Geohydrology

GEOL 4444/5444
Fall, 2018
4 Credits

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

Grading: A-F
Lecture location: GE209
Class times: Tues + Thurs (9:35~10:50 am)
Office hours: Wed (3:00~4:00 pm), GE 220
Email: yzhang9@uwyo.edu
Phone: 307-223-2292

Lab location: GE209
Lab times: Tues (3:10~5:00 pm)
TA: Fangyu Gao
Office hours: TBA by TA
Email:fgao1@uwyo.edu

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 potentiometric 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); Calculus III (optional); Differential Equations I & II (optional); The courses listed as "optional" are desired to have in order to develop a fuller understanding of some of the advanced topics. If a student has not taken these classes, he/she should pay attention to Chapter One where the basic math we'll use in this class will be reviewed.

Textbook, Tools, Questions & Answers:
Textbook (required): Groundwater Science, Charles Fitts, Academic press, 1st or 2nd Edition, 2002.
Tools: ruler, pencil, eraser, calculator, scrap paper; for some problem sets, you can use Excel.
Questions for instructor: (1) during lecture; (2) office hour; (3) email me to set up appointment.
Questions for TA: (1) lab; (2) office hour; (3) email me to set up appointment.

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). The notes however do not contain formula proofs, equation derivations and solutions to exercises, so lecture attendance and class participation are keys to learning well.

Course Calendar:
The lab time: (1) lab projects; (2) homework with TA's help; (3) invited lectures; (4) lectures by instructor.

Lecture		**Topics**	**Lab**	**Due Date**
Week 1	Thur. (8/30)	Introduction; Course policy; HW 1		
	Tues. (9/4)	Math review	No Lab	HW 1 due
Week 2	Thur. (9/6)	Math review (continued); Hydrologic cycle; Fluxes;		
	Tues. (9/11)	Quiz 1 (test Chp1 Math Review); Hydrologic Balance Water properties;	Lab1 (Porosity, Saturation)	
Week 3	Thur. (9/13)	Porous media properties; Fluid mechanics; Hydraulic head;		
	Tues. (9/18)	Hydraulic head (continued); GW wells; HW 2	Lab 2 (Grain Size Analysis);	
Week 4	Thur. (9/20)	Quiz 2 (test Chp2); Aquifer and its properties;		HW 2 due
	Tues. (9/25)	Darcy's law; Hydraulic conductivity; Darcy flux; Average linear velocity; Casper aquifer (Take-home exercise)	Lab 3 (Darcy Test Analysis)	
Week 5	Thur. (9/27)	Quiz 3 (test Chp3); Darcy's law in 3D; Isotropy/Anisotropy; HW 3		
	Tues. (10/2)	Continuum assumption; Laminar flow; Heterogeneity; (if time allows: revisit Exercise 2)	Intrinsic permeability; HM 3	
Week 6	Thur. (10/4)	Quiz 4 (test Chp 4 up to HW 3) Gradient tutorial (3D); 2D Flow analysis;		HW 3 due
	Tues. (10/9)	2D Flow analysis (continued); Streamlines; Equivalent K	Lab 4 (Equivalent K)	
Week 7	Thur. (10/11)	Equivalent K (continued); Transmissivity;		
	Tues. (10/16)	Measuring Conductivity; HW 4	HM4	
Week 8	Thur. (10/18)	Recharge/Discharge; Water Table; Potentiometric surface; Midterm review; HW 5;		HW 4 due
	Tues. (10/23)	**Midterm exam** (same room, same time)	No Lab	
Week 9	Thur. (10/25)	Effective stress; Excavation instability; Liquefaction		HW 5 due
	Tues. (10/30)	Matrix compression;	*Invited talk: Casper*	

			aquifer drilling project by Fangyu Gao	
Week 10	Thur. (11/1)	Aquifer storage;		
	Tues. (11/6)	3D General flow & simplifications	No Lab	
Week 11	Thur. (11/8)	2D Planeview flow; HM 6		
	Tues. (11/13)	Quiz 5 (test Chp6) Uniform steady flow (confined aquifer); Radial steady flow to a well (confined);	Modeling overview; & Lab 5 (Regional Flow Analysis)	HW 6 due
Week 12	Thur. (11/15)	Thiem solution (confined); Superposition of steady-state solutions (confined); *Flow net (Opt.)*		
	Tues. (11/20)	Image well theory (confined);Image well applications (confined);	Pump-and-Treat (TA leads exercise)	
Week 13	Thur. (11/22)	**No class (Thanksgiving)**		
	Tues. (11/27)	Uniform & Radial steady flow (unconfined aquifer); Image well applications; HM7	*Video lecture from Charlies Fitts, Well Capture Zone analysis;*	
Week 14	Thur. (11/29)	Quiz 6 (test Chp 7); Radial transient flow; Theis solution;		HW 7 due
	Tues. (12/4)	Use Thesis for parameter estimation; Theis log-log curve fitting;	Jacob late-time approximation; Semi-log method; HM8;	
Week 15	Thur. (12/6)	Superposition of transient solutions in space; Wrap up; Final exam review;		HW 8
	Tues. (12/11)	**NO class (End of semester: 12/10)**	No Lab	
Week 16	*12/12-12/18*	**Final exam**; 10:15 am~12:15 pm (GE318) Date: TBA		

* In the invited lecture, topics may include: (a) groundwater chemistry & contamination; (b) surface water groundwater interaction; (c) recharge estimation; (d) well capture zone analysis; (e) aquifer storage, (f) real-world case studies. Depending on the time availability of the invited lecturer, the actual date/time of this lab 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	24% (4% x 6 quizzes)
Lab	20% (4% x 5 labs)
Midterm	16%
Final	16%

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.

Concerning homework/lab/exams:
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.

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., serious physical or mental incapacitation) and cannot complete the course as a result, he/she may be issued an "I" (incomplete) grade. The UW policy on how to make up for this grade is:
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. Please refer to UW Regulation 6-802 for details:
http://www.uwyo.edu/generalcounselsupport/clean%20uw%20regulations/UW%20Reg%206-802.pdf

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 in the form of citation must be given.

Students with disability:
Please refer to the University Disability Support Service: http://uwadmnweb.uwyo.edu/UDSS/

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.

Final thoughts:
I set high expectations. 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 others, 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 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. 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.