CEE 5430/6430: Groundwater Engineering

Instructor: Dr. Pin Shuai

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Office Hours: M 11:30-12:30 pm
Class Hours: M/W 03:00-04:15 pm
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Course Description

This course explores the fundamental principles governing the movement of water and contaminants in groundwater systems. Topics include: hydrogeologic properties, governing equations of porous media flow and mass transport, well hydraulics and aquifer testing, groundwater contamination, numerical simulation basics, unsaturated flow, and regional groundwater balance. The objective of the course is to provide the knowledge foundation that can be used in groundwater resources management applications.

Course Materials

- This course uses *Groundwater* by Freeze and Cherry as the main textbook along with several other supplemental reading materials. See details below:
  - *Freeze, R.A. and Cherry, J.A., *Groundwater*, Prentice-Hall, Englewood Cliffs, N.J., 1979. (A free, multilingual online version can be found at The Groundwater Project)
  - Fetter, C.W., *Applied Hydrogeology*, 4th ed. Prentice Hall, 2001.
  - Woessner, W.W. and Poeter, E.P., *Hydrogeologic Properties of Earth Materials and Principles of Groundwater Flow*. (Free on The Groundwater Project)
  - Cohen, A.J. and Cherry, J.A., *Conceptual and Visual Understanding of Hydraulic Head and Groundwater Flow*. (Free on The Groundwater Project
  - Poeter, E. and Hsieh, P., *Graphical Construction of Groundwater Flow Nets* (Free on The Groundwater Project
  - Poeter E, Fan Y, Cherry J, Wood W, and Mackay D, *Groundwater in Our Water Cycle: Getting to Know Earth's Most Important Fresh Water Source*. (Free on The Groundwater Project
  - Woessner W., *Groundwater-Surface Water Exchange* (Free on The Groundwater Project

- Course notes are available on Canvas. Canvas will be used to post course materials, homework assignments, and solutions. *Please do not send emails with questions about lecture material, homework, etc.* Instead, ask these questions using the "Discussions" feature on Canvas, so that all students can benefit. If you need a quick response, send me an email so I know that you have posted to the Discussion Board.

Prerequisites

CEE 3430 or a similar hydrology course

Course Objectives

Successful students will be able to do all of the following:

1. Understand the concepts such as evaporation, infiltration, groundwater recharge, and base flow in groundwater hydrology and their roles in the hydrological cycle.
2. Use critical physical parameters (porosity, hydraulic conductivity, and storativity) of aquifers to understand the groundwater flow systems.
3. Measure and calculate hydraulic head, elevation head, pressure head, and hydraulic gradient.
4. Perform calculations using Darcy's Law and the Dupuit equation to solve various problems such as computing the discharge of groundwater to rivers, computing contaminant travel time from a source to a discharge point, and calculating groundwater flow in horizontal and vertical directions.
5. Interpret local and regional groundwater flows, and the law of refraction for groundwater flow at the interface of two media with different hydraulic conductivity values.
6. Compute drawdowns near a pumping well using Theis, leaky Theis, Hantush-Jacob and Thiem solutions and know which assumptions apply to each method.
7. Interpret different hydraulic well testing results such as Pumping Tests, Single well pumping tests, and Slug Tests.
8. Understand the importance of groundwater-surface water interactions and the role of groundwater in the hydrologic cycle.

Course Structure

Lecture

Lectures will be given twice a week unless otherwise notified. Students are encouraged to ask questions during the lectures. This course does not have a lab component.

Homework Assignments

There will be five (5) homework assignments throughout the semester. You will have 7-10 days to complete each assignment. You are encouraged to work with your classmates.

Exams and Final Project

Two exams will be given in class. Exams are open-book written exams. Phones, tablets, or laptops are not allowed during exams.

For the final project, each student will be given a presentation (**15 minutes**) on a state-of-the-art paper that I will choose and that the entire class will read. The presentations will be given on the last week of class (**Nov 27 - Dec 4**). On **Oct 25**, in class, we will draw names to work out the order of all presentations.

The purposes of the project are to 1) read and understand scientific literature, 2) gain an in-depth understanding of using theories or models to address real-world groundwater issues, and 3) practice scientific communication skills. The rubrics of the oral presentation will be given in class.

Grading Policy

Homework assignments (five total)	**30%**	(6% each)
Exam 1	**25%**	
Exam 2	**25%**	
Final project	**20%**	

Numerical grades on homework assignments, exams, and final projects will be rounded at the first decimal place (e.g. 89.50%→90%, 89.49%→89%). Letter grades for individual assignments will be computed as follows: **A=90-100%, B=80-89%, C=70-79%, D=60-69%, F<60%**.

A limited number of extra credit opportunities (up to 2% of final grade) related to assisting in field or lab research or attending a special lecture on campus will arise throughout the course. The instructor will make every effort to inform the students of these extra credit opportunities as far ahead of time as possible to try to accommodate a range of schedules. These events, however, tend to be relatively spontaneous and hard to predict at the outset of the course.

