the general education requirement in mathematics.
  C. MAT 378 is required of all mathematics majors studying for the B. S. degree in applications of mathematics and recommended for computer science majors going to graduate school.

III. Prerequisites.
  A. C- or better in MAT 151.
  B. C- or better in MAT 250 or MAT 178.
  C. CSC 152.

IV. Purpose. This course is a rigorous introduction to the topics listed in I. and is intended for mathematics majors and computer science majors with a strong mathematics background. Many of the topics in MAT 378 are the same as in MAT 178. The difference is that in MAT 378 there is a deeper coverage of the topics with an emphasis on proofs, not just techniques and definitions. Mathematics majors would normally take this course in their junior year.

V. Format. MAT 378 is a lecture format course with time provided for discussion and problem solving. Computer work that illustrates some of the course concepts is recommended.

VI. Course Outcomes: Candidates apply the fundamental ideas of discrete mathematics in the formulation and solution of problems. (NCATE Standard 13) Students will be able to:
  1. Demonstrate knowledge of basic elements of discrete mathematics such as graph theory, recurrence relations, finite difference approaches, and combinatorics. (NCATE 13.1)
  2. Apply the fundamental ideas of discrete mathematics in the formulation and solution of problems arising from real-world situations. (NCATE 13.2)
  3. Use technological tools to solve problems involving the use of discrete structures and the application of algorithms. (NCATE 13.3)
  4. Demonstrate knowledge of the historical development of discrete mathematics including contributions from diverse cultures. (NCATE 13.4)

VII. Outline. (Based on 42 classes, with 5 classes reserved for testing and review.)
  A. Recursion and Induction (8%)
    1. Review mathematical induction using advanced examples and both forms of induction. (3%)

2. Recursion (3%)
3. Solving linear recurrence relations and difference equations (4%)

B. Combinatorics and Algebra. Note: Cover 1-4 and choose one of 5, 6, 7. (42%)
   1. Pigeonhole principle (5%)
   2. Inclusion-Exclusion – general principles and some applications, for example permutations with forbidden positions or the number of onto functions (6%)
   3. Function counting (11%)
      a. Permutation.
      b. Binomial coefficients and properties.
      c. Stirling numbers and recursions (optional)
      d. Partitions and recursions (optional)
   4. Generating Functions (Note: cover a and choose one from b, c, d) (7%)
      a. Binomial coefficients
      b. Stirling numbers, first and second kind
      c. Partitions
      d. Fibonacci numbers
   5. Polya enumeration (13%)
      a. Equivalence relations
      b. Groups and Burnside's lemma
      c. Cycle index
      d. Polya's theorem
   6. Coding theory (13%)
      a. Error correcting codes
      b. Linear codes
      c. Hamming codes
   7. Partially ordered sets (13%)

C. Graphs, Trees, and Networks (48%)
   1. Graphs. (25%)
      a. Definitions of a graph.
      b. Paths and circuits.
         i. Eulerian paths and circuits
         ii. Hamiltonian paths and circuits
         iii. Incidence matrix
      c. Graph isomorphism
      d. Bipartitie graphs
      e. Planar Graphs
      f. Coloring (Four Color Map Theorem)
      g. Matching (optional)
   2. Trees (8%)
      a. Basic definitions
      b. Searching or sorting algorithm; e.g. binary search, depth first search, merge sort, bubble sort.

3. Networks. Note: Cover a and b and choose one of c, d. (15%)
    a. Definitions
    b. Minimal spanning trees (Kruskal's and/or Prim's algorithm)
    c. Network flows (Dijkstra's algorithm)
    d. Max flow-Min cut theorem

VIII. Recommended Texts:

A. *Discrete Mathematics and Its Applications – Sixth Edition,* Kenneth H. Rosen, McGraw-Hill, 2007

B. *Discrete and Combinatorial Mathematics: An Applied Introduction (4th Edition)*, Ralph Grimaldi, Addison-Wesley, 1998

IX. Waiver Policy. This course cannot be waived.

X. Preparation. Prepared by Michael R. Meck, June 20, 1985. First Revision by Susanna Fishel, Henry Gates, Bodh Gulati, and Michael R. Meck, 1993. Second Revision by Joseph Fields, Martin Hartog, Val Pinciu, and Terry Sandifer, 2007.

XI. References

1. C. Berge. *Principles of Combinatorics.* Academic Press, 1971. A classic introduction in a somewhat terse French style with a delightful foreword by Gian-Carlo Rota.

2. N.L. Biggs, E. K. Lloyd, and R. J. Wilson. *Graph Theory, 1736-1936.* Oxford Press, 1976. An excellent source for original papers and historical information.

3. Norman L. Biggs. *Discrete Mathematics, Revised Edition.* Clarendon Press, 1989. Contians all the outline's topics. Contains many extra computer science topics.

4. Kenneth Bogart. *Introductory Combinatorics, Second Edition*. 1990. Contains all the outline's topics.

5. Bèla Bollobás. *Graph Theory – An Introductory Course.* Springer-Verlag, 1979. Good source for graph theory, in depth. Graduate Text.

6. J. A. Bondy and U. S. R. Murty. *Graph Theory with Applications.* Elsevier North Holland, 1976. Good source for extra graph theory problems.

7. Richrd A. Brualdi. *Introductory Combinatorics.* Elsevier North Holland, 1977. Contains all the outline's topics. More advanced text.

8. Daniel I. A. Cohen, *Basic Techniques of Combinatorial Theory.* Wiley, 1976. A text, with a good selection of problems, based on courses at Harvard and Northeastern.

9. Ronald L. Graham, Donald e. Knuth, and Oren Patashnick. *Concrete Mathematics.* Addison-Wesley Publishing Company, 1989. Good for cominatorics; generating functions in particular.

10. David Gries and Fred. B. Schneider. *A Logical Approach to Discrete Mathematics.* Springer Verlag, 1993. A Text, written for students at Cornell, which takes a non-traditional approach in which "logic is the glue."

11. Ralph P. Grimaldi. *Discrete and Applied Mathematics*, 3rd edition. Addison Wesley Co., 1994.

12. Ralph Grimaldi, *Discrete and Combinatorial Mathematics: An Applied Introduction (4th Edition)*, Addison-Wesley, 1998. A recommended text.

13. Frank Harary. *Graph Theory.* Addison-Wesley, 1964. A classic reference suitable for instructors.

14. C. L. Liu. *Introduction to Combinatorial Mathematics.* McGraw-Hill, 1968. An older but still valuable text.

15. Fred S. Roberts. *Applied Combinatorics*. Prentice Hall, 1984. A recommended text.

16. Steve Roman. *An Introduction to Discrete Math.* Harcourt, Brace, Jovanovich, 1989. Contains background material, more elementary text.

17. Kenneth H. Rosen. *Discrete Mathematics and Its Applications, Second Edition.* McGraw-Hill, Inc., 1991. Contains many but not all of the topics. Many exercises.

18. Richard P. Stanley. *Enumerative Combinatorics, volume 1.* Wadsworth & Brooks/ Cole Advanced Books & Software, 1986. Good for enumeration and partially ordered sets. Graduate text.

19. Dennis Stanton and Dennis White, *Constructive Combinatorics.* Springer-Verlag, 1986. Algorithmic approach to combinatorics, more advanced, many computer projects.

20. H. Joseph Straight. *Combinatorics: An Introduction.* Brooks/cole, 1993. A new text which covers the topics in our course.

21. Alan Tucker. *Applied Combinatorics*, by John Wiley & Sons, 1984. A recommended text.