

## **Syllabus: HWRS/GEOS 431/531 – Hydrogeology (4 credits) – Fall 2022**

### **Experimental course for Fall 2022:**

Mixed lectures and lab, meeting on:

MWF 14:00-14:50

and

T 14:00-16:50

**Office Hours:** MWF, 13:00-14:00 and by appointment.

**Prerequisites:** GEOS 251, MATH 129 (or equivalents).

**Instructor:** Dr. Marek Zreda, Harshbarger, Room 230, [marek.zreda@gmail.com](mailto:marek.zreda@gmail.com)

### **Course description:**

Hydrogeology is the study of water under the land surface. The goal of this course is to learn about physical, chemical, hydrologic, geologic and other factors that control the occurrence and dynamics of groundwater. Students will develop the ability to investigate groundwater systems, perform laboratory and field experiments, and solve problems in hydrogeology.

### **Recommended textbooks:**

Freeze and Cherry, 1979, Groundwater, Prentice Hall.

Class notes (<http://quebec.hwr.arizona.edu/classes/hwr431/hwr431.html>).

### **Course Objectives: Students will**

1. Learn about hydrogeology as one of natural sciences and prepare the concept map.
2. Gain an understanding of physics and chemistry of water in subsurface systems by studying the physical and chemical laws that govern flow and transport.
3. Understand the composition of water and its chemical and physical properties.
4. Understand physical properties of solid materials in the subsurface.
5. Learn about the connection between land surface and subsurface by studying infiltration.
6. Learn field and laboratory methods and instruments for measuring hydrogeological properties, states and fluxes.
7. Learn how to determine residence time and groundwater age.
8. Conduct laboratory and field experiments to derive properties of materials.
9. Learn analytical and numerical modeling of groundwater flow.
10. Learn about groundwater chemistry and quality.

### **Expected Learning Outcomes:**

By the end of this course, students will be able to:

1. Explain the origin and occurrence of ground water on Earth.
2. Understand the movement of water in groundwater systems and explain the concept of residence times and mass balance.
3. Understand the chemical composition of water (including isotopes) and physical properties of water molecule and macroscopic water parcels on contact with solids.
4. Use hydrological data sets to perform computations in groundwater systems.
5. Understand how ground water is used by society and safe yield concept.
6. Understand and appreciate the connections between the global water cycle and groundwater cycle.
7. Understand the controlling factors for transport of chemicals in ground water.

### **Grading Breakdown:**

Homework assignments: 25%

Midterm exam: 25%

Lab reports: 25%

Final exam: 25%

Final Exam policies and schedule information: <http://registrar.arizona.edu/courses/final-examination-regulations-and-information?audience=students&cat1=10&cat2=31> (link is external), and Final Exam Schedule, [registrar.arizona.edu/schedules/finals.htm](http://registrar.arizona.edu/schedules/finals.htm)

### **Requirements:**

Do homework assignments (approximately 8)

Pass both exams.

Do all lab assignments (6 or 7 labs).

### **Grading:**

Floating scale.

Rule of thumb: to get an A in class, student should have at least a B in each of the four components (homework, midterm, lab, final); similarly, to get a B, shoot for at least a C in everything, etc.

**Requests for incomplete (I) or withdrawal (W)** must be made in accordance with University policies, which are available at <http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete> and <http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal> respectively.

## **Course Outline (list of topics):**

(not necessarily equivalent to class hours)

- 1.Relation of hydrogeology to other disciplines
- 2.Water cycle
- 3.Course organization
- 4.History of hydrological concepts
- 5.Soil moisture, wetting and infiltration, recharge
- 6.Physical and chemical properties of water
- 7.Types and origin of subsurface water
- 8.Flow through saturated soil column, Darcy's law
- 9.Hydraulic head and its components
- 10.Seepage velocity, validity of Darcy's law
- 11.Navier-Stokes equation and its integration
- 12.Factors controlling flow in porous media
- 13.Porosity and permeability and their origins
- 14.Types of rocks and their hydraulic properties
- 15.Hydraulic conductivity and its typical values
- 16.Hydraulic conductivity of heterogeneous media
- 17.Description of soil heterogeneity
- 18.Anisotropy of hydraulic conductivity
- 19.Depositional environments and facies
- 20.Postdepositional processes modifying geological materials
- 21.Aquifers and aquitards
- 22.Potentiometric surface
- 23.Storage of water, specific yield and specific storage
- 24.Darcy's law in three dimensions
- 25.General continuity equation
- 26.Groundwater flow equations
- 27.Flow in fractures
- 28.Horizontal flow and concept of transmissivity and storativity
- 29.Horizontal flow in phreatic aquifer

