EVHY 7670 Numerical Methods in Hydrology, Spring, 2016
Instructor: Patricia Wiberg, pw3c@virginia.edu, 924-7546
Clark G054 Tuesdays 2:00-3:45
Monroe Hall 113 Fridays 12:00-12:50

I. Course Description

An introduction to some of the numerical methods that are widely used in hydrology (and in other branches of the environmental science) will be presented. The class will meet for two hours on Tuesday for lecture, and for one hour on Fridays for discussion. Weekly assignments will be made on Tuesdays and discussed on Fridays. These assignments will be to solve problems that are typically encountered in hydrology and other environmental sciences and will include topics related to data analysis and mathematical modeling. The assignments generally will be carried out using MATLAB, although those preferring Python can complete the assignments in that language [though with less assistance from the instructor].

II. Course Materials

Textbook: Hornberger, G.M. and P.L. Wiberg, *Numerical Methods in the Hydrological Sciences*, Special Publications Series, Volume 57, AGU 2006, 233 pp.
Optional reference: Gerald, C. F., and P. O. Wheatley, 1999. *Applied Numerical Analysis,* 6th ed., 768 pp., Addison-Wesley, Reading, MA.

Web page: Collab

III. Grading

Grades are based on performance on the (graded) weekly homework assignments and on participation in the weekly discussions. There will be no exams or papers.

VIII. Schedule

WEEK	DATE	TOPIC	READING
1	1/22/16	Course details; Introduction to numerical methods.	
2	1/26/16	Introduction to MATLAB. Programming using m-files.	Chapter 1
3	2/2/16	Solution of nonlinear equations in surface-water hydrology, specific energy, Manning's equation, etc. Iterative solutions, convergence, accuracy. Writing function files. The MATLAB functions for matrix inversion; FZERO and ROOTS functions.	Chapter 2
4	2/9/16	Numerical differentiation and integration; velocity profiles in open channels. Finite differences. Basics of quadrature. The MATLAB QUAD and TRAPZ functions.	Chapter 3

5	2/16/16	Solution of ODE's for steady flow of ground water, for evolution of water quality with time, and for basic biogeochemical balances. Basic approaches. Stability and accuracy. Runge-Kutta methods. The MATLAB ODE23 and ODE45 functions.	Chapter 4
6	2/23/16	Solution of ODE's (continued) for higher order problems: boundary-layer flow, ground-water flow in multiple aquifers. Boundary conditions. Tridiagonal systems.	Chapter 5
7	3/1/16	Steady ground-water flow in two dimensions using finite differences. Laplace's equation. Sparse matrices. Two-dimensional Poisson equation. The MATLAB SPARSE, SPY, CONTOUR, and MESH functions.	Chapter 6
8	3/8/16	SPRING BREAK	
9	3/15/16	Iterative solution of systems of linear equations. Convergence, relaxation. The MATLAB NORM, CGSOLVE functions.	Chapter 7
10	3/22/16	Solution of transient ground-water flow. Stability. Implicit solutions.	Chapter 8
11	3/29/16	Solution of equations describing transport of dissolved species in surface and ground waters. Stability issues. The advection-dispersion equation. Numerical dispersion.	Chapter 9
12	4/5/16	Introduction to the finite element method for solving flow problems in one dimension The weighted residual (Galerkin) method. Integration of shape functions, assembly of global matrices.	Chapter 10
13	4/12/16	Data analysis using Fourier series. Fitting functions. The FFT. Power spectra. Filtering	Chapter 12
14	4/19/16	Analysis of spatial data. Gridding, contouring, geostatistics.	Chapter 13
15	4/26/16	Final thoughts and discussion	