University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Quantitative Methods in the Environmental Sciences

3 credits

MEES 607
Fall 2018

Course Objectives / Overview

This course will reinforce and extend the mathematical education that students bring to graduate studies in the environmental sciences. It will explore mathematical approaches and solutions (both analytical and numerical) that cut across environmental disciplines, and it will introduce quantitative techniques that are taught infrequently in other courses. The goal is to provide students with the tools and confidence they need to apply quantitative methods in their own research. The mathematical programming language MATLAB is used to solve problems in class, to complete homework sets, and to process and analyze online data.

MEES 607 assumes a background in at least Calculus I (differential calculus); Calculus II (integral calculus) is not required, though it is preferable. MEES 607 will not cover all the materials normally taught in Calculus II. We will review the basics of Calculus II skills needed for this course, but it will be up to individual students to catch up on their own if necessary. Some online resources are provided below.

Expected Learning Outcomes

Upon successful completion of the course, students should be able to:

1. Understand essential elements of differential and integral calculus, linear algebra, and mathematical functions, in the context of environmental science applications.
2. Understand and apply basic aspects of numerical analysis and programming using Matlab.
3. Understand, formulate, and solve different types of difference equations and systems of equations, especially those that govern exponential growth, logistic growth, and age structured population dynamics models.
4. Understand, formulate, and solve different types of ordinary differential equations and systems of equations, especially those that govern exponential and logistic growth, compartment models, models of nutrient uptake and chemostats.
5. Understand and evaluate the stability of steady state solutions of difference and differential equations.
6. Understand and apply the basics of dimensional analysis as applied to environmental science problems.
7. Understand the essential elements of multidimensional systems and partial differential equations, including conservation equations, advection-diffusion equations, and gradient analysis.

INSTRUCTOR DETAILS:
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CLASS MEETING DETAILS:
Dates:
Times:
Originating Site:
IVN bridge number: (*******)
Phone call in number: (***)
Room phone number:(*****)

COURSE TYPE:
Check all that apply
☐ Foundation
☒ Professional Development
☐ Issue Study Group
☐ Seminar
☒ Elective

Prerequisites
Calculus I; Calculus II preferred but not required

Teaching Assistant
TBD

8. Carry out basic numerical differentiation and integration and find numerical solutions of differential equations using Matlab.
9. Identify and download online data from a variety of sources, manipulate and plot vector-valued time series data, carry out spectral analysis and filtering operations on select time series, carry out 2-dimensional interpolation and contouring, and apply these tools to data sets of their choice.

Course Assessment / Grading

Two take-home exams and one final project each worth 30% of the final grade. Homeworks count for 10% of final grade.

The homework problems are essential to understanding this material. Although the homeworks comprise only 10% of the final grade, performance on the exams is usually correlated with effort on the homework problems. Homework will be assigned on Monday, due the next Monday, with discussion during the Friday recitation session.

List of Topics

1. Math Review and Introduction to Matlab
2. Numerical Computing and Matlab Scripting
3. Linear Algebra Review
4. Linear and Non-linear Difference Equations, with applications to Population Dynamics
5. Introduction to Continuous Models, linear ODEs
6. Second Order Linear ODEs and Systems of Equations
7. Nonlinear ODEs - the Chemostat problem
8. Nondimensionalization - the Chemostat problem
9. Introduction to Partial Differential Equations
10. Numerical Differentiation and Integration
11. Curve Fitting
12. Identifying, Downloading, and Plotting Online Data
13. Time series analysis using Matlab
14. Variograms and Spatial interpolation applications using MATLAB

Required textbooks, reading and/or software or computer needs

Students are encouraged to obtain copies of these texts for full resource access, though essential excerpts will be provided as .pdf files on the Moodle site.

Edelstein-Keshet, L., 2005. Mathematical models in biology. SIAM, Philadelphia, 586 pp. ISBN 0-89871-554-7. Available through Amazon.com, possibly other online sites or former students

Hornberger, G. and P. L. Wiberg (2005). Numerical Methods in the Hydrological Sciences, American Geophysical Union. Special Publications Series, Volume 57. ISBN 0-87590-725-1, Student Edition available at http://onlinelibrary.wiley.com/book/10.1002/9781118709528

Access to Matlab is required. This must include at least the Symbolic Math and Signal Processing Toolboxes. Matlab is available through several possible sources, which vary among different campuses. The most widely available source for students registered for UMD classes is the Terpware website (https://terpware.umd.edu), though individual campuses also maintain limited site licenses. A fallback is that the Matlab parent company, Mathworks, offers a complete student version of Matlab for $99, just the core software for $49, and just individual toolboxes for $10.

Course Communication

We will distribute all assignments, tests, and course information through the MOODLE internet site, which may be accessed through https://moodle.cbl.umces.edu. Contacting the TA and/or the instructors via email or in person is encouraged.

Resources

[Course website: https://moodle.cbl.umces.edu/course/view.php?id=106]

There are many useful online references for Mathematics, including some specific to Calculus II. The University of Maryland Libraries Mathematics Resources Guide at http://lib.guides.umd.edu/mathematics is a very good starting point. Dr. Paul Dawkins at Lamar University provides a comprehensive Calculus II resource at http://tutorial.math.lamar.edu/Classes/CalcII/CalcII.aspx .

The University System of Maryland has recently joined the EdX Consortium, which offers many free online courses; https://www.edx.org/. Khan Academy also provides a wealth of online video tutorials for a number of mathematical subjects: http://www.khanacademy.org/.

The Mathworks Website at www.mathworks.com has many useful resources, including online tutorials for using Matlab and help pages for reference. For example, the Symbolic Math Toolbox (SMT) top level page is http://www.mathworks.com/help/releases/R2016a/symbolic/index.html, from which you can find out much more about using the SMT and the Mupad interface. A sequence of interactive, flash-based Matlab tutorials is also available at http://www.mathworks.com/academia/student_center/tutorials/?s_cid=global_nav. These tutorials start with the basics of using and understanding Matlab and build from there.

Campus Policies

The University of Maryland Center for Environmental Science has drafted and approved of various academic and research-related policies by which all students and faculty must abide.

Please visit http://www.umces.edu/consolidated-usm-and-umces-policies-and-procedures for a full list of campus-wide academic policies.

Course-Specific Policies and Expectations

Students are encouraged to work together on homeworks, but must work on their own on take-home tests and the final project.