Complex Systems 535/Physics 508: Network Theory

Fall 2017

Time: Tuesday and Thursday, 10–11:30am
Room: 1028 Dana Building

Instructor: Mark Newman
Office: 322 West Hall
Office hours: Mondays 2–4pm
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Web site:

Everything on this information sheet, along with a complete syllabus for the semester, can be found on the course web site:

`http://www.umich.edu/~mejn/courses/2017/cscs535`

Description:

This course will introduce and develop the mathematical theory of networks, particularly social and technological networks, with applications to network-driven phenomena in the Internet, network resilience, search engines, epidemiology, and many other areas. Topics covered will include experimental studies of social, technological, and biological networks; methods and computer algorithms for the analysis and interpretation of network data; graph theory; models of networks including random graphs and preferential attachment models; community structure; percolation theory; network search.

Requirements:

Students should have studied calculus and linear algebra before taking the course, and should in particular be comfortable with the solution of linear differential equations and with the calculation and properties of eigenvalues and eigenvectors of matrices. In addition, a moderate portion of the course, perhaps four or five lectures, will deal with computer methods for studying networks. Some experience with computer programming will be a great help in understanding this part of the course.

Coursework:

There will be weekly graded problem sets, consisting both of theory questions and of problems demonstrating applications of theory to example networks. There will be three midterm exams but no final. Grade will be 25% on the homeworks and 25% on each of the midterms.

There will be reading assignments for each lecture. The assignments are listed on the web site. Students are expected to do the reading for each lecture in a timely manner.

Course packs (required):

There is no textbook for this course but there will be two course packs. The first will cover the first part of the semester up to the first midterm exam; the second will cover the remainder of the semester. The first course pack is available now from Dollar Bill Copying on Church Street. Ask for CMPLXSYS 535, Bin #6081.

Other books and reviews:

In addition to the course packs, a list of relevant books is given below. None of them is required, but you may find them useful if you want a second opinion or more detail on certain topics.

- A.-L. Barabási, *Network Science*. Cambridge University Press, Cambridge (2016)
- R. Cohen and S. Havlin, *Complex Networks: Structure, Stability and Function*. Cambridge University Press, Cambridge (2010)
- S. Dorogovtsev, *Lectures on Complex Networks*. Oxford University Press, Oxford (2010)
- M. E. J. Newman, *Networks: An Introduction*. Oxford University Press, Oxford (2010)

There are a number of review articles that cover parts of the syllabus:

- S. H. Strogatz, Exploring complex networks. *Nature* **410**, 268–276 (2001)
- R. Albert and A.-L. Barabási, Statistical mechanics of complex networks. *Rev. Mod. Phys.* **74**, 47–97 (2002)
- S. N. Dorogovtsev and J. F. F. Mendes, Evolution of networks. *Advances in Physics* **51**, 1079–1187 (2002)
- M. E. J. Newman, The structure and function of complex networks. *SIAM Review* **45**, 167–256 (2003)
- S. Boccaletti, V. Latora, Y. Moreno, M. Chavez, and D.-U. Hwang, Complex networks: Structure and dynamics. *Physics Reports* **424**, 175–308 (2006)

There also are various specialized books that cover parts of the syllabus in greater depth. If you're interested in these, I'd recommend for graph theory either West or Wilson, and for social network analysis either Scott or Wasserman and Faust. The Ahuja *et al.* book is excellent if you're interested in the computer programming/algorithms side of things, and the books by Jackson and by Easley and Kleinberg are both good for the economics/collective action angle, which we won't be discussing much in the course. The books by Watts and by Barabási are pop-science treatments that are non-serious but fun to read.

- R. K. Ahuja, T. L. Magnanti, and J. B. Orlin, *Network Flows: Theory, Algorithms, and Applications*. Prentice Hall, Upper Saddle River, NJ (1993)
- A.-L. Barabási, *Linked: The New Science of Networks*. Perseus, Cambridge, MA (2002)
- B. Bollobás, *Modern Graph Theory*. Springer, New York (1998)
- S. Bornholdt and H. G. Schuster (eds.), *Handbook of Graphs and Networks*. Wiley-VCH, Berlin (2003)
- A. Degenne and M. Forsé, *Introducing Social Networks*. Sage, London (1999)
- S. N. Dorogovtsev and J. F. F. Mendes, *Evolution of Networks: From Biological Nets to the Internet and WWW*. Oxford University Press, Oxford (2003)
- D. Easley and J. Kleinberg, *Networks, Crowds, and Markets*. Cambridge University Press, Cambridge (2010)
- F. Harary, *Graph Theory*. Perseus, Cambridge, MA (1995)
- M. O. Jackson, *Social and Economic Networks*. Princeton University Press, Princeton (2008)
- R. Pastor-Satorras and A. Vespignani, *Evolution and Structure of the Internet*. Cambridge University Press, Cambridge (2004)
- J. Scott, *Social Network Analysis: A Handbook*. Sage, London, 2nd edition (2000)
- P. van Mieghem, *Graph Spectra for Complex Networks*. Cambridge University Press, Cambridge (2011)
- S. Wasserman and K. Faust, *Social Network Analysis*. Cambridge University Press, Cambridge (1994)
- D. J. Watts, *Six Degrees: The Science of a Connected Age*. Norton, New York (2003)
- D. B. West, *Introduction to Graph Theory*. Prentice Hall, Upper Saddle River, NJ (1996)
- R. J. Wilson, *Introduction to Graph Theory*. Addison-Wesley, Reading, MA, 4th edition (1997)