CE 387C

Geoenvironmental Engineering

	Lectures:	*Laboratory:*
Days:	Monday, Wednesday, Friday	Day to be defined
Time:	10:00 a.m. – 10:50 a.m.	Time to be defined
Building:	Ernest Cockrell, Jr.	Ernest Cockrell, Jr.
Room:	ECJ B.226	ECJ 7.208 or B.140
	Instructor:	*Teaching Assistant:*
	Dr. Jorge G. Zornberg	Michael Plaisted
Office:	ECJ 9.227A	ECJ B.412B
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Office Hours:	Mon, Fri 2:00 p.m. – 3:00 p.m.	Office hours to be defined

Course Notes:

CE 387C – Geoenvironmental Engineering - Available in the Textbook Department of the University Co-op (2246 Guadalupe St.). This packet contains supporting materials for the course lectures. *Please bring these course notes to class each day.*
These course notes will supplement the handouts distributed in class.

Suggested Textbook:

Qian, X., Koerner, R.M., and Gray, D.H. (2002). *Geotechnical Aspects of Landfill Design and Construction*. Prentice Hall.

The suggested textbook is available in the Textbook Department of the University Co-op (2246 Guadalupe St.). However, since the textbook does NOT cover the material as presented in class, you will need to take good, complete notes in the lecture. Lectures will be supplemented by some handouts, but your notes will be very important. In addition, I suggest the following books, which should be available in the library:

Daniel, David E. (1993). *Geotechnical Practice for Waste Disposal*. Chapman & Hall.
Koerner, R.B. (2005). *Designing with Geosynthetics*. Fifth Edition. Prentice Hall.
Lambe, T.W, and Whitman R.V. (1969). *Soil Mechanics*. John Wiley & Sons, Inc.
Lu, N., and Likos, W.J. (2004). *Unsaturated Soil Mechanics*. John Wiley & Sons, Inc.
Mitchell, J.K. (1993). *Fundamentals of Soil Behavior*. Second Edition, John Wiley & Sons, Inc.
Sharma, H.D. and Lewis, S.P. (1994). *Waste Containment Systems, Waste Stabilization, and Landfills: Design and Evaluation*. John Wiley & Sons, Inc.

Sharma, H.D. and Reddy, K.R. (2004). *Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies*. John Wiley & Sons, Inc.

Course material:

Reading assignments and additional course material will be posted in Blackboard. The documents will be posted in electronic version (pdf format). The contents will be updated frequently, so you should check periodically for new material.
A number of articles will be assigned over the course of the semester. These articles have technical and/or historical significance to the current state of practice. You are expected to read these articles critically and be prepared to discuss them in class.

Course Prerequisites:

While there are no prerequisites for this course, a background in geotechnical engineering (at least one or two undergraduate classes) is recommended. Please see me if you have questions about the appropriateness of your background.

Course Objectives:

The overall objective of this course is to provide an understanding of the use of geotechnical concepts in the analysis and design of environmental systems. Focus will be placed on the evaluation of waste containment facilities, with particular emphasis on the behavior and design of geotechnical barriers. The course will also cover relevant aspects of contaminant transport, design of drainage layers, and landfill stability. Class discussions also include case histories, which are particularly relevant to illustrate the process followed in the conceptual design of waste containment facilities. Upon completion of the course, the student should be able to:

- Understand the regulatory framework related to safe containment of wastes.
- Evaluate the mechanical and hydraulic properties of compacted clay and understand the factors governing changes in these properties.
- Select, justify the selection, and design base liner systems, final cover systems, and liquid collection systems for municipal and hazardous waste.
- Master concepts in unsaturated soils related to moisture migration, including moisture retention curves and hydraulic conductivity functions.
- Apply the unsaturated soil concepts to conduct the design of alternative cover systems.
- Select, justify the selection, and design base liner systems, final cover systems, and liquid collection systems for municipal and hazardous waste.
- Identify the types, properties and characteristics of different geosynthetic materials used in the design of geoenvironmental systems.
- Select, justify the selection, and quantify the leakage through geosynthetic barrier systems used in municipal and hazardous waste facilities.
- Apply stability, water balance, and contaminant transport concepts needed in the design of waste containment facilities.

Schedule:

The class will meet for three lectures each week. The laboratory will meet once a week. A tentative schedule and outline of the lecture topics is attached. Because of various national and

international committees, meetings and conference, I will have to travel on university-sanctioned business during this semester. I plan to cover these periods by scheduling activities (e.g. presentations, field trips) during the semester. Your help in scheduling these activities is sincerely appreciated.

Attendance:

Students are expected to attend all class periods. Since the course text will provide only supplementary information, the lectures are clearly the main source of information to be covered in the homework assignments and exams.

Examinations:

There will be one exam, given during the regularly scheduled class time, and a *comprehensive* final examination. Make-up examinations will not be given. Students who miss a midterm exam will receive a grade of zero for that exam. Exceptions to this rule will be made only on a carefully considered basis, and only if the student contacts me *before* the exam.

All exams will be closed-book, closed-notes. However, you are permitted to bring sheets (8.5 x 11 inch) written on one side only, of your *own handwritten* equations to each exam. One sheet will be permitted for the first exam, and two sheets will be allowed for the final exam. This way, the new sheet you prepare for the first exam will be used again for the comprehensive exam. You may write only equations (no notes, no graphs) on one side of these sheets. Some "formulas" will also be given on the exams. All design charts and similar materials will be provided for during the exam. The organizational effort required to create your equation sheets is an effective means of reviewing the course content before an exam. In addition, you need to bring a straight edge, compass, and protractor to the exams.

