

Geohydrology

GEOL 4444/5444
Fall, 2023
4 Credits

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

Grading: A-F

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Office hours: (1) Online: Thursday 4-5 pm at: <https://uwyo.zoom.us/j/3072232292>

(2) F2F: Some of the labs will be instructor-led Q&A sessions;

(3) email instructor to set up an appointment to meet in person or on Zoom.

Lecture: **Online Asynchronous**

Time: Lectures posted on Wyocourse before the traditional week (Tues/Thurs; 9:35~10:50 am)

Lab: **Traditional (i.e., meet in a classroom); 1 hour 50 min; once a week**

Time: Tuesday, 2-3:50 pm

Location: Geology 209

TA: Chris Akurugu

TA Office Hour: TA will email class: (1) office location & office hour; (2) Zoom address

Content: (1) TA-led lab projects; (2) TA-assisted harder homework problems*;

(3) TA: two recorded talks from experts; (4) instructor-led Q&A*;

**Attendance is not required but is strongly encouraged.*

Course Objective:

Groundwater is the largest easily accessible freshwater resource on Earth. Worldwide there is increasing exploration and development of this resource while groundwater contamination due to industrial and agricultural activities is widespread. The science of Groundwater emerges from an early engineering root to become, in recent decades, a full-fledged environmental, engineering, and geological science. Groundwater hydrologists work for environmental companies, government agencies, and research organizations, on wide-ranging topics from water exploration to environmental cleanup. This class will explain the movement of groundwater flow in aquifers (subsurface porous geological formations). Basic principles of groundwater hydrology will be introduced, emphasizing both fundamental theories and their practical application. Besides introducing hydrological concepts (e.g., hydrological cycle, aquifer storage, hydraulic head, and groundwater wells), groundwater flow equations will be developed from first principals and their solutions presented. Pumping tests for aquifer characterization will also be introduced, which practicing hydrologists carry out on a daily basis.

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. Though understanding of differential equations can be useful, for the majority of the exercises or homework, students can solve the problems by hand or using Excel.

Prerequisite:

Calculus I & II (required); Calculus III (optional); Differential Equations I & II (optional); These optional courses are desired in order to develop a fuller understanding of certain advanced topics that rely on higher mathematics. If a student has not taken these optional 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) office hour; and (2) email to set up appointment.

Questions for the TA: (1) office hour; (2) during lab, and (3) email 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 consists of 2 lectures and usually 1 lab each week. Students must independently work out the homework and lab projects, reading/essay assignments, exercises, and exams. The instructor has developed a set of lecture notes, also posted on Wyocourse, that complement the textbook. The notes do not contain formula proofs, equation derivations, and exercise solutions. Some proofs and derivations will be presented during lectures, others will be posted on Wyocourse, usually in the "Advanced" folder.

Course Timetable (Tentative):

- Traditional quizzes will be **take-home graded exercises**, usually due by Friday of the same week (see Wyocourse; below table does not include their due dates).
- Submit to **Wyocourse**: Homework & take-home graded exercises (due dates posted online).
- Submit to TA: all five labs, Midterm, and the Final exam (final exam format is **TBD^{*4}**).

