Comprehensive Examination Proposal
Systems Science M.S. Program
Ryan Spangler

Committee Members

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The members of the comprehensive examination committee for (name) hereby approve the comprehensive examination proposal submitted herewith.

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Approved by

Wayne Wakeland, Ph.D., Acting Director
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Statement of Personal Intent

When I discovered that there was a field called Systems Science, I was overjoyed. I have been preoccupied with the problems of coming to terms with biological complexity my whole life, and have spent much time studying and building models outside of any institution long before I discovered there was a field, a community of people doing similar work. What I had assumed was a solitary and dimly defined journey turned out to be a legitimate and collaborative effort. Taking the Systems Science Masters course has been a fundamental step in that journey that started a long time ago. And it is nowhere near the final step, but it has been an important one. In many ways, it is just the beginning.

Thus it is with a deep sense of accomplishment that I am able to now propose my comprehensive examinations for the Systems Science Masters degree. There are two exams which cover 16 credits of coursework each. The Systems Science coursework covers a wide array of skills and approaches, from the purely philosophical to the highly technical, with some application thrown in for good measure. I have divided the exams roughly in terms of the dichotomy between application and theory. The first covers much of the application side of things, with the second being more of the theoretical underpinnings. In accordance with Systems Philosophy, the wider breadth of topics covered the deeper are the connections between them. The details of all of these exams are enumerated in the coming sections.

With the degree in hand, I plan on putting to use all of the methods and approaches that have been offered in these last few years towards real world scenarios. Building models of biological processes is still a passion that consumes me, and I feel that this has passed from the realm of dreams to something that is immediately applicable in my day to day life. I do not need to wait for anyone's approval, I can forge ahead now with my own initiative and build the things that need to be built. Whether that is in the medical community, design, the arts, computational sciences (or all of the above!), with programming and code as my medium I will put a synthesis of these and other techniques to create truly novel and biologically inspired computational systems. Already many opportunities have appeared, in my current industry and electronics and music, and I plan on making the most of these opportunities. In the immediate future I am working with an electronics company to build analog electronic circuits that display biological adaptation! It is a reassuring sign that when effort is put forth in an area opportunities open up in tandem with that effort.

It is now this last hurdle, that of my comprehensive examinations, I turn towards before embarking on the rest of my life journey. My gratitude to this program is boundless, thank you.

Graduate Coursework at Portland State University

Term	Course Number	Course Title	Grade	Credit Hours
2009 Fall	SYSC 507	Systems Science Seminar	P	1
2009 Fall	SYSC 525	Agent Based Simulation	B	4
2010 Winter	SYSC 507	Systems Science Seminar	P	1
2010 Winter	SYSC 514	System Dynamics	A-	4
2010 Spring	ECE 510	Embedded In Silico and In Materio Computing.	A	4
2010 Spring	SYSC 507	Systems Science Seminar	P	1
2010 Fall	SYSC 501	Introduction to Computational Neuroscience	A	4
2011 Winter	SYSC 511	Systems Theory	A	4
2011 Winter	SYSC 575	AI: Neural Networks I	B	4

2011 Spring	SYSC 557	Artificial Life	A	4
2011 Fall	SYSC 513	Systems Approach	B+	4
2012 Winter	SYSC 551	Discrete Multivariate Modeling	B+	4
2012 Spring	SYSC 521	Systems Philosophy		4
2012 Fall	SYSC 510	Data Mining with Information Theory		4
		Total Credits	47	
		Total Graded Credits	44	

Courses Taken to Meet Systems Science M.S. Degree Requirements (24+ Credits)

Term	Course Number	Course Title	Grade	Credit Hours
2009 Fall	SYSC 525	Agent Based Simulation	B	4
2010 Winter	SYSC 514	System Dynamics	A-	4
2011 Winter	SYSC 511	Systems Theory	A	4
2011 Winter	SYSC 575	AI: Neural Networks	B	4
2011 Spring	SYSC 557	Artificial Life	A	4
2011 Fall	SYSC 513	Systems Approach	B+	4
		Total Credits		24

Courses Taken to Meet Additional Non-Thesis Option Requirements (21+ Credits)

Term	Course Number	Course Title	Grade	Credit Hours
2009 Fall	SYSC 507	Systems Science Seminar	P	1
2010 Winter	SYSC 507	Systems Science Seminar	P	1
2010 Spring	ECE 510	Embedded In Silico and In Materio Computing.	A	4
2010 Spring	SYSC 507	Systems Science Seminar	P	1
2010 Fall	SYSC 510	Introduction to Computational Neuroscience	A	4

