Syllabus

TRANSPORT IN POROUS MEDIA

Course # 15100 / CGN 6933-002

Department of Civil & Environmental Engineering (EGX)

University of South Florida

Cunningham **Spring 2005**

Lectures: Mondays and Wednesdays, 4:30–5:45 PM

Instructor: Prof. Jeffrey A. Cunningham
ENC (Engineering Bldg III), room 3215
cunning@eng.usf.edu (but this address might not work yet -- be patient)
974-9540

Office Hours: To be announced as soon as possible; probably held on Tues. and Thurs.

Credit: 3 units

Objectives: (1) Familiarize students with the fundamental processes that control transport in porous media. (2) Equip students with the tools to solve practical engineering problems related to transport in porous media. (3) Familiarize students with one important class of transport problems, namely, contaminant transport in groundwater.

Text books: Fetter, C.W. Contaminant Hydrogeology, 2nd ed. Prentice-Hall, 1999.
Bear, J. Dynamics of Fluids in Porous Media. Elsevier, 1972 / Dover, 1988.
These books are recommended but not required; we'll rely mostly on course notes.

Other texts: I will try to put books on reserve in the library. These may be helpful if you have questions that are not answered by the primary texts, or if you are curious to learn more about the topic.

Grading:

Homework:	25%
Midterm exam:	25%
Final exam:	50%

Prerequisites:

Required:	differential equations and multi-variable (vector) calculus
Recommended:	some computer programming experience
Helpful:	advanced math (e.g., partial differential equations)

E-Mail: Outside of class, electronic mail will be the preferred means of disseminating information. A class e-mail list will be established (perhaps using BlackBoard).

Web site: A course web site has been established for distributing assignments and posting information: http://www.eng.usf.edu/~cunning/CGN6933-TiPM/CGN-TiPM.htm
Or, use the BlackBoard ("Courses") option through myUSF.

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Course Philosophy, Scope, and Content

This class examines the fundamental phenomena governing scalar transport in porous media, but the subject material is developed and presented for the particular application of *contaminant transport in groundwater*. The class will therefore be most useful to engineers and geoscientists interested in groundwater quality and/or contaminant fate and transport, but the principles and methods developed may also be of use to those studying analogous problems (chromatography, separations processes, packed bed reactors, petroleum production, et cetera).

My aim in this course is to balance fundamentals and applications. We need to develop enough fundamentals that the material you learn here can be easily applied to new problems that you have not encountered before. Conversely, we need to solve enough practical problems that you understand how to apply the fundamentals in practice, and why the material is useful. Although we will focus on *contaminant transport in groundwater* as our practical application, the goal is for you to be able to apply the material learned in this course to other porous-media problems.

In this class, we will use mathematics as one of our tools for solving practical problems. This will include both analytical (i.e., "pencil-and-paper") mathematical solutions as well as numerical (i.e., with a computer program) solutions. When using numerical solutions, we will develop our own computer programs, rather than relying on commercially-available codes. Although a working knowledge of common software programs is, indeed, useful, particularly for students about to enter the job market, I think it is more important that you first understand how those computer programs work. It is dangerous to apply somebody else's computer program to a problem if you don't really understand what the program is doing, or if the reported answer makes sense.

Topics we are likely to see this semester include: Darcy's Law; Processes of advection, diffusion, dispersion, sorption-desorption, reaction, and degradation; Development of the advective-dispersive equation for transport; Analytical solutions to the advective-dispersive equation; Influence of a contaminant's chemical properties on its fate and transport; Numerical methods for solving the advective-dispersive equation; Finite differences and finite elements; Explicit, implicit, and Crank-Nicolson methods; Numerical dispersion; Peclet number and advection-dominated problems; Sorption equilibrium and kinetics, and the local equilibrium assumption.

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Course schedule:

The schedule below is *tentative*. This is the first time I have taught this class at USF, so it is difficult to predict exactly how much class time will be needed for each topic listed. The most likely scenario is that the course will proceed as follows:

Week 1	Course introduction, motivation for this course
Week 2	Properties of porous media
Week 3	Processes: advection, dispersion, sorption/desorption, reaction/degradation
Week 4	Developing the advective-dispersive equation for transport in porous media
Week 5	Analytical solutions to the advective-dispersive equation
Week 6	Effect of chemical properties on transport in porous media
Week 7	Introduction to numerical solution of the advective-dispersive equation
Week 8	Finite difference method; explicit, implicit, and Crank-Nicolson numerical methods
Week 9	Peclet number; more on finite differences; ***midterm exam***
Week 10	*spring break*
Week 11	Linear and non-linear sorption isotherms; numerical solutions with sorption
Week 12	Galerkin finite element method for solving the advective-dispersive equation
Week 13	Galerkin finite element method, continued
Week 14	Physics and chemistry of sorption reactions; modeling sorption kinetics numerically
Week 15	Advanced topic(s), or catch-up if needed
Week 16	Wrap-up, review, and course evaluation
Week 17	***Final exam***