Important Dates

First day of class	Aug 28
Labor Day - no class	**Sep 4**
CIROH meeting - no class	**Oct 2 - 4**
Exam 1	Oct 11*
Thanksgiving Holiday - no class	**Nov 22 - 24**
Exam 2	Nov 29*
Last day of classes	Dec 08

*Subject to changes

Proposed Schedule

Dates	Topics
Aug 28	Introduction to Groundwater
Aug 30 - Sep 13	Physical Properties of Groundwater and Aquifers • Properties of porous media • Darcy's Law • Aquifer properties • Streamlines and equipotential lines (flow nets) **HW#1 Due**
Sep 18 - Sep 25	Principles of Groundwater Flow • Governing equations • Steady flow in confined and unconfined aquifers • Unsaturated flow
Sep 27	Groundwater Flow to Wells • Groundwater flow to wells - Part I (steady flow)
Oct 2 - 4	CIROH Meeting (**No class**) **HW#2 Due**
Oct 9*	Exam 1 Review
Oct 11*	**Exam 1**
Oct 16 - Oct 25	Groundwater Flow to Wells cont'd • Groundwater flow to wells - Part II • Groundwater flow to wells - Part III • Groundwater flow to wells - Part IV • Groundwater modeling basics **HW#3 Due, Draw names on presentations**
Oct 30 - Nov 8	Solute Transport and Groundwater Contamination • Groundwater contamination • Solute transport processes - Part I • Solute transport processes - Part II • Solute transport processes - Part III

	HW#4 Due
Nov 13 - Nov 20	Hydrological Cycle and Groundwater-surface water Interactions • Groundwater in hydrological cycle • Groundwater-surface water interactions • Guest Lecture (TBD) **HW#5 Due**
Nov 27*	Exam 2 Review
Nov 29*	**Exam 2**
Dec 4, 6*	Presentations
*Subject to change	

Course Policies

During Class

I understand that the electronic recording of notes will be important for class and so computers will be allowed in class. Please refrain from using computers for anything but activities related to the class. Phones are prohibited as they are rarely useful for anything in the course. Disruptive classroom behavior will not be tolerated. An individual engaging in such behavior may be subject to disciplinary action. Read Student Code of Conduct for more information.

Attendance Policy

Attendance is expected in all lectures. Valid excuses for absence will be accepted before class. In extenuating circumstances, valid excuses with proof will be accepted after class.

If a student misses a class it is that student's responsibility to catch up on what they missed relying on assigned readings, posted lectures and copying notes from a classmate. To achieve a good grade each student must take responsibility for learning the course material covered in class. There are no "make-up" classes. The instructor will not re-teach entire classroom lectures to the students outside of the class time.

Late Assignment and Makeup Work Policy

Late assignments will be accepted for no penalty if a valid excuse is communicated to the instructor before the deadline. After the deadline, assignments will be accepted for a 25% deduction to the score up to 2 days after the deadline. **After this any assignments handed in will be given 0**.

In the case of when a student misses a quiz or an exam, the student must have an official medical, religious, and university excused absence (with adequate documents provided to the instructor) to be allowed to take the test another time. Students should consult Student Code of Conduct for attendance and excused absence.

Academic Integrity and Honesty

Each student has the right and duty to pursue his or her academic experience free of dishonesty. To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge:
"I pledge, on my honor, to conduct myself with the foremost level of academic integrity."
A student who lives by the Honor Pledge is a student who does more than not cheat, falsify, or plagiarize. A student who lives by the Honor Pledge:

- Espouses academic integrity as an underlying and essential principle of the Utah State University community;

- Understands that each act of academic dishonesty devalues every degree that is awarded by this institution; and
- Is a welcomed and valued member of Utah State University.

The instructor of this course will take appropriate actions in response to Academic Dishonesty, as defined the University's Student Code. Acts of academic dishonesty include but are not limited to:

- **Cheating**: using, attempting to use, or providing others with any unauthorized assistance in taking quizzes, tests, examinations, or in any other academic exercise or activity. Unauthorized assistance includes:
  - Working in a group when the instructor has designated that the quiz, test, examination, or any other academic exercise or activity be done "individually;"
  - Depending on the aid of sources beyond those authorized by the instructor in writing papers, preparing reports, solving problems, or carrying out other assignments;
  - Substituting for another student, or permitting another student to substitute for oneself, in taking an examination or preparing academic work;
  - Acquiring tests or other academic material belonging to a faculty member, staff member, or another student without express permission;
  - Continuing to write after time has been called on a quiz, test, examination, or any other academic exercise or activity;
  - Submitting substantially the same work for credit in more than one class, except with prior approval of the instructor; or engaging in any form of research fraud.
- **Falsification**: altering or fabricating any information or citation in an academic exercise or activity.
- **Plagiarism**: representing, by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes using materials prepared by another person or by an agency engaged in the sale of term papers or other academic materials.

For additional information go to: ARTICLE VI. University Regulations Regarding Academic Integrity

Accommodations for Disabilities

USU welcomes students with disabilities. If you have, or suspect you may have, a physical, mental health, or learning disability that may require accommodations in this course, please contact the Disability Resource Center (DRC) as early in the semester as possible (University Inn # 101, (435) 797-2444, drc@usu.edu). All disability related accommodations must be approved by the DRC. Once approved, the DRC will coordinate with faculty to provide accommodations.