University of Wisconsin, Department of Sociology
Sociology 375: Introduction to Mathematical Sociology
Fall 2014

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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, Soc 376, which is taught in the spring, focuses 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 quite difficult. We will make extensive use of matrix algebra (as well as the matrix-algebra software package Matlab), though the course is intended to be self-contained for motivated students who have not already studied this topic. We will also learn and employ some elementary concepts from set theory and graph theory. Students who have taken Math 240 (Discrete Mathematics) and Math 340 (Matrix Algebra) or equivalents will already know the relevant mathematics. Students who have previously used mathematical software and/or have 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 23**. The final will be held during test week on **Sunday, December 14 at 2:45pm.** Each exam is worth 1/3 of the grade; the problem sets (described below) comprise the final 1/3.

Exams. The exams will follow the format of old exams (see below). While the final exam is not intended to be cumulative, some of the material in the second half of the course builds on concepts introduced in the first half. Students should always 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. 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 usually 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 most of the problem sets. We will spend several 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 can use this software in the Social Science Micro Lab or else access it online through the Social Science Computing Center website.

Readings. The readings will be posted as pdf files at the course site on Learn@UW (accessed through the UW homepage, or directly at https://learnuw.wisc.edu). Because we make extensive use of Matlab, I also recommend the book

*David McMahon, *MATLAB Demystified*, McGraw-Hill, 2007

which has been ordered at the bookstore. (The first several chapters of this book appear on the reading list below. Note that these chapters are *not* posted on the course Learn@UW site. You need to buy the book.)

Honors credit. Undergraduates automatically receive honors credit for this course.

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

Thomas J Fararo, *Mathematical Sociology*. Wiley, 1973.
Robert K Leik and B F Meeker, *Mathematical Sociology*. Prentice Hall, 1975.
Ki H Kim and Fred W Roush, *Mathematics for Social Scientists*. Elsevier, 1980.
Stanley Wasserman and K Faust, *Social Network Analysis*. Cambridge, 1993.
Philippa Pattison, *Algebraic Models for Social Networks.* Cambridge, 1994.
P J Carrington, et al, eds, *Models and Methods in Social Network Analysis*. Cambridge, 2005.
Dieter Jungnickel, *Graphs, Networks, and Algorithms* Springer, 2005.
Matthew O Jackson, *Social and Economic Networks*. Princeton, 2008.
Phillip Bonacich and Philip Lu, *Introduction to Mathematical Sociology*. Princeton 2012.

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 6, 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.

Course Outline

1. Matrices

Ian Bradley and Ronald L Meek (1986), *Matrices and Society*, Chs 1-2, "Matrices and How to Manipulate Them" and "Matrix Inversion," pp 13-41.

2. Getting Started in Matlab

*David McMahon, *MATLAB Demystified*, Chs 1-3, "The MATLAB Environment" and "Vectors and Matrices" and "Plotting and Graphics," esp pp 1-85.

Matlab also contains built-in instructional materials. Click on the links at the top of the Command Window to access Videos or Examples or the Getting Started tutorials.

3. Graphs, Matrices, and Relations

Per Hage and Frank Harary (1983) *Structural Models in Anthropology*. Cambridge University Press. Ch 4, "Digraphs," esp pp 68-80, and Ch 5, "Graphs and Matrices," pp 93-113.

[optional reading on logic and set theory: Keith Devlin (1992) *Sets, Functions, and Logic.* Chapman & Hall. Ch 1.1-.6, "Use of Language in Mathematics," pp 1-34, and Ch 2, "Set Theory," pp 52-72.]

[optional reading for problem set 4: George Homans (1951) *The Human Group.* Ch 3, "The Bank Wiring Observation Room," pp 48-80.]

4. Programming in Matlab

*McMahon, MATLAB Demystified, Ch 4, "Statistics and an Introduction to Programming in MATLAB," pp 97-120

See also the Matlab tutorial. Read the "Programming" section (which follows the "Graphics" section).

5. The Small-World Phenomenon

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 (1986), Matrices and Society, Ch 5, "Dominance in Coops and Courts," pp 79-91

Phillip Bonacich (1987) "Power and Centrality: A Family of Measures," *Am J Soc* 92(5): 1170-82.

[optional reading on Bonacich centrality: Phillip Bonacich and Paulette Lloyd (2001) "Eigenvector-like Measures of Centrality for Asymmetric Relations," *Social Networks* 23: 191-201]

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 (1993) "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.

[optional reading: P G N Digby and R A Kempton (1987) Multivariate Analysis of Ecological Communities. Ch 3, "Ordination," pp 45-75, and Appendix, "Matrix Algebra," pp 193-203]

11. Balance Theory

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

Patrick Doreian and Andrej Mrvar (1996) "A Partitioning Approach to Structural Balance," *Social Networks* 18:149-168.

12. Ranked Clusters and the Triad Census

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).

13. Kinship and Marriage Systems

Bradley and Meek (1986), *Matrices and Society*, Ch 4, "Matrices and Matrimony in Tribal Societies," pp 61-78

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.