PORTLAND STATE UNIVERSITY
Systems Science Ph.D. Program
Professor Martin Zwick
http://www.sysc.pdx.edu/faculty/Zwick
(503) 725-4987

Winter 2007
MW 4:00 - 5:50
Harder House 104
zwick@pdx.edu

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) available at 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 8,10	Introduction: the systems paradigm; basic systems concepts *Ashby*: Preface, Ch. 1; *Casti*: Preface, 269-278; Simon: Ch. 7 *Xerox*: Zwick: from "Elements & Relations"
Jan 15	Holiday
Jan 17,22	Graph theory (networks, structures) *Xerox*: Knoke, Newman, Barbasi, Zwick: "Overview" (II-4), Krippendorff (35-43); *Casti*: 171-191; *Simon*: Ch. 8
Jan 24	Set-theoretic static & dynamic relations; fuzzy sets *Xerox*: Zwick: "Overview" (II-3); *Ashby*: Ch. 2-5, 7; *Rubinstein*: 51-63
Jan 29	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 31	Over exercises
Feb 5	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 7	Dynamics, continued. Over exercises
Feb 12	MIDTERM EXAM (2 hrs)
Feb 14,19	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 21	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 26	Over exercises
Feb 28,Mar 5	Decision theory (& Bayesian probability, Arrow paradox); optimization *Rubinstein*: 114-137, 272-303; 314-315; *Simon*, Ch. 2, 6 *Xerox:* Kahneman, Swets
Mar 7,12	Game theory *Rubinstein*: 303-314; *Casti*: 260-263; *Xerox*: Hamburger, Rapoport
March 14	Over exercises
March 19	FINAL EXAM (2 hrs; on material since midterm exam)

XEROXED MATERIAL

Zwick, Martin. *Elements and Relations.* Manuscript in preparation (not to be distributed/quoted without the author's permission) 2006: Commentary, pp. 32-92 (sections 1 ["An Exact and Scientific Metaphysics"], 2 ["Concepts and Categories"], 3 ["Related and overlapping fields"]).

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.

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

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 (2003, 2005, 2006)