	Lectures (Online)	Lecture Topics on Wyocourse	Lab (Traditional)	Due Date
Week 1	Tues. (8/29) **	Introduction; course policy; Homework 1	<i>Instructor: Intro; Q & A</i>	
	Thurs. (8/31)	Math review; Take-home Ex 1 (Chp1 Math Review);		
Week 2	Tues. (9/5)	Hydrologic cycle; fluxes; hydrologic balance; water properties;	Lab1 (Porosity, Saturation)	Hw 1 due
	Thurs. (9/7)	Porous media properties; fluid mechanics background; Hydraulic head.		
Week 3	Tues. (9/12)	Hydraulic head (continued); GW wells; Homework 2; Take-home Ex 2 (Chp2);	Lab 2 (Grain Size Analysis);	
	Thur. (9/14)	Aquifer and its properties (Chp3); Take-home Ex 3 (on Chp3);		
Week 4	Tues. (9/19)	Darcy's law; Hydraulic conductivity; Darcy flux; Average linear velocity; Isotropy/Anisotropy;	Lab 3 (Steady-State Darcy Test)	Hw 2 due
	Thur. (9/21)	Darcy's law application; Homework 3; Take-home Ex 4		
Week 5	Tues. (9/26)	Continuum assumption; Laminar flow; Heterogeneity;	Intrinsic permeability; Homework 3	
	Thur. (9/28)	Gradient tutorial; 2D Flow analysis		Hw 3 due
Week 6	Tues. (10/3)	Streamlines; Equivalent K (proof);	<i>Instructor: Q & A</i>	
	Thur. (10/5)	Equivalent K (exercise); Transmissivity;		
Week 7	Tues. (10/10)	Measuring Conductivity; Homework 4	Lab 4 (Equivalent K); Homework 4	
	Thur. (10/12)	Interaction with surface water (Chp5); Homework 5; Midterm review		

Week 8	Tues. (10/17)		Midterm Exam (1 hour and 15 minutes): in person	Hw 4 & 5 both due
	Thur. (10/19)			
Week 9	Tues. (10/24)	Effective stress; Excavation instability; Liquefaction	No Lab	
	Thur. (10/26)	Matrix compression & Aquifer storage		
Week 10	Tues. (10/31)	Aquifer storage;	Instructor: Q & A	
	Thur. (11/2)	3D General flow eqn. & simplifications		
Week 11	Tues. (11/7)	2D Planeview flow eqn; Homework 6; Take-home Ex 5 (on Chp6)	Modeling overview & Lab 5 (Regional Flow Analysis)	
	Thur. (11/9)	Uniform steady flow (confined aquifer); Radial steady flow to a well (confined);		
Week 12	Tues. (11/14)	Thiem solution (confined); Superposition of steady-state solutions (confined);	Recorded talk*2: Dr. Charles Fitts, Well Capture Zone analysis	Hw 6 due
	Thur. (11/16)	Image well theory (confined aquifer);		
Week 13	Tues. (11/21)	Uniform & Radial steady flow (unconfined aquifer); Take-home Ex 6 (on Chp 7); Homework 7	Pump-and-Treat analysis (TA-led exercise); Homework 7;	
	Thur. (11/23)	Thanksgiving Holiday (Wed-Friday)		
Week 14	Tues. (11/28)	Chp8: Radial transient flow; Theis solution; log-log curve fitting;	Recorded talk: Dr. Paul Hsieh, Taming the deepwater horizon well	
	Thur. (11/30)	Jacob late-time approximation; Semi-log (straight-line) methods;		
Week 15	Tues. (12/5)	Review of Chp8; Homework 8	Instructor: Q & A	Hw 7 due
	Thurs (12/7)	Optional ³ : Superposition of transient solutions; Final exam review		
Week 16	Final's Week (12/11-12/15)		Final Exam: In person or online*4	Hw 8 due (12/14)

1* Traditional lecture dates are listed to help orient the class for the progress through the semester. We will not meet F2F on those dates for the lectures.

2* Topics may vary over time and may include: (a) groundwater chemistry & contamination; (b) surface water groundwater interaction; (c) recharge estimation; (d) well capture zone analysis; (e) aquifer storage & recovery; (f) computer modeling; (g) aquifer management. Depending on the availability of the invited lecturers, date/time of the lectures may be adjusted. If an invited lecture cannot proceed as scheduled (e.g., due to last-minute cancelation), the corresponding lab will be canceled and announcement be made.

3* Optional topics will not be tested in the exams.

4* Due to the conflict of the Final's Week with the AGU 2023 Fall Meeting where instructor and TA (Chris) may plan to attend in person, there is a possibility that the Final Exam will be Online Synchronous. In this case, 10 minute before **the regular Lab time**, TA will email class the exam and his Zoom link, meet the class on Zoom to proctor the exam, and expect the scanned exams back by email 10 min post-exam. On the other hand, if the TA will not go to AGU in person, the final exam will be in person, in the same classroom for the Lab during **the regular Lab time**. Because the final exam duration is 2 hours, it will be 10 min longer than the regular lab time.

