

## Geohydrology

GEOL 4444/5444  
Fall, 2024  
4 Credits

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

**Grading:** A-F

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**Instructor Office hours:** (1) Online: Thursday 4-5 pm at: <https://uwyo.zoom.us/j/3072232292>  
(2) F2F: instructor-led Q&A sessions (during 3 labs)  
(3) email to set up appointment in person (GE220) or on Zoom

*Please come prepared: review Lecture 1 (e.g., expectation, grading policy),  
Lectures 2 & 3 (math review), and lectures relevant to your questions first*

**Lectures: Online Asynchronous (see class website on Wyocourse)**

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

Time:

Thu, 6:10-8 pm

Location:

ESB 1038

TA:

Chris Akurugu

get GE318 with a  
larger board instead

TA Office Hour:

TA will email class his/her: (1) office location & hour; (2) Zoom address

Lab Content:

(1) TA-led lab projects; (2) TA-assisted harder homework\*;  
(3) TA-proctored recorded talks & discussion; (4) instructor-led Q&A\*;

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

### Course Objective:

Groundwater is the largest 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); The listed optional courses are desired in order to develop a deeper understanding of certain advanced topics that use more mathematics. If a student has not taken these optional classes, please 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, 1<sup>st</sup> or 2<sup>nd</sup> Edition.

Tools: ruler, pencil, eraser, calculator, scrap paper; for some problems, 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 study the lectures and attend the laboratories. 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.uwo.edu/legal/Uniregs/ur713.htm>

**Course requirements:**

The class consists of 2 online lectures and usually 1 in-person lab each week. Students must independently work out all 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 problem-set 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 are replaced by **take-home graded exercises**, usually due by Friday of the same week. Exact due dates of all homework and graded exercises are posted on Wyocourse class website.
- Submit online to **Wyocourse**: Homework & take-home graded exercises.
- Submit in-person to TA in Lab: five lab projects, Midterm, and the Final exam

TA will meet class  
if instructor is out

Lectures (Online)		Lecture Topics	Lab (Traditional F2F)	Due Date
Week 1	Tues. (8/27) **	Introduction; course policy; Homework 1	Instructor: Intro; Q & A	
	Thurs. (8/29)	Math review; Take-home Ex 1 (Chp1 Math Review);		
Week 2	Tues. (9/3)	Hydrologic cycle; fluxes; hydrologic balance; water properties;	Lab1 (Porosity, Saturation)	Hw 1 due
	Thurs. (9/5)	Porous media properties; fluid mechanics background; Hydraulic head.		
Week 3	Tues. (9/10)	Hydraulic head (continued); GW wells; Homework 2; Take-home Ex 2 (Chp2);	Lab 2 (Grain Size Analysis);	
	Thur. (9/12)	Aquifer and its properties (Chp3); Take-home Ex 3 (on Chp3);		
Week 4	Tues. (9/17)	Darcy's law; Hydraulic conductivity; Darcy flux; Average linear velocity; Isotropy/Anisotropy;	Lab 3 (Steady-State Darcy Test)	Hw 2 due
	Thur. (9/19)	Darcy's law application; Homework 3; Take-home Ex 4		
Week 5	Tues. (9/24)	Continuum assumption; Laminar flow; Heterogeneity;	Intrinsic permeability; Homework 3	
	Thur. (9/26)	Gradient tutorial; 2D Flow analysis		
Week 6	Tues. (10/1)	Streamlines; Equivalent K (proof);	Instructor: Q & A	Hw 3 due
	Thur. (10/3)	Equivalent K (exercise); Transmissivity;		
Week 7	Tues. (10/8)	Measuring Conductivity; Homework 4	Lab 4 (Equivalent K); Homework 4	
	Thur. (10/10)	Interaction with surface water (Chp5); Homework 5; Midterm review		

Week 8	Tues. (10/15)		Midterm Exam (1 hour and 15 minutes): In person	Hw 4 & 5 both due
	Thur. (10/17)			
Week 9	Tues. (10/22)	Effective stress; Excavation instability; Liquefaction	No Lab	
	Thur. (10/24)	Matrix compression & Aquifer storage		
Week 10	Tues. (10/29)	Aquifer storage;	Instructor: Q & A	
	Thur. (10/31)	3D General flow eqn. & simplifications		
Week 11	Tues. (11/5)	2D Planeview flow eqn; Homework 6; Take-home Ex 5 (on Chp6)	Modeling overview & Lab 5 (Regional Flow Analysis)	
	Thur. (11/7)	Uniform steady flow (confined aquifer); Radial steady flow to a well (confined);		
Week 12	Tues. (11/12)	Thiem solution (confined); Superposition of steady-state solutions (confined);	Recorded talk*2: Dr. Charles Fitts, Well Capture Zone analysis	Hw 6 due
	Thur. (11/14)	Image well theory (confined aquifer);		
Week 13	Tues. (11/19)	Uniform & Radial steady flow (unconfined aquifer); Take-home Ex 6 (on Chp 7); Homework 7	Pump-and-Treat (TA-led exercise); Homework 7;	
	Thur. (11/21)	Chp8: transient flow & Theis solution;		
Week 14	Tues. (11/26)	Semi-log (straight-line) methods;	Recorded talk*3: Dr. Paul Hsieh, Taming the deepwater horizon well	
	Thur. (11/28)	<b>Thanksgiving (Wed-Friday)</b>		
Week 15	Tues. (12/3)	Review of Chp8; Homework 8	Instructor: Q & A	Hw 7 due
	Thurs (12/5)	Optional*4: Superposition of transient solutions; Final exam		
Week 16	Final's Week (12/9-12/13)		Final Exam (2 hours): In person	Hw 8 due (12/12)

1\* Traditional lecture dates help orient the class for progress. We will not meet F2F on those dates for lectures.

2\* Topics 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. TA will proctor each recorded talk and ask discussion questions. Recorded talks have no graded assignments.

3\* If the regular lab time occurs during Wednesday to Friday of the Thanksgiving week: TA will post a link to this recorded talk (highly recommend) and some discussion questions. Otherwise, there will be no in-person lab for this week.

4\* Optional topics will not be tested in the exams.

### 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/exercise/lab/exams:**

Four points must be emphasized:

- (1) For problems involving equations, if appropriate, provide a full and complete analysis.
- (2) Be professional in your presentations. If applicable, write down the units for your results and round off real numbers to 1 or 2 decimal points. Do not submit scratch-paper calculations. If the problem involves an essay, give it some thoughts and then write it out clearly and concisely.
- (3) You can discuss the problems with fellow students, but complete all assignments by yourself. Copying other's work is considered cheating and no points will be given for that work.
- (4) Hand in all assignments 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 its due date (usually within one week after it is assigned); If not uploaded on time, each day it is delayed, 10 points will be taken out of the total grade (100) of that assignment until no points remain. Late assignments are accepted by Wyocourse which tracks the submission time.
- Unless otherwise stated, **each completed lab project is expected to be handed in to TA at the end of the lab** (a later due date, however, is 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 assignment(s) to Wyocourse or hand in 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 may result in the forfeiture of 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 all work 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 although 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 cell phone.
- No smoking.
- Wear appropriate clothes.
- Do not bring food or drinks to classroom.
- Be respectful
- Disruptive behaviors (e.g., small talks, giggling, making noises, arguing/fighting) are not tolerated. The instructor or TA will give: (1) 1<sup>st</sup> time: verbal warning; (2) 2<sup>nd</sup> time: email warning; (3) 3<sup>rd</sup> time: the student(s) will be asked to leave the classroom.

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.