University of Wisconsin, Department of Sociology
Sociology 375: Introduction to Mathematical Sociology
Fall 2007

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2436 Social Science
Office hours: Friday 9:30-11:30 AM or by appointment

Overview. Mathematical sociologists use mathematics to represent and analyze sociological concepts and theories. In this course, we explore mathematical models of *social structure*, focusing especially on social network analysis and related methods. [A second course in mathematical sociology (tentatively planned for Spring 2008) will focus on mathematical models of *social process*, addressing the use of Markov chains and dynamical systems in sociology.]

Prerequisites. There is no particular mathematics prerequisite. However, past experience suggests that students with weak backgrounds in math often find the course difficult. We will make extensive use of matrix algebra, but the course is intended to be self-contained for students who have not previously studied this topic. Students will also learn and apply some elementary set theory, graph theory, and abstract algebra. Students who have taken Math 240 (Discrete Mathematics) and Math 340 (Matrix Algebra) or equivalents will already know the relevant mathematics, and students with some background in computer programming may have an advantage. There is no sociology prerequisite, so the course is well-suited for students with other (quantitative) majors.

Evaluation. Grades will be based on two exams (a midterm and a final), as well as problem sets. The midterm exam will be held in class on **Thursday, October 25**. The final will be held during test week on **Thursday, December 20, at 10:05 am.** Each exam is worth 1/3 of the grade; the problem sets comprise the final 1/3.

Exams. The exams will follow the format of old exams (see below). Students should bring calculators to the exams. Graphing calculators (which can multiply matrices) are permitted but not necessary.

Old exams. Copies of old exams (with solutions) are posted on my website: www.ssc.wisc.edu/~jmontgom These old exams are an importance resource for learning the course material, and students are strongly encouraged to work through these problems as we go along. (Don't wait until the night before the exam!) Note that, because the content of the course changes from year to year, some old exam problems will be irrelevant. [The material covered this term will be very similar to the material covered in Spring 2007. For earlier years, some material addressed on the second exam (e.g., Markov chains, demography, network influence models) has been shifted to the second mathematical sociology course. Please see me if you are unsure whether we have covered particular questions on old exams.]

Problem sets. There will be approximately one problem set assigned per week. Problem-set questions are usually more complicated than test questions, and often require the use of Matlab software (see below). Problem sets will be graded on a three-point scale, corresponding roughly to full credit (3), a good-faith effort (2), a bad-faith effort (1), and no effort (0).

Software. In this course, we will make extensive use of the mathematical software package Matlab. You are not expected to have any previous familiarity with this software **but must be willing to learn**. Knowledge of Matlab will be necessary to follow the lectures (which are often supplemented with Matlab handouts) and to complete many of the problem sets. We will spend two class periods in the Social Science Computing Lab learning Matlab, but some students may need to spend additional time on their own with the Matlab tutorial to become more proficient. Students will be able to use this software in the Social Science Micro Lab. (Alternatively, this software is available in some DoIT labs on campus, and can also be purchased from DoIT at a special student price. I'm happy to e-mail m-files to students working outside the SSML.)

Readings. There are two textbooks for this course, along with a reading packet. One text is *Introduction to Mathematical Sociology* by Phil Bonacich, available in manuscript form at his website:

http://www.sscnet.ucla.edu/soc/faculty/bonacich/textbook.htm

While it covers many of the same topics as the Bonacich book, you may also find useful the book *Matrices and Society* by Ian Bradley and Ronald L Meek (Pelican 1986). This book is unfortunately out of print, but photocopies will be available for purchase at the University Book Store. The remaining readings will be contained in a photocopied reader available from the Social Science Copy Center.

Honors credit. To receive honors credit for the course, students need to write their own problem sets (and provide solutions) for 4 of the topics numbered 5 through 13 on the course outline below. You can choose whichever four topics you wish. Your problems may supplement or extend the problems on the class problem set, but you should also feel free to be more creative, exploring other applications of course material. Some of the honors problems sets may be used as class problem sets in future years.

Further reading. This course is intended as a first introduction to mathematical sociology. For more advanced treatment of the topics of this course (and many other topics not covered), see

James S Coleman (1964) *Introduction to Mathematical Sociology*. Free Press.
Thomas J Fararo (1973) *Mathematical Sociology*. Wiley.
Robert K Leik and B F Meeker (1975) *Mathematical Sociology*. Prentice Hall.
Ki H Kim and Fred W Roush (1980) *Mathematics for Social Scientists*. Elsevier.
Stanley Wasserman and K Faust (1993) *Social Network Analysis*. Cambridge.
Philippa Pattison (1994) *Algebraic Models for Social Networks*. Cambridge.
P J Carrington, J Scott, S Wasserman, editors (2005) *Models and Methods in Social Network Analysis*. Cambridge.
Dieter Jungnickel (2005) *Graphs, Networks, and Algorithms* Springer.