Grading Policy:

The final grades will be given based on your homework, labs, Take-home Exercise, and exams. The appropriate percentage is shown:

Homework	24% (3% x 8 homework)
Take-home Ex	24% (4% x 6 exercises)
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 grading can be found in course notes which also include an example of grade calculation.

Concerning homework/lab/exams:

Four points must be emphasized:

- (1) For problems involving equations, if appropriate, provide a complete analysis.
- (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. Leave random calculations to scratch papers. 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:

- Unless otherwise stated, each homework/take-home exercise is expected to be uploaded to Wyocourse by the due date (usually within one week after it is assigned); If not uploaded on time, each day it's delayed, 10 points will be taken out of the total grade (100) of that homework/exercise until no points remain. Note that late assignments are accepted by Wyocourse which tracks the submission time.
- Unless otherwise stated, **each completed lab project is expected to be submitted to TA at the end of the lab** (some assignments may be submitted later at the TA's discretion).
- Exams are expected to be submitted to TA at the end of the exam.

If student can first provide a valid and signed proof of absence, the above rules do not apply. Within a reasonable time (1 week), the student is expected to upload the late homework/exercise to Wyocourse or submit the late lab to TA (and/or arrange for a makeup lab). It is the student's responsibility to contact the TA 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.

Some thoughts:

I set high expectations. Please be prepared to study regularly, work out all assignments independently (though you are welcome to discuss it with others, you must ultimately work it out yourself), hand in assignments on time, write professionally (clear, precise, concise), and 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 timely and rewarding. It solves real-world problems using the physical and mathematical principles you have learned since grade school. It is rewarding because 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 useful skills, rather than just getting a grade. Consider this class a chance to challenge yourself.

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/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.

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.

– COVID-19 Policies –

During this pandemic, you must abide by all UW policies and public health rules put forward by the City of Laramie (or by Natrona County if at UW-Casper), the University of Wyoming and the State of Wyoming to promote the health and well-being of fellow students and your own personal self-care. The current policy is provided for review at: <https://www.uwyo.edu/alerts/campus-return/index.html>

As with other disruptive behaviors, we have the right to dismiss you from the classroom (Zoom and physical), or other class activities if you fail to abide by these COVID-19 policies. These behaviors will be referred to the Dean of Students Office using the UWYO Cares Reporting Form for Student Code of Conduct processes (https://cm.maxient.com/reportingform.php?UnivofWyoming&layout_id=5).

Syllabus Changes: I will alert you to any possible course format changes in response to UW decisions about community safety during the semester.

HyFlex, Zoom, and WyoCourses expectations:

As with all UW coursework, this course will be educational and useful to you. I will respond to questions, concerns, and feedback in a timely manner.

Your responsibilities:

- Give and receive feedback from me and your classmates respectfully and constructively in all interactions. This includes in Zoom chats, on WyoCourses boards, and within physical classroom spaces.
- Actively engage in civil discourse in a respectful manner. Use professional language in all course related forums.
- Communicate professionally. Whenever you send class-related email or messages, please include a clear, specific subject line and use the body of the email or message to explain the purpose for the email and any attached materials. Conduct yourself professionally.

- Meet assignment deadlines. We expect that you're interacting with course material multiple times during the week.

- Ask for help when you need it. For academic assistance for this course please contact me for available resources. For Dean of Students assistance, please see: <https://www.uwyo.edu/dos/student-resources/covid-19-student-resources.html>

- Please let us know if you notice another student who needs help in our (anonymous) WyoCares referral option (<https://www.uwyo.edu/dos/students-concern/index.html>).

Information Technology (IT): If you have any IT related challenges, please contact the UWIT Service Center: <https://uwyo.teamdynamix.com/TDClient/1940/Portal/Requests/ServiceDet?ID=8890>

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.