Geosci 561: Mathematical Modeling for Geoscientists

Spring, 2009

Meeting time and location:  MW  9:00-10:00 AM  8 Deike
                        F  9:00-11:00 AM  337 Deike

Instructors:  James Kasting        Richard Alley
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Lecture/lab schedule

Week

Jan. 12/14  Course overview; introduction to the Linux computer lab (Alley/Kasting)
            Solving simple algebraic equations on the computer
            K1--Newton’s method in 1 dimension: solving a quadratic equation

Jan. 19/21  The carbon cycle and the uptake of fossil fuel CO₂ (Kasting)
            K2--Application of Newton’s method to more complex systems:
               carbonate equilibria

Jan. 26/28  Solving simultaneous systems of algebraic equations (Kasting)
            K3--Newton’s method in N dimensions/solving matrix problems
               numerically

Feb. 2/4    CO₂ uptake in a constant alkalinity ocean (Kasting)
            K4--Application: carbonate equilibria revisited

Feb. 9/11   Ordinary differential equations (ODE’s) (Kasting)
            Stiff systems of equations
            K5--Simple implicit and explicit methods for solving ODE’S (forward
               and reverse Euler method, Crank-Nicholson method)

Feb. 16/18  Box models of the carbonate-silicate cycle (Kasting)
            K6--Application of implicit methods to a stiff, nonlinear system: the
               BLAG model

Feb. 23/25  Climate models and climate feedbacks (Kasting)
            (No new lab—continue K6)
Mar. 6/8  Introduction to PDE’s (Kasting)
       Finite differencing
       **K7—A simple heat conduction problem**

Mar. 9-13  **Spring break**

Mar. 16/18 Stability analysis of different numerical methods for PDE’s (Kasting)
           **(No new lab—continue K7)**

Mar. 23/25 Models of diffusion (Alley)
       Ficks laws applied to heat flow
       **A1--Solving Laplace’s equation (steady-state heat conduction): Jacobi iteration, Gauss-Seidel iteration, and successive over-relaxation**

Mar. 30/  Initial conditions and boundary conditions (Alley)
Apr. 1    **A2--Steady-state heat conduction with gradient boundary conditions and internal heat generation**

Apr. 6/8  Time-dependent heat conduction (Alley)
       **A3--Nonsteady, 1-D heat conduction with sinusoidal surface T and constant T at depth/tridiagonal matrix solvers**

Apr. 13/15 Groundwater flow (Alley)
       **A4--Numerical solution of simple groundwater flow problems**

Apr. 20/22 Groundwater flow cont. (Alley)
           **(No new lab—continue A4)**

Apr 27/29  TBD (Alley)

**Grading:**  100% based on the lab assignments
            No exams

**Course philosophy:** Come see us if you need help. If you put in the work, we’ll do our best to get you through the assignments.

**Recommended text (if you need help with Fortran):**

*Introduction to FORTRAN 90 for Engineers and Scientists*
Larry R. Nyhoff, Sanford Leestma

Alternatives:

*Fortran 90/95 Explained,* Michael Metcalf, John Reid, Malcolm Cohen
*Fortran 90/95 for Scientists and Engineers,* Stephen J. Chapman