Winter 2012	SYSC 551	Discrete Multivariate Modeling	4
Spring 2012	SYSC 521	Systems Philosophy	4
Fall 2012	SYSC 510	Data Mining with Information Theory	4
		Total Credits	23

Exam Summary

Exam 1: Systems Approach, Dynamics, and Neural Networks

Instructor	Course Number	Course Title	Grade	Credit Hours
Wakeland	SYSC 513	Systems Approach	B+	4
Wakeland	SYSC 514	System Dynamics	A-	4
Wakeland	SYSC 525	Agent Based Simulation	B	4
Lendaris	SYSC 575	AI: Neural Networks	B	4
		Total Credits		16

Exam 2: Systems Theory, Philosophy, and Agent-Based Applications

Instructor	Course Number	Course Title	Grade	Credit Hours
Zwick	SYSC 551	Discrete Multivariate Modeling	B+	4
Zwick	SYSC 521	Systems Philosophy		4
Shannon	SYSC 511	Systems Theory	A	4
Fletcher	SYSC 557	Artificial Life	A	4
		Total Credits		16

Examination 1: Systems Approach, Dynamics, Agent Based Systems and Neural Networks
Examiner: Wayne Wakeland 75%, Lendaris 25%
Length: 4 Hours
Open Notes: No

Supporting Coursework:

Instructor	Course Number	Course Title	Grade	Credit Hours
Wakeland	SYSC 513	Systems Approach	B+	4
Wakeland	SYSC 514	System Dynamics	A-	4
Lendaris	SYSC 575	AI: Neural Networks I	B	4
Wakeland	SYSC 576	Agent Based Simulation	B	4
		Total Credits		16

Examination Topics:

- **Systems Approach (25%)**
- System definition and structure
- System archetypes
- Systems thinking
- Multiple perspectives
- **System Dynamics (25%)**
- Feedback
- Causal Loop Diagrams
- Dynamics
- Stocks and flows
- Model specification and calibration
- Model verification and validation
- Using Vensim simulation software
- **Neural Networks (25%)**
- Network Topologies
- Lecture Notes for NN-1
- Handouts for NN-1
  - Single-layer (Perceptron, Adaline)
  - Multi-layer (MLP, RBF)
  - Associative Memory (Hopfield, BAM)
  - Self-Organizing Networks (LVQ, SOM)
  - Gradient Descent, Error Surfaces

- Mappings, Generalization
- Backpropagation
- Reinforcement Learning
- **Agent Based Simulation (25%)**
- Netlogo
- Emergence
- Distributed Computing
- Applications of ABS
    - Agents and rules
    - Model simplicity vs. complexity
    - Sugarscape

Source Materials:

Systems Approach

Senge, P.M. *The Fifth Discipline: The Art and Practice of the Learning Organization*, Doubleday, 1990.

System Dynamics

John Sterman, *Business Dynamics*, Irwin-McGraw Hill, 2000
SySc 514 WebCT Course Notes: https://webct.pdx.edu/SCRIPT/sysc514ww2/scripts/serve_home

AI: Neural Networks I

Haykin, Simon, *Neural Networks – A Comprehensive foundation*, Prentice Hall 1999.

Agent Based Simulation

Resnick, M., *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds*, MIT Press, 1997
Gilbert, G.N., and Troitzsch, K.G., *Simulation for the Social Scientist*, 2nd Ed., Open University Press, 2002
Epstein, J.M., *Growing Artificial Societies: Social Science from the Bottom Up*, Brookings Institution Press, 1996

Examination 2: Systems Theory, Philosophy, Discrete Multivariate Modeling and Artificial Life
Examiner: Martin Zwick
Length: 4 Hours
Open Notes: No

Supporting Coursework:

Instructor	Course Number	Course Title	Grade	Credit Hours
Shannon	SYSC 511	Systems Theory	A-	4
Zwick	SYSC 521	Systems Philosophy		4
Zwick	SYSC 551	Discrete Multivariate Modeling	B+	4
Fletcher	SYSC 557	Artificial Life	A	4
		Total Credits		16

Examination Topics:

- **Systems Theory (25%)**
- • Object-Relation Model
- • The Systems Movement
- • Systems Hierarchy
- • Complexity
- • Information
- • Cybernetics
- • Fuzzy Systems
- **Systems Philosophy (25%)**
- The systems paradigm
- Synchronics
  - Incompleteness
  - Constraint
  - Distinction
  - Persistence
  - Identity
  - Agency
  - Complexity
  - Adaptation
- Diachronics
  - Origins

- Development
- Limitation
- Complexification
- Internal Opposition
- Environment
- Change
- Impermanence
- **Discrete Multivariate Modeling (25%)**