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Class Policies: 1., Homework Policy

- There will be 9 ± 1 homework sets to be performed throughout the semester.
- It is the instructor's goal that all homework assignments be graded. However, it is possible that, on occasion, a particular homework assignment might not be graded.
- It is in your best interests to invest the time in doing the homework well. If you do a good job on the homework assignments, you are likely to perform well on the examinations. If you don't spend the time on the homework, then you are likely to have difficulty on the examinations.
- The instructor will be available at least one hour each week, and probably more, to assist with homework problems.
- Students may discuss the assignments among themselves, but each student must conduct the actual computations and write up his/her work without referring to others' solutions. Copying the work of others (including sections of computer programs) will be considered cheating.
- Assignments will usually be distributed at least one week before the due date.
- Assignments are due *in class* on their due date unless otherwise noted.
- Homework solutions will be provided to students, usually after the next class following the due date.
- Homework submitted in class on the due date will be considered on time and thus eligible for full credit. Thereafter, a 20% *late penalty* will be subtracted up until the homework solutions are distributed. After the solutions are distributed, late homework will not be accepted.
- Homework should be neat and legible, on standard 8.5-by-11 or A4 paper, stapled.
- Report your numerical answers to a reasonable number of significant digits. You may be graded down for reporting an excessive number of significant digits.
- Your homework solutions must include at least enough detail that the grader can follow your reasoning and calculations. An answer provided without this level of detail will be considered insufficient.
- Helpful hint: when performing calculations, be careful of your units!

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Class Policies: 2., Exam Policy

- Both the midterm and final will be written examinations.
- Exam questions will be primarily quantitative (problem-solving), but there may be qualitative (definition, discussion) questions as well.
- Both examinations are *closed-book*, but students are permitted to use *personal note sheets*: one double-sided 8.5-by-11 inch sheet for the midterm, and two such sheets for the final exam. Personal note sheets must be hand-written -- no laser printing, scanning, photocopying, etc. Retrieval of information by other means during an examination will be considered cheating.
- The midterm exam will be given in class, probably on Monday, 7 March. Any changes to this date will be announced sufficiently ahead of time.
- The final exam will be given at the time set by the registrar, if applicable, or otherwise at a time to be announced during the semester.
- Exams can be re-scheduled or "made-up" only in the event of a legitimate reason for absence and/or *prior* consent of the instructor.
- The instructor's intention is to design exam questions such that students who have attended class and have done the homework assignments will be familiar with all the material needed to answer the question (i.e., it will not be my intention to "surprise" you, only to challenge you).
- Helpful hint: when performing calculations, be careful of your units!

Class Policies: 3., Americans with Disabilities Act (ADA)

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Office of Academic Support and Accommodations for Students with Disabilities (ASASD) as soon as possible.

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Class Policies: 4., Academic Honesty

- The handouts used in this course are copyrighted. By "handouts," I mean all materials generated for this class, which include, but are not limited to: syllabi, notes, quizzes, exams, in-class materials, review sheets, and additional problem sets. Because these materials are copyrighted, you do not have the right to copy the handouts unless I expressly grant permission.
- No form of scholastic dishonesty (cheating, plagiarism, etc.) will be tolerated. As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you have permission of that person. This includes copying material from books, reports, journals, pamphlets, handouts, other publications, web sites, etc., without giving appropriate credit for those ideas and/or without identifying material as quotations when taken directly from another source.
- Cheating on homework and exams will not be tolerated. Cheating will be dealt with according to university policy.
- Examinations are *closed-book*, but students are permitted to use *personal note sheets*: one double-sided 8.5-by-11 inch sheet for the midterm, and two such sheets for the final exam. Personal note sheets must be hand-written -- no laser printing, scanning, photocopying, etc. Retrieval of information by other means during an examination will be considered cheating.
- Students may discuss homework assignments among themselves, but each student must conduct the actual computations and write up his/her work without referring to others' solutions. Copying the work of others, including homework, will be considered cheating.
- Violation of these rules can result in disciplinary action including a grade penalty, up to and including an F or FF in the course, suspension, dismissal, and expulsion from USF. If you have any questions regarding plagiarism or other forms of scholastic dishonesty, please consult the relevant sections of the USF student catalogs, and/or ask the instructor.