Many social network analysts use the software package UCINET available from Analytic Technologies. Their website is http://www.analytictech.com

Changes in the schedule. The tentative course outline is below. As already noted, the exam dates are fixed. I anticipate that the midterm will cover sections 1 to 7, while the final exam will cover the remaining material. But the actual content of the exams will be announced in class before the exam. More generally, announcements of changes in course material and procedures may from time to time be made in class and students will be responsible for the changes whether present or not.

I. Mathematical and Computational Preliminaries

1. Logic

Keith Devlin (1992) *Sets, Functions, and Logic*. Chapman & Hall. Ch 1.1-1.4, "Use of Language in Mathematics," pp 1-20.

2. Sets and Relations

Bonacich, Chs 1-3.

3. Matrices

Bonacich, Chs 4-5.
Bradley and Meek, Chs 1-2.

4. Introduction to Matlab

Instruction will be given in class, but students might also work through the tutorial contained in Matlab documentation on the computers in Social Science Micro Lab. Begin with the section "Getting Started."

II. Structure

5. Connectivity and the Small-World Phenomenon

Per Hage and Frank Harary (1983) *Structural Models in Anthropology*. Cambridge University Press. Ch 5, "Graphs and Matrices," pp. 93-113.

Duncan Watts (1999) "Networks, Dynamics, and the Small-World Phenomenon," *American Journal of Sociology* 105(2): 493-527.

Jeffrey Travers and Stanley Milgram (1969) "An Experimental Study of the Small World Problem," *Sociometry* 32(4): 425-443.

Duncan Watts, Peter Sheridan Dodds, and M E J Newman (2002) "Identity and Search in Social Networks," *Science* 296(17 May 2002): 1302-1305.

6. Cohesion

Stanley Wasserman and Katherine Faust (1994) *Social Network Analysis*. Cambridge University Press. Ch 7.1-7.2, "Cohesive Subgroups," pp 249-263 and 743-744.

James Moody and Douglas R White (2003) "Structural Cohesion and Embeddedness: A Hierarchical Concept of Social Groups," *American Sociological Review* 68:103-127.

7. Positions in Social Networks

Patrick Doreian (1988) "Equivalence in a Social Network," *Journal of Mathematical Sociology* 13:243-82.

Alain Degenne and Michel Forse (1999) *Introducing Social Networks.* Sage Publications. Ch 4, "Equivalence and Cohesion," pp 78-106.

8. Dominance Hierarchies

Bradley and Meek, Ch 5.

Phillip Bonacich (1987) "Power and Centrality: A Family of Measures," *American Journal of Sociology* 92(5): 1170-82.

9. Persons and Groups

Ronald Breiger (1974) "The Duality of Persons and Groups," *Social Forces* 53:181-190.

Linton C Freeman and Douglas R White (1983) "Using Galois Lattices to Represent Network Data," *Sociological Methodology* 23:127-146.

Ronald L Breiger (2000) "A Tool Kit for Practice Theory," *Poetics* 27:91-115.

Iven Van Mechelen and Paul De Boeck (1995) "The Conjunctive Model of Hierarchical Classes," *Psychometrika* 60:505-521.

10. Factor Analysis and Correspondence Analysis

Susan C Weller and A Kimball Romney (1990) *Metric Scaling: Correspondence Analysis*. Sage. Chs 2-3, "The Basic Structure of a Data Matrix" and "Principal Components Analysis," pp. 17-34.

Roderick P McDonald (1985) *Factor Analysis and Related Methods*. Lawrence Erlbaum. Ch 2.3.a, "Principal Component Theory," pp 62-68.

Stanley Wasserman and Katherine Faust (1994) *Social Network Analysis*. Cambridge University Press. Ch 8.6.2, "Correspondence Analysis," pp 334-342 and 755.

11. Balance Theory, Ranked Clusters, and the Triad Census

Bonacich, Ch 7

Gary Chartrand (1977) *Introductory Graph Theory*, Dover. Ch 8, "Graphs and Social Psychology," pp 171-190.

Paul W Holland and Samuel Leinhardt (1971) "Transitivity in Structural Models of Small Groups," *Comparative Group Studies* 2:107-124.

James A Davis and Samuel Leinhardt (1972) "The Structure of Positive Interpersonal Relations in Small Groups," in Sociological Theories in Process, Vol 2, ed by J Berger, et al, pp 218-231 (first part).

12. Kinship and Marriage Systems

Bradley and Meek, Ch 4
Bonacich, Ch 8

Tony Barnard and Hugh Neill (1996) *Mathematical Groups.* Teach Yourself Books. Ch 5, "Groups," pp. 33-48.

John Paul Boyd (1969) "The Algebra of Group Kinship" *Journal of Mathematical Psychology* 6:139-167.