30. Graphical solutions to steady flow in two dimensions
31. Equipotentials, streamlines and flow nets
32. Methods of groundwater resources evaluation
33. Parameter estimation using aquifer pumping tests
34. Principle of superposition and method of images
35. Recharge, infiltration and unsaturated flow
36. Storage in unsaturated media
37. Hydraulic conductivity of unsaturated media
38. Geology and ground water
39. Regional flow
40. Interactions between ground water and surface water
41. Groundwater fluctuations
42. Introduction to aqueous chemistry
43. Chemical reactions, major ions
44. Equilibria and disequilibria
45. Water chemistry in different geological environments
46. Carbonate system
47. Hydrologic tracers and their applications
48. Environmental isotopes, groundwater dating
49. Carbon-14, chlorine-36 and tritium methods of dating ground water
50. Solute transport, advection, dispersion, diffusion
51. Groundwater contamination
52. Sea-water intrusion, salinization

## UA Course Policies

### **Code of Conduct:**

Please review the University's Code of Conduct information, which can be found at:

<https://deanofstudents.arizona.edu/policies-codes>

### **Classroom Behavior**

To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.). You may use technology to type your notes, but cell phones and other communication devices should be put away unless otherwise stated.

The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the University community, including to one's self.

### **Disruptive Student Behavior:**

It is REQUIRED that you respond with respect to each other during discussions or other activities. Be mindful of how you frame your responses, and even if you disagree you must express yourself in a mature and academic manner only. If a situation occurs, action will be taken according to the level and frequency of the offense.

Students are expected to be familiar with the UA Policy on Disruptive Student Behavior in an Instructional Setting found at:

<http://policy.arizona.edu/education-and-student-affairs/disruptive-behavior-instructional-setting>

### **Threatening Student Behavior:**

The University of Arizona seeks to promote a safe environment where students and employees may participate in the educational process without compromising their health, safety or welfare. The Arizona Board of Regents' Student Code of Conduct, ABOR Policy 5-308, prohibits threats of physical harm to any member of the university community, including to one's self. Threatening behavior can harm and disrupt the University, its community and its families.

Threatening behavior means any statement, communication, conduct or gesture, including those in written form directed towards any member of the university

community that causes a reasonable apprehension of physical harm to a person or property. A student can be guilty of threatening behavior even if the person who is the object of the threat does not observe or receive it, so long as a reasonable person would interpret the maker's statement, communication, conduct or gesture as a serious expression of intent to physically harm. You are encouraged to read more on this at: [Threatening Student Behavior: Dean of Students](#)

The Policy on Threatening Behavior by Students found at: <http://policy.web.arizona.edu/education-and-student-affairs/threatening-behavior-students>

### **Online Class Etiquette**

What is Netiquette? Simply stated, it's network etiquette -- that is, the etiquette of cyberspace. And "etiquette" means "the forms required by good breeding or prescribed by authority to be required in social or official life." In other words, Netiquette is a set of rules for behaving properly online. Please refer to this website to further your understanding of online class etiquette: <http://www.albion.com/netiquette/introduction.html>

### **Student Code of Academic Integrity**

Academic Integrity at the University of Arizona is the principle that stands for honesty and ethical behavior in all homework, tests and assignments. All students should act with personal integrity and help to create an environment in which all can succeed.

Dishonesty will not be tolerated in this course. This includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will be reported to the Dean of Students Office and receive a sanctions, such as a failing grade on the assignment, exam, and/or in the course. Students should refer to the UA Code of Academic Integrity if they can questions.

