Geohydrology

GEOL 4444/5444
Spring, 2008
4 Credits

Dept. of Geology & Geophysics
University of Wyoming
Instructor: Ye Zhang

Grading: A-F
Location: GE318
Class times: Tues + Thurs (9:35~10:50 am)
Office hours: Mon (4:00~5:30 pm), Fri (1:30~3:00 pm), GE 220
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Phone: 307-766-2981

Lab times: Thurs (3:10~5:00 pm), GE318
TA: Mr Daniel Sturgis
Office hours: 1:00~2:00 pm **(**M-W-F), ESB 2040
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Phone: 307-766-6679

Course Objective:
Groundwater hydrology studies the movement of underground water in the saturated zone. It emerges from an early engineering root (development of water resources) to become, in recent decades, a full-fledged environmental, engineering and geological science. The mathematical and physical principles of groundwater hydrology are intimately related to many other fields, e.g., petroleum and soil/agricultural engineering, where flow, transport, and reaction through porous media play a fundamental role. In this class, the basic principles of groundwater hydrology will be introduced, emphasizing both the fundamental development and practical applications. Analytical solutions to the classic steady-state and transient flow problems in well hydraulics will be provided. Although calculus and differential equations are needed to fully comprehend the development of many equations and formulas, the exercises, homework, and exam problems can usually be solved by hand with a calculator.

Learning Outcome:
The students will learn the basic concepts, theorems and their applications in hydrogeology including the Hydrologic Cycle, Aquifer, Aquitard, Recharge, Discharge, the Mass Balance principle, properties of water and porous media, the principles of Hydrostatics and Hydrodynamics, Hydraulic head, Water Wells, Darcy's Law, Hydraulic Conductivity, Darcy Flux, Heterogeneity, Anisotropy, Equivalent Conductivity, Effective Stress, Aquifer Storage, the General Groundwater Flow Equation and an Introduction to Well Hydraulics (e.g., Thiem Solution, Theis Solution, Image Well Theorem). The students will learn to infer flow directions from the water table map or the potentiametric surface. They'll learn to calculate the head gradient and then use Darcy's law to compute the groundwater velocity for both isotropic and anisotropic media. The students will also be able to conduct pumping test analysis to infer aquifer parameters. For the graduate students (the 5444 group), Lab 5 will introduce the Finite Difference Method. For this lab, Matlab programming is needed. For the majority of the exercises or homework, students can solve the problems by hand or using Excel, by applying the equations or formulas learned.

Prerequisite:
Calculus I & II (required);
Matlab (optional);*
Calculus III (optional);
Linear Algebra (optional);
Differential Equations I & II (optional);

* A good Matlab tutorial (will take 2~3 hours to complete):
http://faculty.gg.uwyo.edu/yzhang/files/Matlab_Basics.pdf

Note that the courses listed as "optional" are desired to have in order to develop a fuller understanding of some of the advanced topics encountered in this class. However, if a student has not taken these classes, he/she must pay close attention to Chapter One where the basic math we'll use will be reviewed.

Attendance Policy:
Each student is expected to attend the lectures and laboratories of this class to fulfill the academic requirements. For participation in a University-sponsored activity or for unusual circumstances (personal hardship), an authorized absence may be issued to the student by the Director of Student Life or the Director's authorized representative. If a student has been hospitalized, or if the student has been directed by the Student Health Service or the student's private physician to stay at the student's place of residence because of illness, the Health Service medical staff or the student's private physician must issue a statement to the student giving the dates of the student's confinement. If a student produces the proof of absence, a makeup session can be arranged with the instructor. http://uwadmnweb.uwyo.edu/legal/Uniregs/ur713.htm

Course requirements:
This class is composed of 2 lectures and 1 lab per week. Students are expected to independently work out the homework and lab projects, reading/assay assignments, and exams/quizzes. The instructor has developed a set of lecture notes which will complement the textbook. These notes will be periodically posted via Wyoweb (merged course site). The notes however do not contain formula proofs, equation derivations and solutions to exercises, so lecture attendance and class participation are key to learning well.

Course Calendar:
All Thursdays (when lecture and lab concur) are highlighted in grey. Note that with the exception of Homework 1, 2 & 5 (small assignments), the lab projects are alternating with homework problems (your TA will help you in both instances).

