

**ECSE-4968/6963**  
**NONLINEAR PHENOMENA IN ENGINEERING AND BIOLOGY**  
**Spring 2008**

**Instructor:** Dr. Murat Arcak

**E-mail Address:** [arcakm@rpi.edu](mailto:arcakm@rpi.edu)

**Class Hours:** Monday, Thursday - 4:00 - 5:20 PM

**Room:** JEC 4304

**Instructor's Office & Phone:** JEC 6028, x6535

**Office Hours:** Wednesday, 5-6 pm, or by appointment.

**Textbooks:**

1. Steven H. Strogatz, *Nonlinear Dynamics and Chaos*, Perseus Books, 1994.
2. Leah Edelstein-Keshet, *Mathematical Models in Biology*, SIAM, 2005. (First published by Random House, 1988.)

Additional class notes will be provided as necessary. Below is a list of reference books on reserve in the library:

- |                                |  |                         |
|--------------------------------|--|-------------------------|
| 1. Hale, J.K.                  | <u>Ordinary Differential Equations</u>     | call #: QA372.H184 1980 |
| 2. Khalil, H.K.                | <u>Nonlinear Systems</u>                   | QA427.K48 2002          |
| 3. Nayfeh, A.H. and Mook, D.T. | <u>Nonlinear Oscillations</u>              | QA402.N34               |
| 4. Murray, J.D.                | <u>Mathematical Biology, vol. I and II</u> | QH323.5.M88 2001        |
| 5. Keener, J. and Sneyd, J.    | <u>Mathematical Physiology</u>             | QP33.6.M36K44 1998      |
| 6. Winfree, A.T.               | <u>The Geometry of Biological Time</u>     | QH527.W55 2001          |

<b>Grading:</b>	Homework:	25%
	Midterm:	25%
	Final:	35%
	Project:	15%

**Homework:** About 10 homework sets will be assigned. 20% penalty for each session late. Submission will **NOT** be accepted if more than two sessions late. Solutions will be posted on the Web.

**Project:** Detailed instructions will be provided later during the semester. Presentations will be given during the last week of classes.

**Prerequisites:** MATH 2400 (Introduction to Differential Equation) and ECSE-2410 (Signals and Systems) or their equivalents.

**Note the following dates:**

January 21, Monday:	No class. (Martin Luther King, Jr. Day)
February 18, Monday:	No class. (Presidents' Day)
February 19, Tuesday:	Follows Monday schedule.
<b>March 6, Thursday:</b>	<b>Midterm (in class).</b>
March 10-14:	Spring break.
April 28:	Last class.
May 1-2:	Reading days.

### **Tentative Course Outline:**

- **Nonlinear Systems, Equilibria and Stability:** Flows on the line, bifurcations, flows on the circle. Second order systems, phase plane and index theory, stability and linearization. Bacterial growth in a chemostat. Population dynamics.
- **Oscillations:** Limit cycles, Poincaré-Bendixson Theorem, relaxation oscillations. Bifurcations. Models of neural excitation. Oscillations in population models.
- **Chemical Kinetics:** Mass action law and reaction network models. Michealis-Menten kinetics. Cooperativity and Hill equation. Inhibition. Multi-stability. Oscillations in chemical systems.
- **Spatially Distributed Systems:** Introduction to partial differential equation models. Steady states and traveling waves. Diffusion and diffusive instability.
- **Chaos:** Analysis of Lorenz equations. Strange attractors. Period doubling bifurcations.

### **Statement of Academic Integrity:**

Student-teacher relationships are built on trust. The students must trust that the instructor has made appropriate decisions about the structure, content, etc., of the courses they teach, and the instructors must trust that assignments which students turn in are their own. Acts which violate this trust undermine the education process.

The *Rensselaer Handbook* defines various forms of Academic Dishonesty and procedures for dealing with them. All forms are violations of the trust between the students and instructors. All students should familiarize themselves with this portion of *the Rensselaer Handbook* and should note that the penalties for the various forms of dishonesty can be harsh.