7065	Complex Systems and Networks
Required/Elective:	Elective
Catalog Data:	20-EECE-7065. Complex Systems and Networks. This course provides a comprehensive introduction to complex systems and networks. The focus is on applying general principles derived from biological and human complex systems to the analysis, design and productive use of artificial systems with the same attributes of autonomy, adaptivity and resilience. Credit Level: G. Credit Hrs: 3.00.
Prerequisites/ Corequisites:	Required: None Recommended: EECE6036 (Intelligent Systems), EECE6019 (Probability & Random Processes)
Prerequisites by Topic:	1. Basic calculus, matrix methods and probability theory. 2. A programming language (e.g., MATLAB, Java, C++)
Textbook:	Class notes and slides, papers from the literature.
References:	M.E.J. Newman, *Networks: An Introduction*, Oxford University Press, 2010. Braha, D., Minai, A.A., and Bar-Yam, Y. (eds.) *Complex Engineered Systems: Science Meets Technology*, Springer Verlag, 2006. M. Scheffer, *Critical Transitions in Nature and Society*, Princeton University Press, 2009. Easley, D. and Kleinberg, J., *Networks, Crowds, and Markets: Reasoning about Highly Connected World*. Cambridge University Press, 2010.
Goals:	To familiarize students with**:** 1) The principles underlying successful complex systems such as biological organisms, brains, ecosystems and markets; 2) Approaches for applying these insights to building smart, adaptive and robust artificial complex systems such as self-organizing structures and resilient networks; and 3) Concrete analysis, design, search, control and optimization methods derived from the study of complex systems. Most of the course will focus on methods and applications.
Topics:	Weekly activities and assignments: 1. General theory, characteristics and principles of complex systems 2. Models of complex networks: Small-world, scale-free, scale-rich, etc. 3. Characterization of complex networks: Degree distribution, clustering, radius, assortativity, centralities, etc. 4. Examples of complex networks in engineering, biology, economics, etc. 5. Methods for analyzing and characterizing complex networks. 6. Attributes of successful complex systems: Modularity, near-decomposability, diversity, selectivity, robustness and resilience. 7. General principles for engineering complex systems 8. Search, design, optimization, control, and adaptation algorithms based on complex systems: simulated annealing; genetic algorithms; particle swarm optimization; evolutionary design; collaborative computing; mimetic algorithms. 9. Robustness and failure in complex systems: Signatures of critical transitions; techniques for enhancing robustness. 10. Applications (e.g., multi-agent systems, web intelligence, sensor networks, swarms, self-configuring structures and algorithms, artificial cognitive systems, artificial life, etc. 11. Discovery and innovation in complex adaptive systems
[Laboratory Topics:]	None
Class/Laboratory Schedule:	Class meets 2 times a week for 80 minutes