Lecture	Topics	Lab	Due Date
1/13	Introduction; Course policy; Basic Math Homework 1		
1/15	Basic math	**No lab**	
1/20	Quiz 1; Hydrologic cycle; Fluxes affecting Groundwater; Hydrologic Balance		Homework 1 due;
1/22	Water properties; Porous media properties;	Lab1 (Porosity, Saturation, Effective Porosity)	
1/27	Porous media properties; Fluid mechanics & hydrostatics;		
1/29	Hydraulic head measurements; Well schematics; Homework 2	Lab 2 (Grain Size Analysis; bring your own laptop if possible).	
2/3	Quiz 2; Aquifer and its properties; Darcy's law; Hydraulic conductivity (K); Darcy flux;		
2/5	Average linear velocity; Isotropy/Anisotropy; Darcy's law in 3D;	Lab 3 (Darcy Test)	Homework 2 due
2/10	Quiz 3 (test Chapter 3);		

	Darcy's law in 3D; Intrinsic permeability; Homework 3		
2/12	Continuum assumption; Navier-Stokes equation (Optional) Laminar flow; Heterogeneity;	Homework 3	
2/17	Quiz 4 (Chapter 4 until Homework 3) Anisotropy; Flow across interface;		Homework 3 due
2/19	Equivalent K;	Lab 4 (Equivalent K)	
2/24	Transmissivity; Measuring Conductivity; Variable-density flow (Optional); Homework 4		
2/26	Quiz 5; Aquifer/Aquitard; Recharge/Discharge; Water Table/Potentiometric surface;	Homework 4	
3/3	Groundwater/surface water interaction; Groundwater in Geological Processes; Midterm review Homework 5;		Homework 4 due
3/5	**Midterm exam** (same room, same time)	**No lab**	
3/10	Effective stress; Excavation instability; Liquefaction		
3/12	Matrix compression; Aquifer storage;	**No lab**	Homework 5 due
3/17	**No class (Spring break)**		
3/19	**No class (Spring break)**	**No lab**	
3/24	3D General flow;		
3/26	2D Planeview flow; Homework 6	Homework 6	
3/31	Quiz 6 Modeling overview		
4/2	Uniform steady flow (confined aquifer); Radial steady flow to a well (confined); Thiem solution (confined);	Lab 5 (Regional Flow Analysis – FDM)[a] **Canceled**	Homework 6 due
4/7	Superposition of steady-state solutions (confined); Image well theory (confined); Flow net (Optional)		
4/9	Uniform steady flow (unconfined aquifer);Radial steady flow to a well (unconfined); Image well applications;	Invited lecture 1*[b] (*Groundwater chemistry & contamination* – Dr. Geoff Thyne)	
4/14	Homework 7 (Big assignments with complex problems; TA must attend)		
4/16	Radial transient flow; Theis solution;	Homework 7	
4/21	Quiz 7 (on chapter 7 only) Use Thesis for parameter estimation; log-log curve fitting		
4/23	Jacob late time approximation; Semi-log methods Homework 8	Homework 8	Homework 7 due
4/28	Superposition in space of transient flow solutions; Superposition in time		

	(Optional);		
4/30	Wrap up; Final exam review;	Invited lecture 2*[b] *(The groundwater business* – Dr. Dave Stephenson)	Homework 8 due
5/4~5/8 (TBA)	**Final exam**; 10:15~12:15 (location TBA)		

*(a) Lab 5 is required for the GEOL 5444 group. It will be taught by the instructor. Due to its advanced nature, the undergraduate students are not required to complete the lab, nor will they be graded for it. However, their participation in the lab is welcome.
*(b) In each lecture, real-world case studies will be emphasized. Depending on time availability of the invited lecturer, the actual date/time may be adjusted.

Grading Policy:
The final grades will be given based on your homework, labs, quizzes and exams. The appropriate percentage is shown:

Homework	24% (3% *x* 8 homework)
Quiz	21% (3% x 7 quizzes)
Lab	20% (4% x 5 labs)
Midterm	17%
Final	18%

Note that each homework/lab/exam has a standalone grade of 100 points. When determining the final grade, these will be normalized reflecting the percentage distribution above. The final letter grade is given based on the numerical grade:

A	B	C	D	F
90-100	80-89	70-79	60-69	< 60

More info on the grading policy can be found in the course notes which also include an example of how grade is determined.

