

PORTLAND STATE UNIVERSITY
Systems Science Ph.D. Program
Professor Martin Zwick
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Winter 2009
MW 4:40-6:30
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SYSTEMS THEORY
SySc 511

SySc 511 surveys fundamental systems concepts and central aspects of systems theory. The course begins with an overview of the systems paradigm and the systems field as a whole. Topics then include introductions to set- and information-theoretic multivariate relations, dynamic systems, regulation and control, model representation and simulation; decision analysis, optimization, and game theory; artificial intelligence, complex adaptive systems. Readings draw from mathematics, the natural and social sciences, and the professional disciplines (e.g., engineering, business). The course content derives both from “classical” general systems theory, cybernetics, and operations research as well as from more contemporary systems research which is organized around the themes of nonlinear dynamics, complexity, and adaptation.

TEXTS:

1. W. Ross Ashby, *An Introduction to Cybernetics*, Chapman, & Hall, 1964 (paper; ISBN 0-416-68300-2): at PSU bookstore or <http://pespmc1.vub.ac.be/books/IntroCyb.pdf>
2. Herbert A. Simon, *The Sciences Of The Artificial* (3rd edition), MIT Press, Cambridge, Massachusetts, 1996 (paper; ISBN 0-262-69191-4).
3. Moshe Rubinstein and Iris Firstenberg, *Patterns Of Problem Solving* (2nd Edition), Prentice-Hall, New Jersey, 1994 (cloth; ISBN 013-122706-8).
4. John Casti, *Complexification*, Harper-Collins, New York, 1995 (paper: ISBN 0-06-092587-6).
5. Supplementary xeroxed materials: obtain at Smart Copy, 1915 SW 6th, 503-227-6137.

Prerequisites: Graduate status or permission of the instructor; familiarity with calculus including simple differential equations, probability, and computer programming.

Grades will be based on the midterm (50%) and final (50%).

OUTLINE: {}=reference; []=lower priority; read all relevant Rubinstein summaries.

- Jan 5, 7 Introduction: the systems paradigm; basic systems concepts
Ashby: Preface, Ch. 1; *Casti*: Preface, 269-278; *Simon*: Ch. 7
Xerox: Zwick: from “Elements & Relations”
- Jan 12,14 Graph theory (networks, structures)
Xerox: Knoke, Zwick: “Overview” (II-4), Krippendorff (35-43), *Simon*: Ch. 8;
 Newman, Barabasi, *Casti*: 171-191;
- Jan 19 Holiday
- Jan 21 Set-theoretic static & dynamic relations; fuzzy sets
Xerox: Zwick: “Overview” (II-3); *Ashby*: Ch. 2-5, 7; *Rubinstein*: 51-63
- Jan 26 Information-theoretic relations; a little thermodynamics
Ashby: Ch. 9; *Rubinstein*: [63-68, 100-114], 137-142
Xerox: Miller, Zwick: “Overview” (II-1), {Cover & Thomas, Krippendorff}
- Jan 28 Over exercises
- Feb 2 More on dynamics: catastrophes & chaos
Casti: 25-42, Ch. 2, 3, 6; [267-269]; *Xerox*: Crutchfield, Zeeman [Kauffman]
Rubinstein: Ch. 9, esp. 369-372, [412-419,] 422-426
- Feb 4 Dynamics, continued. Over exercises
- Feb 9 MIDTERM EXAM (2 hrs)
- Feb 11,17 Over midterm; Cybernetics: regulation & control, feedback
Ashby: Ch. 10-12 (esp. 11); *Xerox*: Fletcher; *Casti*: 37-42, 150-170, 263-264
Rubinstein: Ch. 9, esp. 372-376, 383-389, 393-395, 400-412
- Feb 18 Modeling; problem-solving; formal systems; AI
Ashby: Ch. 6; *Simon*: Preface, Ch. 1, 5; *Casti*: 1-25, 115-150, 269-278
Rubinstein: Ch. [1], 5
- Feb 23 Over exercises
- Feb 25,Mar 2 Decision theory (& Bayesian probability, Arrow paradox); optimization
Rubinstein: 114-137, 272-303; 314-315; *Simon*, Ch. 2, 6
Xerox: Kahneman, Swets
- Mar 4,9 Game theory
Rubinstein: 303-314; *Casti*: 260-263; *Xerox*: Hamburger, Rapoport
- March 11 Over exercises
- March 16 FINAL EXAM (2 hrs; on material since midterm exam)

XEROXED MATERIAL

Knoke, David & Kuklinski, James H. *Network Analysis. Quantitative Applications in the Social Sciences Paper #28*, Sage Publications, Beverly Hills CA, 1982, pp. 35-69.

Newman, Mark, Barabasi, Albert-Laszlo, & Watts, Duncan J., eds. *The Structure and Dynamics of Networks*. Princeton University Press, 2006, Chapters 1,2,3,4 (overviews of editors).

Barabasi, Albert-Laszlo, & Bonabeau, Eric. "Scale-Free Networks." *Scientific American* May 2003, pp. 60-69.

Zwick, Martin. "Overview of Reconstructability Analysis." *Kybernetes* 33 (5/6) pp. 877-905, 2004. <http://www.syssc.pdx.edu/download/papers/wholesg.pdf>

Krippendorff, Klaus. *Information Theory: Structural Models for Qualitative Data*. Sage Quantitative Applications in the Social Sciences, Paper #62, London, 1986, pp. 1-43.

Miller, George A. "What is Information Measurement." *American Psychologist*, 8, 3-11, 1963.

Cover, Thomas M. and Thomas, Joy A. Thomas, *Elements of Information Theory*, pp. 12-31, John Wiley, New York, 1991.

Crutchfield, James P., Farmer, J. Doyne, Packard, Norman, & Shaw, Robert. "Chaos." *Scientific American*, Dec 1986, pp. 46-57.

Zeeman, E. C. "Catastrophe Theory." *Scientific American*, Apr 1976, pp. 65-83.

Kauffman, Stuart A. "Antichaos and Adaptation." *Scientific American*, Aug 1991, pp.78-84.

Fletcher, Jeffrey, Bedau, Mark, and Zwick, Martin. "Effect of Environmental Structure on Evolutionary Adaptation," in *Proc. of Artificial Life VI*, Los Angeles, June 26-29, 1998; C. Adami, R. Belew, H. Kitano, and C. Taylor, eds., pp.189-198, MIT Press
<http://www.syssc.pdx.edu/download/papers/alife6.pdf>

Kahneman, Daniel & Tversky, Amos. "The Psychology of Preferences." *Scientific American* June 1978, pp. 160-173.

Swets, John A., Dawes, Robyn M., & Monahan, John. "Better Decisions through Science." *Scientific American* Oct 2000, pp.82-87.

Hamburger, Henry. Selections from *Games as Models of Social Phenomena*. W. H. Freeman & Co., San Francisco, 1979: Ch. 4.2, 7.

Rapoport, Anatol. "Games." *Peace and Change*, vol. XIII, 1988, pp.18-43.

Old midterm and final exams (2006, 2007, 2008)

Distributed separately:

Zwick, Martin. *Elements and Relations*. Manuscript in preparation (not to be distributed/quoted without the author's permission) 2008: Commentary, pp. 37-99 (chapters 1 ["An Exact and Scientific Metaphysics"], 2 ["Concepts and Categories"], 3 ["Related fields"]).