Geohydrology

GEOL 4444/5444
Fall, 2022
4 Credits

Grading: A-F
Email: yzhang9@uwyo.edu
Phone: 307-223-2292
Office hours: Thursday (4:00~5:00 pm): https://uwyo.zoom.us/j/3072232292

Lecture: Online Asynchronous
Time: Lecture will be posted on Wyocourse before the intended week (Tues/Thurs; 9:35~10:50 am)

Lab: Online Synchronous (1 hour 50 min)
Time: TBD. Instructor will email class once a common time is determined.
Format: (1) projects; (2) harder homework problems*; (3) additional lectures; (4) invited lectures.
TA: Danchen Li (dli3@uwyo.edu)
TA Office Hour/Zoom: TBA by TA

*Attendance for (2) is not required: students are free to complete homework on their own.

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); The courses listed as “optional” are desired to have in order to develop a fuller understanding of some 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 first reviewed.

Textbook, Tools, Questions & Answers:
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 is composed of 2 lectures and usually 1 lab per week. Students are expected to independently work out the homework and lab projects, reading/assay assignments, and exams. The instructor has developed a set of lecture notes that complement the textbook. These notes will be posted on Wyocourse. The notes however do not contain formula proofs, equation derivations and exercise solutions. Some of these will be presented in lectures, others will be posted on Wyocourse (usually in the “Advanced” folder).

**Course Calendar (Tentative):**
- **Old quizzes will become take-home graded exercises** due by Friday 9 am of the same week (see Wyocourse; below table does not include these due dates).
- **Submit to Wyocourse:** Homework & take-home graded exercises. Due dates are on Wyocourse.
- **Submit to TA by email:** labs, mid-term, and final exams.

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Lecture Topics</th>
<th>Lab</th>
<th>Due Date</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>Tues. (8/23) Introduction; course policy; Homework 1</td>
<td>No Lab</td>
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<td></td>
<td>Thurs. (8/25) Math review; Take-home Ex 1 (Chp1 Math Review);</td>
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<td>Week 2</td>
<td>Tues. (8/30) Hydrologic cycle; fluxes; hydrologic balance; water properties;</td>
<td>Lab1 (Porosity, Saturation)</td>
<td>Hw 1 due</td>
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<td>Thurs. (9/1) Porous media properties; fluid mechanics background; Hydraulic head.</td>
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<td>Week 3</td>
<td>Tues. (9/6) Hydraulic head (continued); GW wells; Homework 2; Take-home Ex 2 (Chp2);</td>
<td>Lab 2 (Grain Size Analysis);</td>
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<td></td>
<td>Thur. (9/8) Aquifer and its properties (Chp3); Take-home Ex 3 (on Chp3);</td>
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<td>Week 4</td>
<td>Tues. (9/13) Darcy’s law; Hydraulic conductivity; Darcy flux; Average linear velocity; Isotropy/Anisotropy;</td>
<td>Lab 3 (Steady-State Darcy Test)</td>
<td>Hw 2 due</td>
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<td>Thur. (9/15) Darcy’s law application; Homework 3; Take-home Ex 4</td>
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<td>Week 5</td>
<td>Tues. (9/20) Continuum assumption; Laminar flow; Heterogeneity;</td>
<td>Intrinsic permeability; Homework 3</td>
<td>Hw 3 due</td>
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<td>Thur. (9/22) Gradient tutorial; 2D Flow analysis</td>
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<td>Week 6</td>
<td>Tues. (9/27) Streamlines; Equivalent K (proof);</td>
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<td>Thur. (9/29) Equivalent K (exercise); Transmissivity;</td>
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<td>Week 7</td>
<td>Tues. (10/4) Measuring Conductivity; Homework 4</td>
<td>Lab 4 (Equivalent K); Homework 4</td>
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<td>Thur. (10/6) Groundwater, Surface water, Geology (Chp5); Homework 5;</td>
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<td>Week 8</td>
<td>Tues. (10/11) Midterm review;</td>
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<td>Wed-Thur. (10/13)-Friday</td>
<td>Online midterm: during “lab” time of this week</td>
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<td>Hw 4 &amp; 5 both due</td>
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<td>Week 9</td>
<td>Tues. (10/18)</td>
<td>Effective stress; Excavation instability; Liquefaction</td>
<td>No Lab</td>
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<td>Thur. (10/20)</td>
<td>Matrix compression &amp; Aquifer storage</td>
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<td>Week 10</td>
<td>Tues. (10/25)</td>
<td>Aquifer storage;</td>
<td>No Lab</td>
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<td>Thur. (10/27)</td>
<td>3D General flow eqn. &amp; simplifications</td>
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<td>Week 11</td>
<td>Tues. (11/1)</td>
<td>2D Planeview flow eqn; Homework 6; Take-home Ex 5 (test Chp6)</td>
<td>Modeling overview &amp; Lab 5 (Regional Flow Analysis)</td>
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<td>Thur. (11/3)</td>
<td>Uniform steady flow (confined aquifer); Radial steady flow to a well (confined);</td>
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<td>Week 12</td>
<td>Tues. (11/8)</td>
<td>Thiem solution (confined); Superposition of steady-state solutions (confined);</td>
<td>video lecture, Dr. Charles Fitts, Well Capture Zone analysis*3</td>
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<td>Thur. (11/10)</td>
<td>Image well theory (confined aquifer);</td>
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<td>Week 13</td>
<td>Tues. (11/15)</td>
<td>Uniform &amp; Radial steady flow (unconfined aquifer); Take-home Ex 6 (test Chp 7); Homework 7</td>
<td>Pump-and-Treat analysis (TA-led exercise); Homework 7 (additional help)</td>
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<td>Thur. (11/17)</td>
<td>Chp8: Radial transient flow; Theis solution; log-log curve fitting;</td>
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<td>Week 14</td>
<td>Tues. (11/22)</td>
<td>No class</td>
<td>No lab</td>
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<td>Thur. (11/24)</td>
<td>No class (Thanksgiving holiday)</td>
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<td>Week 15</td>
<td>Tues. (11/29)</td>
<td>Jacob late-time approximation; Semi-log (straight-line) methods;</td>
<td>video lecture, Dr. Paul Hsieh, Taming deepwater horizon well</td>
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<td>Thurs (12/1)</td>
<td>Review of Chp8; Homework 8</td>
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<td>Week 16</td>
<td>Tues. (12/6)</td>
<td>Optional topics*: Superposition of transient solutions in space &amp; time;</td>
<td>No lab</td>
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<tr>
<td>Thurs (12/8)</td>
<td>Final exam review</td>
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<td>Week 17</td>
<td>Final Exam</td>
<td>Online: during “lab” time of this week</td>
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1* The traditional (F2F) lecture contents are listed to help orient the class for our typical progress in time. We will not meet F2F on those dates/times.
2* Similarly, the lab date & time for this online class is TBD.
3* Topics of invited lectures may vary over time and may include topics such as: (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.
4* Optional topics will not be tested in the quizzes or 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:
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 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. Late assignments are accepted by Wyocourse which tracks the submission time.
- Unless otherwise stated, each 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 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.

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.

### 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](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&amp;layout_id=5](https://cm.maxient.com/reportingform.php?UnivofWyoming&amp;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](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](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](https://uwyo.teamdynamix.com/TDClient/1940/Portal/Requests/ServiceDet?ID=8890)

**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.