

Geohydrology

GEOL 4444/5444
Fall, 2019
4 Credits

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

Grading: A-F

Lecture location: GE318

Class times: Tues + Thurs (9:35~10:50 am)

Office hours: Thurs (4:00~5:00 pm), GE 220

Email: yzhang9@uwyo.edu

Phone: 307-223-2292

Lab location: GE318

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 equations presented. 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, either 1st or 2nd Edition.

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://uwadmweb.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 homework and lab projects, reading assignments, and exams and quizzes. The instructor has developed a set of lecture notes to complement the textbook. These notes will be periodically posted via WyoCourse. The notes do not contain formula proofs, equation derivations, and solutions to exercises, so lecture attendance and class participation are key to learning this challenging topic.

Course Calendar:

The labs: (1) projects; (2) select homework with TA's help; (3) invited lectures; (4) lectures by instructor.

Lecture		Topics	Lab	Due Date
Week 1	Thur. (9/5)	Introduction; Course policy; HW 1		
	Tues. (9/10)	Math review	No Lab	HW due 1
Week 2	Thur. (9/12)	Math review (continued); Hydrologic cycle; Fluxes;		
	Tues. (9/17)	Quiz 1 (test Chp1 Math Review); Hydrologic Balance Water properties;	Lab1 (Porosity, Saturation)	
Week 3	Thur. (9/19)	Porous media properties; Fluid mechanics; Hydraulic head;		
	Tues. (9/24)	Hydraulic head (continued); GW wells; HW 2	Lab 2 (Grain Size Analysis);	
Week 4	Thur. (9/26)	Quiz 2 (test Chp2); Aquifer and its properties;		
	Tues. (10/1)	Darcy's law; Hydraulic conductivity; Darcy flux; Average linear velocity;	Lab 3 (Darcy Test Analysis)	HW due 2
Week 5	Thur. (10/3)	Quiz 3 (test Chp3); Darcy's law in 3D; Isotropy/Anisotropy; HW 3		
	Tues. (10/8)	Continuum assumption; Laminar flow; Heterogeneity; (if time allows: revisit Exercise 2)	Intrinsic permeability; HW 3	
Week 6	Thur. (10/10)	Quiz 4 (test Chp 4 up to HW 3) Gradient tutorial (3D); 2D Flow analysis;		HW due 3
	Tues. (10/15)	2D Flow analysis (continued); Streamlines; Equivalent K	Lab 4 (Equivalent K)	
Week 7	Thur. (10/17)	Equivalent K (continued); Transmissivity;		
	Tues. (10/22)	Measuring Conductivity; HW 4	HW4	
Week 8	Thur. (10/24)	Recharge/Discharge; Water Table; Potentiometric surface; Midterm review; HW 5;		HW due 4
	Tues. (10/29)	Midterm exam (same room, same time)	No Lab	
Week 9	Thur. (10/31)	Effective stress; Excavation instability; Liquefaction		HW due 5
	Tues. (11/5)	Matrix compression;	<i>Invited talk: Casper aquifer drilling project</i>	

			<i>by Fangyu Gao</i>	
Week 10	Thur. (11/7)	Aquifer storage;		
	Tues. (11/12)	3D General flow & simplifications	No Lab	
Week 11	Thur. (11/14)	2D Planeview flow; HM 6		
	Tues. (11/19)	Quiz 5 (test Chp6) Uniform steady flow (confined aquifer); Radial steady flow to a well (confined);	Modeling overview; & Lab 5 (Regional Flow Analysis)	
Week 12	Thur. (11/21)	Thiem solution (confined); Superposition of steady-state solutions (confined); <i>Flow net (Opt.)</i>		HW due 6
	Tues. (11/26)	Image well theory (confined); Image well applications (confined); No class: recorded lecture.	No Lab;	
Week 13	Thur. (11/28)	No class (Thanksgiving)		
	Tues. (12/3)	Uniform & Radial steady flow (unconfined aquifer); Image well applications; HM7	1) Pump-and-Treat (TA led exercise) 2) Fitts' lecture: Well capture zone analysis	
Week 14	Thur. (12/5)	Quiz 6 (test Chp 7); Radial transient flow; Theis solution;		
	Tues. (12/10)	Use Theis for parameter estimation; Theis log-log curve fitting; TA lectures.	Jacob late-time approximation; Semi-log method; HW8;	HW due 7
Week 15	Thur. (12/12)	Superposition of transient solutions in space; Wrap up; Final exam review; TA lectures.		
	Tues. (12/17)	No class (end of semester: 12/13)	No Lab	
Week 16	12/16-12/20	Final exam (proctored by TA) 10:15 am~12:15 pm Location & date: TBA		HW due 8

