CEE 498GE/GO – GeoEnergy Systems

Course Syllabus

Instructor: Assistant Professor Roman Y. Makhnenko, PhD (217) 300-4587 (phone)
2221 Newmark Civil Engineering Laboratory romanmax@illinois.edu
Office hours: Once a week via Zoom (T, 2:00 pm) or by appointment

Class Meetings: Time: TTh 12:30 – 1:50 pm
Rm.: 1311 Newmark Civil Engineering Laboratory

Class Websites https://canvas.illinois.edu/courses/40987 and http://mediaspace.illinois.edu
Prerequisites: TAM251/ CEE340 or CEE350 or CEE380/ instructor consent

Textbooks and Reading:

There is no required textbook, but there is some supplementary reading:

1. Jackson, *Earth Science for Civil and Environmental Engineers*, 2019, Cambridge University Press.
2. Bjorlykke, *Petroleum Geoscience*, 2015, Springer
3. Laloui (ed.), *Mechanics of Unsaturated Geomaterials*, 2010, Wiley.

Other: Additional reading from handouts

Course description:

CEE498ges GeoEnergy Systems course focuses on engineering principles behind the design of sustainable subsurface energy solutions, including energy geostructures, geothermal systems, unconventional petroleum recovery, carbon, hydrogen, and nuclear waste storage. Multiphase and multiphysical processes that govern coupled behavior of these systems are discussed. Additional topics include subsurface exploration, construction of geoenergy systems, and analysis of behavior using soil and rock mechanics and thermodynamics principles.

Course Scope:

Increasing energy demand associated with population growth requires exploitation of renewable and sustainable resources of earth. This growth has emerged a new area in civil engineering – **geoenergy** that focuses on theory and applications of using the subsurface as an energy resource and potential storage media to reduce the carbon footprint caused by anthropogenic activities. This course will provide a thorough understanding of theoretical concepts and guidelines including but not limited to energy geostructures, geothermal systems, carbon storage, and nuclear waste containment systems that enable students simulate, predict, and monitor the subsurface via combination of principles of physical processes, thermodynamics, and mechanics. Students will be equipped with the tools needed to describe and monitor the processes of subsurface for renewable and sustainable design. **GeoEnergy Systems** combines multiple disciplines in a single coherent course, which makes it unique in Geotechnical, EWES, and SRIS programs at the Civil and Environmental Engineering department.

Students will have to present convincing written arguments to define geoenergy types and testing to solve specific geoenergy engineering problems. Actual laboratory tests and field exploration procedures are discussed and the connections between the concepts that are taught and applied engineering problems are established. The course objectives listed below are based on the desired program outcomes identified for engineering education by the Accreditation Board for Engineering and Technology (ABET). Upon completion of this course, students will be able to:

- Understand the soil and rock mechanics principles that can be applied to describing the behavior of geoenergy systems
- Specify necessary laboratory tests to understand the site-specific behavior of geoenergy systems
- Evaluate laboratory and field data to select appropriate material values to use in the system design
- Specify material types for various geoenergy applications
- Find the most sustainable (in terms of use of resources) solutions for particular geoenergy problems

Class Sessions: Sessions begin at 12:30 pm and end at 1:50 pm. Class notes or slides will be posted to the Canvas website on the day of the lecture. All lectures are recorded and available live or as videos on mediaspace platform, where you could login using your UIUC credentials. It is highly recommended to save on printing (and be sustainable) and try to take written notes (including using electronic devices). You are responsible for what is presented verbally, what is presented on the chalkboard, and what is presented on the slides and the assigned reading materials.

Participation and Attendance: In-person participation is an important part of learning and will be strongly encouraged. There will be no penalty for excused absences.

Homeworks: There will be 4 homeworks that will include theoretical questions and technical problems based on the course material covered. You are encouraged to provide detailed solutions and discussions if needed. The homework problems can be discussed with the peers individual solutions should be submitted.

Lab Project: There will be two laboratory-based projects worth 30% of your grade. The lab reports should cover background information, testing methods, experimental results, and discussion of the lab tests, as well as everything that you thing might affected the lab results and calculations. The lab demonstrations will be filmed and available via mediaspace website. The test data will be shared after the completion of the lab and properly reporting it is part of the assignment.