Textbook, Tools, Questions & Answers
Textbook: Groundwater Science by Charles Fitts, Academic press, 2002.
Tools: ruler, pencil, eraser, calculator, scrap paper; for some exercises/labs involving repetitive calculations, a personal laptop is ideal to have.
Questions for the instructor: (1) during lecture; (2) office hour; (3) message board for this class on Wyoweb.
Questions for the TA: (1) during lab; (2) office hour.

Policy on Late papers, make-up exams, grade of incomplete
Policy for this class:

- Unless otherwise stated, each homework is expected to be handed in to the instructor in the beginning of the class one week after the homework is assigned; If not handed in on time, each day it's delayed, 10 points will be taken out of the total grade (100) of that homework until no points remain.

- Unless otherwise stated, each Lab project is expected to be completed and handed in to the TA at the end of the lab (some assignments using computers may be handed in to the TA, in the beginning of the next lab).

- Quiz and exams are expected to be handed in at the end of the quiz/exam.

If a student can provide valid proofs of absence, the above rules do not apply. Within a reasonable time (1 week), the student is expected to hand in the late homework to the instructor,

or, hand in the late lab to the TA (and/or arrange for a makeup lab with the TA), or, arrange with the instructor on a make-up quiz/exam. It is the student's responsibility to contact the TA or the instructor to make arrangement in a timely manner and in advance if at all possible, failing to do so will result in the forfeiture of the relevant points.

Grade of incomplete:
During the semester, if a student has suffered severe problems (e.g., physical or mental incapacitation) and cannot complete the course as a result, he/she may be issued an "I" (incomplete) grade. Best to be avoided to reduce the frustrations and confusions for both the student and the instructor. The UW regulation on this is long and complex: http://uwadmnweb.uwyo.edu/legal/Uniregs/ur720.htm

Academic dishonesty
As defined by UW, academic dishonesty is:

An act attempted or performed which misrepresents one's involvement in an academic task in any way, or permits another student to misrepresent the latter's involvement in an academic task by assisting the misrepresentation.

UW has a time-tested procedure to judge such cases, and serious penalties may be assessed.

So, do not cheat and do not help others cheat! In this class, if a student is caught cheating, he or she will not only lose the full point of the assignment/test, but may also be assigned a "F" for the course.

Plagiarism is considered a form of cheating. Both students will lose the full points on the particular homework or lab assignments. However, when writing papers, a student may cite other's work, but proper attribution must be given.

Classroom decorum
Turn off the cell phone.
No smoking.
Wear appropriate clothes.
Do not bring food or drinks to the classroom.
Be respectful to your fellow students.

Disruptive behaviors (e.g., small talks, giggling, making noises, arguing/fighting) are not tolerated. The instructor will give: (1) 1st time: verbal warning; (2) 2nd time: email warning; (3) 3rd time: the student(s) will be asked to leave the classroom.

Concerning homework/lab/exams styles
Four points must be emphasized: (1) For problems involving equations, if appropriate, provide a complete analysis rather than a single number. (2) Be professional in your presentations. If applicable, write down the unit for your results and round off the final number to 1 or 2 decimal points. If the problem involves a short essay, give it some thoughts and then write it out clearly, precisely, and concisely. (3) You can discuss the problems with fellow students, but complete your assignments by yourself. Copying other's work is considered cheating and no points will be given for that homework. (4) Hand in the homework on time.

Final thoughts
I set high expectations in this class Please be prepared to come to class, pay attention, participate in exercises, work out the homework by yourself (though you are welcome to discuss it with the TA or me or other students, you must ultimately work it out yourself), hand in homework on time, write professionally (clear, precise, concise), and finally be helpful to your fellow students (students are encouraged to form study groups).

The subject of groundwater hydrology is a challenging one though at the same time highly rewarding. It solves real-world problems using the physical and mathematical principles you have learned ever since grade school. It is rewarding in the sense that your past training can help you understand and solve new problems. Though you will encounter unfamiliar concepts, keep in mind that your primary goal is to learn something useful, rather than just getting a grade. So consider this class a chance to challenge yourself!

Disclaimer

The syllabus is subject to changes as deemed necessary by the instructor. If a significant change were to be made, all students will be informed of it and given appropriate reasons for such a change.