Modeling of Earth Systems
GEOL 326 SP 2012

lecture	Tu & Th 8:30 to 9:50	CH S17
lab	Tu & Th 14:00 to 15:50	CH 1
	Tu & Th 16:00 to 17:50	CH 1
final	Th 6/9/2011 8:00 to 9:50	

`http://web.pdx.edu/~chulbe/COURSES/MODEARTHSYS`

recommended text: *Numerical Methods with Matlab* Recktenwald (Prentice Hall)
list price accessed online 3/19/2011: $ 63.50 (used) $77.30 (new) at Powell's Books

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office hours: M 11:00 to 13:00 and T 13:00 to 14:00 (or by appointment)

1 overview

Mathematical models are used widely in Geology and Earth system science. Computational simulations are used to study modern systems, predict future behavior of those systems, and investigate past events. This course is an introduction to the formulation and solution of such models. It is not a tutorial for the use of off-the-shelf modeling software. Our objectives are to gain experience with the mathematical framework required to build and use models, and to consider how models behave and how model results are to be interpreted. Throughout the term, we will emphasize how fundamentals from calculus are applied in the mathematical description of Earth system processes.

This course is intended to follow GEOL 324. It is expected that students have some level of comfort with calculus, as well as an introduction to vectors and matrices, and to the MATLAB software. Unfortunately, I have not yet found a textbook that is completely appropriate for this course. We will rely heavily on lecture material and on laboratory assignments. The recommended text, *Numerical Methods with Matlab* by Professor Gerald Recktenwald is a valuable reference.

Our time will be divided between the traditional lecture format and the computer classroom. Lectures will provide the foundations for model development while lab time will be devoted to implementation and evaluation of our work. Laboratory assignments and a term project will support these endeavors. Lab time is instructional time, don't miss it.

If you are a student with a documented disability and are registered with the Disability Resource Center, please contact me so that we can arrange whatever academic accommodations you need.

If you are a Veteran and have questions about University services or need assistance with your transition from military to campus life, please contact Chris Goodrich, Coordinator of Veterans Services at the Office of Veterans' Services, SMSU room 425.

2 schedule

2.1 lecture by week, approximately

1. What is a model? formulation of a mathematical model
2. formulation of a model
3. ordinary differential equations: order of an equation, series approximation of a continuous function
4. solutions to ODEs; initial value problems
5. midterm week; solutions to ordinary differential equations
6. boundary value problems; basic tools
7. boundary value problems; numerical solution using finite differences
8. partial differential equations: conservation, diffusion in one dimension
9. PDEs: advection in one dimension; PDEs in two dimensions, classification of equation type
10. PDEs in two dimensions; review for final

2.2 lab topics by week

1. Matlab introduction/review; arrays; programming style
2. building a model; flow control and functions
3. ODE solvers in Matlab; initial value problems
4. ODE solvers in Matlab; initial value problems
5. "simple models"; iteration
6. midterm week; tools from linear algebra
7. finite difference operators & simultaneous equations;
8. finite difference models in one dimension
9. finite difference models in one dimension; term projects
10. term projects

2.3 term project

In the course of discussing how models are designed and implemented, we will consider several problems in Earth science. Lab time will be spent developing Matlab programs to explore those problems using appropriate modelling techniques. For a term project, you are asked to:

1. Select a new topic that can be explored using one of the general techniques we discuss in class.
2. Find or develop a mathematical model to study the problem. The method you use to solve the equation(s) does not have to be numerical, analytical solutions are preferred when available.
3. Implement the model.

4. Write a short report describing the problem and how you solved it, including an explanation of the equation(s), a list of variables and the initial or boundary conditions used to solve them, and your Matlab program(s). The report should be written in a scientific style and include an introduction with problem statement, description of methods, presentation of results, and conclusion.

You should find one or two references, scientific literature and textbooks are both appropriate, relevant to the problem you choose. The references are not required to be modeling studies but that may be helpful. Using code from another project, for example the lab assignments, as a template for new work is a good idea although uninformed implementation of somebody else's code is not. If you do use somebody else's code as the basis for your project, you should make a significant new contribution to it and you should reference the original work. Failure to correctly reference the work of others may be plagiarism and it is always disrespectful.

The report need not be long, but it must adequately describe your work, be written in a scientific style, and include an introduction, methods section, results, conclusion, and figures appropriate to describing the work and model outcome. Your report should not be about your experience in creating this model, it should be about the model and what it demonstrates. (That is, do not write in the conclusion "this did not work because I started the project too late.")

It is not a requirement that the model work as you intended. Model development is a learning process in its own right and not every idea is a brilliant idea (your instructor is an authority on this). Nevertheless, you must demonstrate that the Matlab scripts you write work. That is, that they are error-free.

3 laboratory assignments

The computer lab is an important part of this class and your attendance in lab sections is expected. Each new lab assumes you have some level of mastery over material from prior weeks so it is important that you do no fall behind with lab assignments. This fraemwork is reflected in the lab grading policy.

Our time in the lab will be divided between lecture material relevant to the lab topic, and work writing and running simple programs. We will use the Matlab programming environment, a robust software package that is widely used in both applied and theoretical work. The lab handouts contain supporting information, specific assignments and related questions, and Matlab scripts. You will learn more if you use the provided scripts as guides to coding your own programs, than if you "copy-and-paste" the material provided for you.

Due dates for lab assignments will be announced in class and on the class website. Once graded, labs will be returned to you for revision. If you score less than 90% you are required to turn in your revisions, along with the original, for regrading. Please only rework the problems with incorrect elements. Failure to turn in a revision will incur a penalty of 50% of the version 1 score. It is more important that you understand the material than that you get it right the first time. The revision policy means that in this class, it is always better to turn in an incomplete assignment on the due date than to turn in nothing at all and that everybody has the opportunity to earn at least 90% on the lab assignments.

The total possible value V of a lab assignment decreases with time t in proportion to V according to a

rate constant λ:

$$\frac{\mathrm{d}V}{\mathrm{d}t} = -\lambda V$$

The value of λ is of 1/48 $hour^{-1}$.

4 code of conduct

As a member of the Portland State University faculty, I "strive to ensure that the highest ethical standards of professional behavior are realized within the University," as established in the *Faculty Code of Conduct*. As a member of the PSU student body, you are bound by a *Student Code of Conduct*. It is your responsibility to be familiar with the code of conduct, which can be read at the Dean of Students website `http://www.pdx.edu/dos/codeofconduct`.

5 evaluation

lab exercises	30%
midterm: lecture	15%
midterm: lab	10%
final	20%
term project	25%