- Reconstructability Analysis
- Information Theory
- Graph Theory
- Entropy
- Probabilities
- Degrees of Freedom
- Markov Processes
- **Artificial Life (25%)**
- Evolutionary and Ecological Dynamics
- Prisoner's Dilemma
  - Automata Dynamics
  - Cellular automata
  - Edge of chaos
  - Complexity and Complex Adaptive Systems
- Genetic Algorithms
- Computer Life
- Self-Organized Criticality

Source Materials

Systems Theory

George J. Klir, Facets of Systems Science, 2nd Ed., Kluwer/Plenum, 2001.
Herbert A. Simon, The Sciences of the Artificial, 3rd Ed., MIT Press, 1996

Systems Philosophy

Zwick, Martin, *Elements and Relations*, Manuscript in preparation.
Bunge, Mario. Method, *Model and Matter*. D. Reidel, Boston, 1973: Ch. 2 "Testability Today", Ch. 8 "Is Scientific Metaphysics Possible", Ch. 5 'Concepts of Model".
Boulding, Kenneth, "General Systems Theory – The Skeleton of Science", *Management Science 2*, 197-208, 1956.
von Bertalanffy, Ludwig. "General System Theory – A Critical Review," *General Systems VII*, 1-20, 1962
Ashby, W. Ross., "What is New"(Ch. 1), *An Introduction to Cybernetics*, Methuen, London, 1964
Zwick, M. "Towards an Ontology of Problems," *Advances in Systems Science and Applications*, 1, pp. 37-42, 1995.

Zwick, M. "Understanding Imperfection," In *Proceedings of the World Congress of the Systems Sciences and ISSS 2000*, Allen, J.K. and Wilby, J.M. eds., Toronto, Canada: International Society for the Systems Sciences, 2000.
Zwick, M. "Wholes and Parts in General Systems Methodology," *The Character Concept in Evolutionary Biology,*Gunter Wagner, ed., Academic Press, NY, 2001.
Feibleman, J. and Friend, J.W. "The Structure and Function of Organization." Philosophical Review, 54, pp. 19-44, 1945. Reprinted in Emery, F.E., Systems Thinking. op cit. (pp. 30-55)
Wiener, Norbert. "Progress and Entropy" (Ch. II). *The Human of Human Beings*. Avon Books, New York, 1967
Deutsch, Karl W. "The Self-Closure of Political Systems" (Ch. 13). *The Nerves of Government*. The Free Press (Macmillan), New York, 1966.
Jantsch, Erich. *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution.* (Ch. 1-3). Pergamon Press, New York, 1980.
Emery, F.E. and Trist, E.L. "The Causal Texture of Organizational Environments." Human Relations. 18, pp.21-32, 1965. Reprinted in Emery, F.E., *Systems Thinking*. Penguin Books. New York, 1969. (pp. 241-257)
Gell-Mann, Murray. "Complex Adaptive Systems." *Complexity: Metaphors, Models, and Reality* G. A. Cowan, D. Pines, & D. Meltzer, eds., Addison-Wesley, Reading Mass, pp. 17-45, 1994.
Zwick, M. "Information, Constraint, and Meaning (ICM)." *General Systems* 29, 41-47, 1986.
Marcus, Solomon. "No system can be improved in all respects." *Systems: New Paradigms for the Human Sciences*, ed. by Gabriel Altmann & Walter A. Koch, Walter de Gruyter, New York, pp. 143-164, 1998.
Arthur, W. Brian. "On the Evolution of Complexity." *Complexity: Metaphors, Models, and Reality*, pp. 65-82, 1994.
Zwick, M. "Some Analogies of Hierarchical Order in Biology and Linguistics (HBL)." *Applied General Systems Research: Recent Developments and Trends*, George Klir, ed., Plenum Press, New York, pp.521-529, 1978.
Zwick, Martin. "Dialectics & Catastrophe." In: *Sociocybernetics*, vol. I, Martinus Nijhoff, Boston, pp. 129-154, 1978.
Forrester, Jay W. "Understanding the Counterintuitive Behavior of Social Systems." Testimony to Committee on Banking & Currency, US House of Representatives, 10/7/70.
Laszlo, Ervin. Introduction, "The Rise of the Evolutionary Paradigm" (Ch. 1), "Foundations of the Grand Synthesis" (Ch. 2) in Evolution*, The Grand Synthesis*. Shambhala, Boston, 1987.
Zwick, M. "Incompleteness, Negation, Hazard (INH): On the Precariousness of Systems." *Nature and System*, 6 (1984) 33-42.

