1.0 Course Designations and Approvals:

Required Course Approvals:

<table>
<thead>
<tr>
<th>Approval Request Date</th>
<th>Approval Grant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Unit Curriculum Committee</td>
<td>10-20-10</td>
</tr>
<tr>
<td>College Curriculum Committee</td>
<td>11-01-10</td>
</tr>
</tbody>
</table>

Optional Course Designations:

<table>
<thead>
<tr>
<th>Approval Request Date</th>
<th>Approval Grant Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>✓</td>
</tr>
<tr>
<td>Writing Intensive</td>
<td>✓</td>
</tr>
<tr>
<td>Honors</td>
<td>✓</td>
</tr>
</tbody>
</table>

2.0 Course information:

Course Title: Advanced Dynamical Systems
Credit Hours: 3
Prerequisite(s): COS-MATH-631 or permission of instructor
Co-requisite(s): None
Course proposed by: School of Mathematical Sciences
Effective date: Fall 2013

Contact Hours | Maximum Students/section
--- | ---
Classroom | 3 | 25
Lab | |
Workshop | |
Other (specify) | |

2.1 Course Conversion Designation:

Semester Equivalent (SE) to: [ ]
Semester Replacement (SR) to: parts of 1016-707, 1016-709 [✓]
New [ ]

2.2 Semester(s) offered:

[ ] Fall [ ] Spring [ ] Summer
[ ] Offered every other year only [ ] Other
2.3 Student Requirements:

Students required to take the course:
Applied and Computational Mathematics graduate students in the Dynamical Systems concentration

Students who might elect to take the course:
Graduate students and advanced undergraduate students in mathematics, physics, imaging science, or engineering

3.0 Goals of the course: (including rationale for the course, when appropriate)

3.1 To introduce the modern theory and techniques of dynamical systems.
3.2 To model physical systems that involve dynamical systems.

4.0 Course description: (as it will appear in the RIT Catalog, including pre- and co-requisites, semesters offered)

COS-MATH-731 Advanced Dynamical Systems
This course covers an analysis of iterations of maps, symbolic dynamics, their uses, and fractals. It includes methods for simplifying dynamical systems (center manifolds and normal forms), Melnikov’s method, and applications. (COS-MATH-631 or permission of instructor)
Class 3, Credit 3 (S)

5.0 Possible resources: (texts, references, computer packages, etc.)

5.1 S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer, New York, NY
5.2 C. Robinson, An Introduction to Dynamical Systems, Continuous and Discrete, Pearson, Upper Saddle RIver, NJ

6.0 Topics: (outline) Topics with an asterisk(*) are at the instructor’s discretion, as time permits

6.1 Iterations of Functions as Dynamics
   6.1.1 Periodic points of one-dimensional maps
   6.1.2 The Schwarzian derivative
   6.1.3 Bifurcation of periodic points
   6.1.4 Topological conjugacy
   6.1.5 Symbolic dynamics
   6.1.6 Topological transitivity and sensitive dependence on initial conditions
   6.1.7 Invariant sets for one-dimensional maps
   6.1.8 Periodic points of higher dimensional maps
   6.1.9 Stable manifolds
   6.1.10 Hyperbolic toral automorphisms

6.2 Invariant Sets
6.2.1 Invariant sets for higher dimensional maps
6.2.2 Geometric horseshoe
6.2.3 Homoclinic points and horseshoes
6.2.4 Chaotic attractors
6.2.5 Fractals

6.3 Methods for Simplifying Dynamical Systems
6.3.1 Center manifolds for vector fields and maps
6.3.2 Normal form for vector fields and maps

6.4 Melnikov’s Method
6.4.1 Poincaré maps and the geometry of the Melnikov function

6.5 Pattern Formation*
6.6 Applications*

7.0 Intended learning outcomes and associated assessment methods of those outcomes:

<table>
<thead>
<tr>
<th>Learning Outcomes</th>
<th>Assessment Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Homework</td>
</tr>
<tr>
<td>7.1 Analyze one- and higher-dimensional maps</td>
<td>✓</td>
</tr>
<tr>
<td>7.2 Analyze shift maps</td>
<td>✓</td>
</tr>
<tr>
<td>7.3 Compute stable manifolds</td>
<td>✓</td>
</tr>
<tr>
<td>7.4 Analyze fractals</td>
<td>✓</td>
</tr>
<tr>
<td>7.5 Compute center manifolds</td>
<td>✓</td>
</tr>
<tr>
<td>7.6 Compute normal forms</td>
<td>✓</td>
</tr>
</tbody>
</table>

8.0 Program goals supported by this course:

8.1 To develop an understanding of the mathematical framework that supports engineering, science, and mathematics.
8.2 To develop critical and analytical thinking.
8.3 To develop an appropriate level of mathematical literacy and competency.
8.4 To provide an acquaintance with mathematical notation used to express physical and natural laws.

9.0 General education learning outcomes and/or goals supported by this course: Not applicable
10.0 **Other relevant information:** (such as special classroom, studio, or lab needs, special scheduling, media requirements, etc.)

None