Available at: <http://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity>

## **Plagiarism**

Basically, plagiarism is using other's work as if it were yours. You may not realize it, but certain practices lead others to conclude that other's works are your own. Here are some of these practices:

1. Using someone's exact words and not putting quotation marks around them, which means the reader has no way of understanding that this is not the work of the author.
2. Using someone's work and not referencing the source.
3. Paraphrasing so closely (same order of sentences, same order of paragraphs, same order of sections), with merely a word substituted here and there. This indicates that the work is really still someone else's. The intellectual work of re-thinking the meaning wasn't done. This is true even if the source is given.
4. Cut and Paste: Using parts of several people's work, which some think is original - Not! The sum of sentences from other authors doesn't make the combination original. Plagiarism will not be tolerated in this course. If you have any doubt, please check with the instructor.

Source: <https://owl.english.purdue.edu/owl/resource/589/02/>

The University Libraries have some excellent tips for avoiding plagiarism, available at: <http://www.library.arizona.edu/help/tutorials/plagiarism/index.html><http://www.library.arizona.edu/help/tutorials/plagiarism/index.html>  
<http://www.library.arizona.edu/help/tutorials/plagiarism/index.html>

## **Discrimination and Harassment:**

Policies against discrimination and harassment, along with offices for reporting concerns related to discrimination or harassment, <http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy>

## **Communication:**

You are responsible for reading emails sent to your UA account from your professor and the announcements that are placed on the course web site. Information about readings, news events, your grades, assignments and other course related topics may be communicated to you with these electronic methods. The official policy can be found at: <http://www.registrar.arizona.edu/emailpolicy.htm>

**Absence and Class Participation Policies:**

I encourage you to talk to your instructor if there is an issue that arises and you must miss class. Those matters will be dealt with on a case by case basis. Otherwise, it is expected that you complete every online lecture, and complete any homework, discussions, activities, or videos that may be posted within those lectures.

The UA's policy concerning Class Attendance and Administrative Drops is available at: <http://registrar.arizona.edu/grades/administrative-dropsreinstatements>

Absences for any sincerely held religious belief, observance, or practice will be accommodated where reasonable. For more information, see the following link: [policy.arizona.edu/human-resources/religious-accommodation-policy](http://policy.arizona.edu/human-resources/religious-accommodation-policy).

Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored. See: <https://deanofstudents.arizona.edu/absences> , under "Absence and Class Participation Policies" section.

Participating in course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all lectures and discussion section meetings. Students who miss class due to illness or emergency are required to bring documentation from their healthcare provider or other relevant, professional third parties. Failure to submit third-party documentation will result in unexcused absences.

**University's Intellectual Property Policy:**

<http://policy.arizona.edu/research/intellectual-property-policy>

**Accessibility and Accommodations:**

At the University of Arizona we strive to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability or pregnancy, you are welcome to let me know so that we can discuss options. You are also encouraged to contact Disability Resources ([520-621-3268](tel:520-621-3268)) to explore reasonable accommodation.

If our class meets at a campus location: Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.



**Grievance Policy:**

Should a student feel he or she has been treated unfairly there are a number of resources available. With few exceptions, students should first attempt to resolve difficulties informally by bringing those concerns directly to the person responsible for the action, or with the student's graduate advisor, Assistant Dean for Student and Alumni Affairs, department head, or the immediate supervisor of the person responsible for the action. If the problem cannot be resolved informally, the student may file a formal grievance. Information can be found at: [Student Grievance Policy](#)

**Confidentiality of Student Records:**

Family Educational Rights and Privacy Act of 1974 (FERPA) is the federal law that governs the rights of students and institutional responsibilities with respect to student records. FERPA is a federal law designed to protect the privacy of a student's educational record. More details on what FERPA is about and specifics of what constitutes an Education Record can be accessed at: <http://www.registrar.arizona.edu/ferpa/default.htm> .

If you have any questions regarding any of the information provided on this site, please contact the University of Arizona Office of the Registrar via email at: [REG-reghelp@email.arizona.edu](mailto:REG-reghelp@email.arizona.edu).

**Tutoring**

UA THINK TANK provides free academic assistance for writing and math, and various other related subjects, at multiple locations and fully online. Students can access free tutoring in-person at the UA Think as well as fully online from the UA Think Tank.