Final Project: There will be an individual final project assigned to every student 6-7 weeks before the end of the semester. The project will be related to the solution of applied geoenergy problem and providing suggestions for a sustainable design for a particular application, as well as it might involve interpretation of the lab/field data. 8-10 pages project reports should be submitted to the instructor during the week of finals. 10-minute presentations of the projects will happen in-person and online during the last class of the semester.

Grade Distribution:

Homeworks	40%
Lab Projects	30%
Final project	30%
Extra Credit	5%

Grades & Performance:

Superior 90 – 100 A (including +/-)
Proficient 80 – 89.9 B (including +/-)
Satisfactory 70 – 79.9 C (including +/-)
Mediocre 60 – 69.9 D (including +/-)
Unacceptable below 60 F

COVID-19

Following University policy, all students are required to engage in appropriate behavior to protect the health and safety of the community, including COVID-19 testing protocol. Students who feel ill must not come to class. In addition, students who test positive for COVID-19 or have had an exposure that requires testing and/or quarantine must not attend class. These students are judged to have excused absences for the class period and should contact the instructor via email about making up the work. Students who fail to abide by these rules will first be asked to comply; if they refuse, they will be required to leave the classroom immediately. If a student is asked to leave the classroom, the non-compliant student will be judged to have an unexcused absence and reported to the Office for Student Conflict Resolution for disciplinary action. Accumulation of non-compliance complaints against a student may result in dismissal from the University.

Emergency Response Recommendations

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/.

Accessibility

To insure that disability-related concerns are properly addressed from the beginning, students with disabilities who require reasonable accommodations to participate in this class and related activities are contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu..

Inclusivity

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential. Other information about resources and reporting is available here: wecare.illinois.edu.

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/. Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Impact on Society and Environment

As civil engineers, through the projects we design and build, we have the potential to significantly impact our communities and the environment we live in. Always be mindful of the impact of your projects, and always try to ensure that they are positive.

Sustainability

Here at Illinois, we are concerned about being sustainable. Please, be aware that everything you do has an environmental impact. Be conservative printing course materials and recycle used papers. Recycle cardboard, plastic, glass, aluminum, and compost – there are facilities for that available on campus and in Urbana-Champaign area. Save energy and water: turn of the lights if you do not need them and avoid having water running down the sink for no reason. Walk and bike instead of driving – it is more healthy and environmentally friendly.

Course Schedule – Tentative and subject to change

1. Aug 22: Introduction, outline of main topics
2. Aug 24: Geomaterials in geonergy systems
3. Aug 29: Behavior of geomaterials
4. Aug 31: Mechanical properties of subsurface soil and rock
5. Sept 5: Failure of geomaterials
6. Sept 7: Geophysical vs mechanical methods in rock characterization
7. Sept 12: Fluid flow in the subsurface
8. Sept 14: Poromechanics, **HW#1 is due**
9. Sept 19: Lab#1- Seismic methods in rock characterization
10. Sept 21: Implications of poroelastic solutions
11. Sept 26: Partially saturated materials
12. Sept 28: Unsaturated behavior
13. Oct 3: Mechanical response of unsaturated materials
14. Oct 5: Multiphase fluid flow, **LR#1 is due**
15. Oct 10: Geologic CO_2 and H_2 storage
16. Oct 12: Barriers for geological storage
17. Oct 17: Lab #2 – Sealing capacity of barrier materials
18. Oct 19: Fluid driven fractures, **HW#2 is due**
19. Oct 24: Induced seismicity
20. Oct 26: Hydraulic fracturing
21. Oct 31: Aspects of petroleum engineering
22. Nov 2: Petroleum applications, **LR#2 is due**
23. Nov 7: Thermal effect in geoenergy applications
24. Nov 9: Shallow geothermal structures
25. Nov 14: Enhanced geothermal systems, **HW#3 is due**
26. Nov 16: Nuclear waste storage

    Nov 18-Nov 26: THANKSGIVING BREAK
27. Nov 28: Numerical modeling of geoenergy systems
28. Nov 30: Course review, **HW#4 is due**
29. Dec 5: Project presentations
30. Dec 14: **Project report is due**