The University of Toledo
CIVE 6230 Groundwater Modeling
Spring Semester, 2009

W 5:30 to 8:00 p.m. PL 3180, and computer labs as announced

Instructor: Dr. Andrew Heydinger
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Office Hours: Mondays and Wednesdays 2:00 – 3:30 and by appointment, as required.

References: A textbook is not required. The following text is available for reference at the Carlson Library, Applied Groundwater Modeling by Anderson and Woessner (1992).
The following two references are available and recommended for download and use as a reference. The second reference can be printed.
1) http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1421/toc.htm.
2) http://www.epa.gov/tio/tsp/download/issue13.pdf (11 pages).
The following reference is the original documentation for the program MODFLOW that is used by most modelers for groundwater modeling. It can be downloaded but is too long to be printed and contains much of the information about data formatting that is no longer necessary since data inputs are completed using software. Some course notes to accompany lectures will be available from instructor. Printable versions of GMS software documentation available through online help.

Reading: The following book A Civil Action by Jonathan Harr is recommended for reading. The instructor has one copy that will be available for loan for up to two weeks.

Prerequisites: Graduate standing or consent of instructor.

Objectives: Become familiar with the concept and form of continuum models of groundwater flow. Solve the identification problem to quantify model coefficients. Select appropriate domains, boundary and initial conditions to approximate reality. Use of one, two and three dimensional numerical models to solve management and forecasting problems. Errors inherent with solution schemes. Discuss modeling strategies and case studies.

Article review: An article review should be submitted on March 25. For the review, you must find a single reference that describes a groundwater modeling study from a journal article or conference proceedings paper and then select one of the references from the list of references. Write a short (3-4 pages, double spaced) review of the article. Give a short critique, commenting on the validity of the assumptions and techniques to model the groundwater flow. Appropriate sources are journals such as Groundwater, J. of the Soil Science Society of America and Water Resources Research, among others. All are held by UT libraries.

Modeling report: A modeling report should be sumitted on April 29. Reports should contain all necessary assumptions, data, boundary and initial conditions, computations and figures, including precalculations used to set up the model. The report should be written in a professional manner. Conclusions are expected. Data and information on the report is provided here.

Reading assignments: It is assumed you will read the appropriate sections of the references before attending class. This is particularly important for days when a software demonstration is scheduled.

Grading:		
	Homework, review and report	50%
	Midterm exam	25%
	Final exam	25%

Lectures	**Subject**
5	Hydrogeology, Total Head and Darcy's Law, Extensions of Darcy's Law, Mass and Momentum Balance Equations, Velocity Potential and Stream, Function, Equipotential Lines and Streamlines, Boundary Conditions.
3	Flow Nets, Confined Flow, Unconfined Flow, Seepage and Uplift Problems.
2	Numerical Modeling in 2-Dimensions
3	Numerical Modeling in 3-Dimensions, MODFLOW
8	Grid Design and Conceptual Model Development, GMS
3	Model Calibration, Parameter Estimation and Sensitivity Analysis
4	Unsaturated Flow, Use of FEMWATER