* 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 availability of the lecturer, date/time of this lab may be adjusted.

Grading Policy:

The final grades will be given based on homework, labs, quizzes and exams. The appropriate percentage for each category is shown below:

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:

University policies on excused absences as outlined in UW Regulation 2-108 (Student Attendance Policy). Below is the policy for this course:

- 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 the TA (and/or arrange for a makeup session), or arrange with the instructor on a make-up quiz/exam. It is the student's responsibility to contact the instructor/TA to make arrangement in a timely manner and in advance, 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: <http://www.uwyo.edu/generalcounsel/support/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.

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) will not be 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.

Statement on Diversity:

The University of Wyoming values an educational environment that is diverse, equitable, and inclusive. The diversity that students and faculty bring to class, including age, country of origin, culture, disability,

economic class, ethnicity, gender identity, immigration status, linguistic, political affiliation, race, religion, sexual orientation, veteran status, worldview, and other social and cultural diversity is valued, respected, and considered a resource for learning.

Disability Support:

The University of Wyoming is committed to providing equitable access to learning opportunities for all students. If you have a disability, including but not limited to physical, learning, sensory or psychological disabilities, and would like to request accommodations in this course due to your disability, , please register with and provide documentation of your disability as soon as possible to Disability Support Services (DSS), Room 128 Knight Hall. You may also contact DSS at (307) 766-3073 or udss@uwyo.edu. It is in the student's best interest to request accommodations within the first week of classes, understanding that accommodations are not retroactive. Visit the DSS website for more information at: www.uwyo.edu/udss.

Duty to Report:

UW faculty are committed to supporting students and upholding the University's non-discrimination policy. Under Title IX, discrimination based upon sex and gender is prohibited. If you experience an incident of sex- or gender-based discrimination, we encourage you to report it. While you may talk to a faculty member, understand that as a "Responsible Employee" of the University, the faculty member MUST report information you share about the incident to the university's Title IX Coordinator (you may choose whether you or anyone involved is identified by name). If you would like to speak with someone who may be able to afford you privacy or confidentiality, there are people who can meet with you. Faculty can help direct you or you may find info about UW policy and resources at <http://www.uwyo.edu/reportit> You do not have to go through the experience alone. Assistance and resources are available, and you are not required to make a formal complaint or participate in an investigation to access them.

Student Resources:

- DISABILITY SUPPORT SERVICES: udss@uwyo.edu, 766-3073, 128 Knight Hall, www.uwyo.edu/udss
- COUNSELING CENTER: uccstaff@uwyo.edu, 766-2187, 766-8989 (After hours), 341 Knight Hall, www.uwyo.edu/ucc
- ACADEMIC AFFAIRS: 766-4286, 312 Old Main, www.uwyo.edu/acadaffairs
- DEAN OF STUDENTS OFFICE: dos@uwyo.edu, 766-3296, 128 Knight Hall, www.uwyo.edu/dos
- UW POLICE DEPARTMENT: uwpd@uwyo.edu, 766-5179, 1426 E Flint St, www.uwyo.edu/uwpd
- STUDENT CODE OF CONDUCT WEBSITE: www.uwyo.edu/dos/conduct

Disclaimer:

The syllabus, including deadlines, requirements, and course structure, 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 in class or via email notifications.

Final thoughts:

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