



## UVM CERTIFICATE of GRADUATE STUDY in COMPLEX SYSTEMS

### ***Responsible Unit:***

This Certificate will be wholly administered by the COLLEGE OF ENGINEERING AND MATHEMATICAL SCIENCES and awarded by THE GRADUATE COLLEGE at THE UNIVERSITY OF VERMONT. Post-baccalaureate students from any discipline may earn the Certificate, whether or not they are in another graduate program at UVM.

### ***Director and Program Coordinator:***

Margaret J. Eppstein, Computer Science Department; Director, Complex Systems Center  
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### ***Enrolling in the Complex Systems (CSYS) Graduate Certificate Program:***

The CSYS certificate can be earned in conjunction with existing graduate degrees and the courses applied to the certificate can be applied to the students' primary degree. The CSYS certificate can also be earned as a stand-alone certificate for students already holding a Bachelor's degree but who are not matriculated in any other UVM graduate programs. All students wishing to enroll in the certificate program must apply through the Graduate College (<http://www.uvm.edu/~gradcoll/?Page=programs.html>), with subsequent applicant review by the CSYS Steering Committee. Note that if you are applying or already enrolled in a UVM graduate program, you do not need to provide additional letters of recommendation for the Certificate.

### ***Student Advising:***

Members of the CSYS Steering Committee will advise students as to which available CSYS certificate electives would be best suited to their interests, needs, and academic backgrounds. For matriculated graduate students, the student's primary advisor will also be consulted regarding the most appropriate CSYS courses. Students wishing to apply a course that is not pre-approved for the certificate may request this, in writing, of the CSYS Steering Committee.

### ***Academic Standards:***

Certificate students must maintain at least a 3.0 average in the courses applied to the certificate, as specified by the Officer's Handbook.

### ***Overview of requirements for the Complex Systems certificate:***

Because complex systems science (like mathematics and computer science) includes many different methodologies that can be applied to problems in many disciplines, we have structured the Graduate Certificate in Complex Systems to give students both a broad understanding of the field of complex systems science (2-course core) as well as depth in one or more specific methodologies of complex systems science (A-list) and a choice of application contexts which are most relevant to the students' primary degree areas (A-list, B-list). We believe this certificate structure offers a desirable balance of giving certificate students a common knowledge base and culture, while allowing enough flexibility to adequately serve students with diverse educational backgrounds and interests.



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The **Certificate Requirements** are **5 courses for a minimum of 15 credits**, with a minimum gpa of 3.0 in these courses, distributed as follows:

- CSYS 300 Principles of Complex Systems (3 cr). Introduction to theory and concepts of complex systems, including emergence, complexity metrics, scaling phenomena and mechanisms, multi-scale systems, robustness, collective dynamics, complex networks, phase transitions.
- CSYS 302 Modeling Complex Systems (3 cr). An integrative breadth-first introduction to computational methods for modeling nonlinear dynamic systems, including error analysis, stability, numerical methods for differential equations, fractals and L-systems, chaos, agent-based models (including grid-based, real-space, and network based), game theory, artificial neural networks, and evolutionary computation.
- one course (3 credits) selected from the A-list of core complex systems methodologies (see below)
- two additional courses (6 credits) selected from **either** the A-list **or** B-list of complex systems electives (see below)

In some cases, other graduate courses not already pre-approved for the certificate may be used in fulfillment of A-list or B-list requirements, with explicit approval from the Complex Systems Steering Committee.

### **Required Core (2 courses):**

CSYS/MATH 300 (Principles of Complex Systems)
CSYS/CS 302 (Modeling Complex Systems)

### **A-List (select 1-3 courses):**

CSYS/MATH 266 (Chaos, Fractals, and Dyn. Sys)
CSYS/MATH 303 (Complex Networks)
CSYS/BIOL/CS 352 (Evolutionary Computation)
CSYS/STAT/CS 256 (Neural Computation)
CSYS/STAT/CS 355 (Statistical Pattern Recognition)
CSYS/STAT 253 (Appl Time Series & Forecasting)
CSYS/STAT/CE 369 (Applied Geostatistics)
CSYS/CE 359 (Applied Artificial Neural Networks)

### **B-List (select 0-2 courses):**

CSYS/MATH 221 (Deterministic Modls Oper Rsch)
CSYS/MATH 268 (Mathematical Biology & Ecology)
CSYS/CS 205 (Software Engineering)
CSYS/CS 251 (Artificial Intelligence)
CSYS/CE 245 (Intelligent Transportation Sys)
CSYS/CE 226 (Civil Engr Systems Analysis)
EE/STAT 270 (Stochastic Processes)
CSYS/ME 301 (Multi-scale bioengineering)
CSYS/ME 350 (Multi-Scale Modeling)