Scientific American Articles
James P. Crutchfield, J. Doyne Farmer, Norman Packard, & Robert Shaw, *Chaos*. 12/86: 46-57.
Bart Kosko & Satoru Isaka, *Fuzzy Logic*. 7/93:, 76-8 1.

Stuart A. Kauffman, *Antichaos and Adaptation.* 8/91: 78-84.
Jurgens, H., Peitgen, H., & Saupe, D., *The Language of Fractals*, 8/90: 60-67
E. C. Zeeman, *Catastrophe Theory.* 4/76: 65-83.
John A. Swets, Robyn M. Dawes, & John Monahan, *Better Decisions through Science.* 10/00:82-87
John Maynard Smith, *The Evolution of Behavior.* 9/78: 176-192.
Barabasi, A., & Bonabeau, E., *Scale-Free Networks*, 5/03: 60-69
Bonabeau, E. & Therauloz, G., *Swarm Smarts*, 3/00: 72-79
Susan Blackmore, *The Power of Memes.* 10/00: 64-73.
W. Brian Arthur, *Positive Feedbacks in the Economy. 2/90: 92-99.*
John Holland, *Genetic Algorithms.* 7/92: 66-72.
Bak, Per & Chen, Kan, *Self-Organized Criticality*, 1/91:46-53

Artificial Life

Christopher Langton, ed., *Artificial Life: An Overview*, MIT Press, Cambridge, 1997
Langton, C.G., Taylor, C., Farmer, J.D., & Rasmussen, S, eds., *Artificial Life II (Vol. X, SFI Studies in the Sciences of Complexity)*, Addison-Wesley, Redwood City, CA, 1991.
George Cowan, David Pines, David Meltzer, ed., "Complexity: Metaphors, Models, and Reality," *Santa Fe Institute Studies in the Sciences of Complexity*, Addison-Wesley, New York, 1994.
Fletcher, J.A., & Zwick, M., "N-Player Prisoner's Dilemma in Multiple Groups: A Model of Multilevel Selection," *Seventh International Conference on Artificial Life*, Workshop on Group Selection, Portland, 2000.
Fletcher, J.A., and Zwick, M., "Hamilton's Rule Applied to Reciprocal Altruism", *IEEE Congress of Evolutionary Computation*, pp. 994-1000, vol. 1, Portland OR, June 2004.
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Hillis, W. D., "Co-Evolving Parasites Improve Simulated Evolution as an Optimization Procedure", *ALife* II, pp. 313-324, 1991.

Weisbuch, G., *Complex Systems Dynamics: An Introduction to Automata Networks (Vol. II, SFI Studies in the Sciences of Complexity)*, Addison-Wesley, Redwood City CA, pp. 1-44, 1991.
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Wuensche, A., "Genomic Regulation Modeled as a Network with Basins of Attraction," *Pacific Symposium on Biocomputing*, 1998.
Liang, S., Fuhrman, S., and Somogyi, R., "REVEAL, A General Reverse Engineering Algorithm for Inference of Genetic Network Architectures," *Pacific Symposium on Biocomputing*, 1998.
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Carlson, S., "Boids of a Feather Flock Together," *Scientific American*, Nov. 2000, pp. 112- 114.
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Mitchell, M., *An Introduction to Genetic Algorithms*, MIT Press, Cambridge, 1999, Ch. 1, 5.
Shervais, S. and Zwick, M., "Ordering Genetic Algorithm Genomes with Reconstructability Analysis," *Int. J. General Systems*, Vol. 32, No. 5, pp. 491-502, 2003.
Koza, J. R., "Genetic Evolution and Co-Evolution of Computer Programs," ALife II, 1991.
Koza, J.R., "Evolving Inventions," *Scientific American*, Feb. 2003, pp. 52-59.
Ackley, D. and Littman, M., "Interaction Between Learning and Evolution," *ALife II*, 1991.
Belew, R.K., McInerney, J., and Schraudolph, N.N., "Evolving Networks: Using the Genetic Algorithm with Connectionist Learning," ALife II, 1991.
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Ray, T.S., "An Approach to the Synthesis of Life," *ALife II*, pp. 371-408, 1991.
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Kauffman, S. and Johnsen, S., “Coevolution to the Edge of Chaos: Coupled Fitness Landscapes, Poised States, and Co-Evolutionary Avalanches,”ALife II, 1991.
Baka, P., and Chen, K., “Self-organized Criticality,” *Scientifc American*, Jan. 1991, pp. 46-53
Bak, P., “Self-organized Criticality: A Holistic View of Nature,” *Complexity*, pp. 477-495, 1994.