The final examination will cover all of the material from the semester. According to the university schedule, the final exam will be held from 9:00 a.m. to 12:00 noon on Tuesday, December 15, 2009.

Laboratories:

The laboratory schedule will be provided separately. You will prepare a brief report for each lab, including the raw data, data summaries, analysis and reduction of the data, and a discussion of the results. Additional information on the laboratory assignments will be provided by the TA.

Homework Assignments:

Homework problems will be assigned on a regular basis. Extra copies of the assignments, as well as other class handouts, will be placed in the class box outside of ECJ 9.227. Completed assignments are due at the *beginning of class* on the date specified; late assignments will not be accepted for grading. Homework is intended principally as a means of helping you to learn and understand the course material, rather than as a means of assigning points which directly determine your final grade. The assignments also are aimed at developing your engineering skills.

Each assignment must be submitted with a cover memorandum. A professional engineer's work entails much more than analysis. Hence, all assignments in this class must be submitted with a

cover memorandum that briefly discusses your analysis. The cover memo should be typed, addressed to the instructor, and no more than one page long. The text of your memo should:

- Briefly state the purpose of your work (remind the reader of what was requested and what you did).
- Describe the data, material properties, and other information used to solve the problem, including any assumptions you may have used.
- Review important aspects of the problem and your solution.
- Refer to any attached drawings, plots, and other figures and identify the significant information they contain.
- Summarize important results, conclusions, and recommendations.

Attach your calculations, plots, and drawings behind the cover memo. Write your cover memo as if you were submitting your results to a professional client.

Report:

The ***term project*** involves preparation of a written report and its presentation in a seminar. The written report will be compiled throughout the term. The term project represents a significant portion of the grade, so you should dedicate adequate time during the semester rather than leaving the work towards the end of the term. Details regarding the scope and schedule of the different aspects of the final project will be provided separately.

Grading Policy:

Your final letter grade will be determined by your performance relative to others in the class. Divisions between grade levels, as well as a likely "class curve", are not pre-determined. Participation in class is explicitly considered in your final grade. In borderline cases your participation and attendance in class will also be considered. Your final score for this course will be computed using the following weights:

- Homeworks and term project: 20%
- Laboratory: 15%
- Class participation: 5%
- Midterm examination: 25%
- Final examination: 35%

University Policies and Deadlines:

Dropping the Course:

- From the 1st through the 4th class day, graduate students can drop or add a course on Rose or TEX. Beginning with the 5th class day, graduate students must initiate any adds or drops in their department.
- Graduate students can drop a class until the last class day with permission from the departmental Graduate Advisor and the Dean.
- Graduate students with GRA/TA/Grader positions or with Fellowships may not drop below 9 hours in a long session.

Course Evaluation: A course/instructor evaluation will be conducted in class near the end of the semester. The standard form and procedure from The University of Texas Measurement and Evaluation Center (MEC) will be used.

Religious Observances: A student who is absent from a class or examination for the observance of a religious holyday may complete the work missed within a reasonable time after the absence, provided the student has notified the instructor in writing before the absence and not later than the 15th class day.

Students with Disabilities: The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities. Any student with a documented disability (physical or cognitive) who requires academic accommodations should contact the Services for Students with Disabilities area of the Office of the Dean of Students at 471-6259 as soon as possible to request an official letter outlining authorized accommodations. For more information, contact that Office at 471-6259, TTY at 471-4641, or the College of Engineering Director of Students with Disabilities at 471-4321.

Course Outline:

The tentative outline of lecture topics for the course is as follows:

- **The Environmental Geotechnics Field**
  - Introduction
  - Waste containment overview
  - Regulatory framework
  - Types of liner systems
- **Clay Behavior**
  - Saturated flow
  - Clay minerals
  - Clay properties
  - Water in soil
- **Compacted Clay Barriers**
  - Soil compaction
  - Properties of compacted clay
  - Design of compacted clay barriers
  - Field compaction, QC/QA
- **Unsaturated Soil Behavior**
  - Unsaturated soil Concepts
  - Soil water retention curves
  - K-function
  - Unsaturated flow
- **Unsaturated Soil Barriers**
  - Conventional cover systems
  - Types of alternative covers
  - Design of evapotranspirative covers
  - Monitoring of cover systems
- **Geosynthetic Materials**
  - Types and functions of geosynthetics
  - Polymers

    - Geomembranes
    - GCLs
- **Geosynthetic Barriers**
    - Leakage through GMs
    - Leakage through composite liners
    - Details in GM liner design
    - Exposed geomembrane liners
- **Contaminant and Solid Waste**
    - Types of waste and contaminants
    - Characterization
    - Engineering properties of waste
- **Contaminant Transport through Barriers**
    - Advection, dispersion, diffusion
    - Reactive constituents
    - Analytic solutions
- **Liquid Drainage Layers**
    - Water balance for landfills
    - Soil and geosynthetic drainage systems
    - Design of drainage layers
- **Stability and Settlement of Landfills**
    - Failure modes
    - Stability analysis and design aspects
    - Seismic design
    - Settlement of waste
- **Additional Aspects in Geoenvironmental Engineering**
    - Mining geotechnics
    - Beneficial reuse of waste materials
    - Bioreactors
    - Pump and treat
    - Bioremediation, thermal treatment, solidification
    - Grouting, ground improvement applications

Case histories will be presented to illustrate the different concepts