

CEE 627 Mathematical Principles of Environmental Systems

Catalog data: 20-CEE-627. Mathematical Principles of Env. Systems. 4 cr.

Fundamental mathematical concepts and numerical algorithms that are important for developing and solving mathematical models of environmental systems. Use of these fundamental concepts and algorithms as building blocks for simulating and studying environmental processes and systems. Computer use. Linear algebra; ordinary differential equations recommended.

Prerequisites: Typical undergraduate mathematics courses in ordinary differential equations, linear algebra.

Textbook: Steven H. Strogatz, *Nonlinear Dynamics and Chaos, With Applications to Physics, Biology, Chemistry, and Engineering*, Addison-Wesley, 1994.

References: Journal articles; Notes and homework assignments available at <http://www.cee.uc.edu/~juber/courses/cee627/cee627.html>

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Goals: This is an introductory course covering the core concepts in linear and nonlinear dynamic systems, using a few applications that illustrate these concepts and are relevant to environmental engineering and science (e.g., river dissolved oxygen depletion, nonlinear chemical reaction kinetics, biological growth dynamics). The models are expressed as systems of differential equations. The analytical solution to linear models is reviewed, while the solutions to nonlinear models are investigated via computer simulation. Emphasis is placed on understanding the characteristics of the solutions, both through graphical (visual) analysis and analytical techniques. Nondimensionalization of models is stressed as a way to generalize results and understand solution behavior. Concepts and techniques relevant to solution stability, or solution behavior under perturbations, are a core concept to be studied, including the classical linearization techniques and linear stability analysis.

Lecture or Lab Topics:

Dynamic Systems

- Linear dynamic systems
- The geometry of solutions
- Basic Matlab programming
- Introduction to modeling using Simulink
- 1-D Fixed-points and stability
- 1-D Linear stability analysis
- Linear systems -- analytical solutions
- Phase plane analysis/Linearization/Stability
- Application to model and analyze microbial growth dynamics

Parameter Estimation / Model Calibration

- Numerical methods for linear and nonlinear least squares estimation
- Interpretation of the parameter estimates

Space--Time Dynamic Systems (Partial Differential Equations)

- 1-D Advective-Dispersive equation
- Numerical solution techniques
- Numerical dispersion

Other Ways to Model Dynamic Systems

Cellular Automata (as time permits)

**Computer
Usage:**

Students make extensive use of Matlab for general numerical computation and programming projects, and Simulink for modeling of dynamical systems. The course includes both classroom and laboratory instruction on computer programming using Matlab.

**ABET
criterion 3:**

a, b, c, d, e

**ABET
criterion 8:**

a, b

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prepared:**

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