To find tutoring hours and availability near you, please select your location below to find the schedule at your learning center.

Tucson: <http://thinktank.arizona.edu/http://thinktank.arizona.edu/tutoring/online>

*\*Syllabus Subject to Change Clause: Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.*

## Recommended syllabus language for Fall 2021 classes (by UA)

These are recommendations to augment the information contained in the approved Undergraduate and Graduate syllabus templates. They are meant to communicate

- Course modality: This class is scheduled to be taught in the (in person, flex in-person, live online) modality.
- Class meetings (choose the language corresponding to your course modality)
  - Meeting times and location for in-person classes:
  - Meeting schedule and logistics for flex in-person classes:
    - In-person meeting times and locations:
    - What groups of students will meet in person on what days? How will students know what group they are in, and what their meeting pattern will be?
    - What work will students complete on class days they are NOT in person?
  - Meeting logistics for live-online classes
    - Days and times for Zoom class meetings
    - Expectations for work to be routinely completed outside Zoom class meetings
- Classroom attendance:
  - If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
  - Notify your instructor(s) if you will be missing a course meeting or an assignment deadline.
  - Non-attendance for any reason does **not** guarantee an automatic extension of due date or rescheduling of examinations/assessments.
    - Please communicate and coordinate any request directly with your instructor.
  - If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office [DOS-deanofstudents@email.arizona.edu](mailto:DOS-deanofstudents@email.arizona.edu) to share documentation about the challenges you are facing.
  - Voluntary, free, and convenient [COVID-19 testing](#) is available for students on Main Campus.
  - If you test positive for COVID-19 and you are participating in on-campus activities, you must report your results to Campus Health. To learn more about the process for reporting a positive test, visit the [Case Notification Protocol](#).
  - COVID-19 vaccine is available for all students at [Campus Health](#).
  - Visit the [UArizona COVID-19](#) page for regular updates.
- Office Hours: (Insert days, times, and distinguish whether held in person or by Zoom, or both. Insert Zoom link and/or location; see [this link](#) for some advice about helping students to make the most of office hours.)
- Academic advising: If you have questions about your academic progress this semester, please reach out to your academic advisor (<https://advising.arizona.edu/advisors/major>). Contact the Advising Resource Center (<https://advising.arizona.edu/>) for all general advising questions and referral assistance. Call 520-626-8667 or email to [advising@arizona.edu](mailto:advising@arizona.edu)

- **Life challenges:** If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The [Dean of Students Office](#) can be reached at (520) 621-2057 or [DOS-deanofstudents@email.arizona.edu](mailto:deanofstudents@email.arizona.edu).
- **Physical and mental-health challenges:** If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520) 621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.
- **Exams and Assessments:** [describe when exams/major assessments will take place, what the format will be, for how long the exam/assessment will be open or available in D2L, and whether and how exams will be proctored.] **Final exam information:** [insert information about the date, time, and logistics for the final exam].
- **Equipment and software requirements:** For this class you will need daily access to the following hardware: [laptop or web-enabled device with webcam and microphone]; regular access to reliable internet signal; ability to download and run the following software: [web browser, Adobe Acrobat, etc.].
- **Staying current:** You are required to complete (describe which activities, with what deadlines) on your own time to accomplish (enumerate course goals).
- **Class Recordings:**
  - **Note to instructors:** If course recordings are being made, notify students, and suggest ways to address if they do not wish to be identified by name. [For instructor guidance, view [FERPA Privacy Protection guide](#).]
  - **Note to instructors:** It is strongly recommended that content delivery for in-person and flex in-person is recorded and available online.
  - **Language for syllabus:** For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with [UArizona values](#) and educational policies ([Code of Academic Integrity](#) and the [Student Code of Conduct](#)) are also subject to civil action.

### iCourses, Arizona Online, Global Direct (Asynchronous Online)

Please see resources at [The Office of Instruction and Assessment](#) and/or the [Arizona Online's Digital Learning](#). To review frequently asked questions relevant to Fall 2021 teaching, please see the [COVID-19 Instructor FAQs](#).