PET E 520 Energy Rock Engineering

Fall 2025 - September 03 to December 08

Class time: Tuesday, Thursday 14:00-15:20 Location: NRE 2-080

Instructor:

Alireza Nouri, PhD, P.Eng
(780)492-9660
anouri@ualberta.ca
Donadeo Innovation Centre For Engineering 6-295
Office Hours: By appointment

Course Description:

*3 (fi) (either term, 3-0-0) Elements of rock mechanics, rock mechanical properties and their assessment from lab testing and sonic logs, in-situ stresses and their assessment, single and multi-stage hydraulic fracturing, rock fracability, perforation for fracturing, stress shadow, wellbore stability during drilling, sand production, reservoir porosity and permeability evolution, caprock and wellbore integrity.

Prerequisites: PET E 364 and PET E 365 or consent of instructor

Course synchronous and asynchronous content delivery schedule:

All lectures are delivered in person.

Land Acknowledgment:

The University of Alberta respectfully acknowledges that we are situated on Treaty 6 territory, traditional lands of First Nations and Métis people.

TA Information:

Nima Shojaei <nshojaei@ualberta.ca>

Course Objectives & General Content:

Rock Mechanics plays a crucial role in addressing significant issues in reservoir and wellbore engineering across the petroleum, geothermal, and carbon storage sectors. Topics include wellbore stability, sand production, hydraulic fracturing, and wellbore and caprock integrity, among others.
This course aims to introduce the fundamentals of rock mechanics and their application in describing and predicting various phenomena.

Learning Outcomes:

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

1. Understand basic concepts in rock mechanics

2. Understand how to assess mechanical rock properties from laboratory testing and well logs
3. Understand the concept of in situ stress and its assessment
4. Calculate stress distribution around boreholes
5. Apply rock mechanics knowledge for wellbore engineering issues such as wellbore stability, sand production, hydraulic fracturing, and wellbore integrity
6. Apply rock mechanics knowledge for reservoir and ground issues such as reservoir permeability and porosity evolution, caprock integrity, and land subsidence/heave in petroleum, geothermal and carbon storage engineering

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Homework		TBA	15%
Term Project		04-Dec-2025 (Thursday) @ 4:00 p.m.	20%
Midterm Exam		TBD	30%
Final Exam		11-Dec-2025 (Thursday) @ 1:00 p.m.	35%

The Faculty recommended grade point average for a 500 level course is 3.2.Instructors have the leeway to deviate from this average and can assign grades based on their own scheme. All grades are approved by the department chair (or delegate). The office of the Dean has final oversight on all grades.

Term Work

All term work solutions will be posted no later than the last day of classes. All term work will be returned to students by the final day of classes, with the exception of major term work due in the last week of classes. The latter will be returned by the day of the final examination or the last day of the examination period if there is no final examination in the course as per university policy; instructors will make accommodations to return these term work. It is the responsibility of the student to pick up all their term work at the specified time and place. Any unreturned term work, shall be retained and then shredded six months after the deadline for reappraisal and grade appeals. Final examinations will be kept for one year as required by university guidelines and the Government of Alberta's Freedom of Information and Protection of Privacy Act.

Calculator Policy

There is no calculator policy in this course; students are free to use the calculator they wish for all assessments.

Expectations for AI use

On the first day of class, we will as a community co-create an agreement identifying expectations on the use of AI tools that ensures everyone: 1) understands the benefits and limitations of the tools, 2) is able to differentiate between appropriate and inappropriate uses, 3) has equal access to such tools, and 4) is clear on the University of Alberta's relevant policies and procedures.
The Community of Learners agreement will align with the University of Alberta's academic integrity policies

and procedures (See relevant section on cheating in University of Alberta (November 2022) Code of Student Behaviour). As necessary, we will agree to revisit and reconsider aspects of the agreement throughout the course to ensure all members of the course's Community of Learners continue to have the required shared understanding of the expectations for AI tool use in this class.

Important: Any and all use of AI and AI tools in assessment tasks must be transparently and honestly identified and referenced as directed. Follow-up reflection assignments explaining AI use must be completed and uploaded to eClass assignments within one (1) day of major assessment task completion.

Text and References (Recommended):

1. Course notes (on eClass Site)
2. Fjar, E., Holt, R.M. , Raaen, A.M., Risnes, R., Horsrud, P. (2008) Petroleum Related Rock Mechanics, 2nd Edition, Elsevier
3. Zoback, M.D. (2007) Reservoir Geomechanics, Cambridge University Press
4. Smith, M.B., Montgomery, C.T. (2015) Hydraulic Fracturing, CRC Press, Taylor & Francis Group
5. Wang, H. (2000) Theory of Linear Poroelasticity, Princeton University Press
6. Peng, S., Zhang, J. (2007) Engineering Geology for Underground Rocks, Springer
7. Maurice Duessault course notes, University of Waterloo
8. Amadei, B. and Stephansson, O. (1997) Rock Stress and its measurement. Chapman & Hall, London
9. Atkinson, B.K. (1989) Fracture Mechanics of Rock, Academic Press, London

Website:

https://canvas.ualberta.ca/courses/22366

Previous Examples of Evaluative Materials:

Sample exams will be uploaded on Canvas

Did you know that the University of Alberta has various low-to-no-cost services to help students succeed? Visit http://www.deanofstudents.ualberta.ca/ for information about the academic, wellness, and various other support services available to U of A students. It's never too early or too late to seek help!

Course Content

1. *An Introduction to energy geomechanics (1 session)*
2. *Elements of Rock Mechanics*
    - *Stress tensor, strain tensor, stress-strain relationship, pore pressure, effective stress, Equilibrium equation (2 sessions)*
    - *Rock stiffness, tensile and shear strength (1 session)*
    - *Mechanical properties from laboratory testing, core representativeness and influence of sample size, core alteration, core handling, sample preparation, tensile tests, UCS, triaxial test, hydrostatic test, TWC test, strength profiling, fracture toughness test (1 session)*
    - *Rock properties from wireline logs and geophysical exploration, elastic modulus, Poisson's ratio, UCS, strength estimation from physical properties (1 session)*
3. *Stress with constant and variable pore pressure around boreholes (2 sessions)*
4. *In-situ stress regimes, overburden stress, min and max horizontal stress, pore pressure (2 sessions)*
5. *In situ stress assessment (2 sessions)*
    - *Overburden stress calculation*
    - *Minimum horizontal stress assessment from DFIT*
        - *G-function method*
        - *Pressure derivative and square root method*
        - *After closure analysis*
    - *Maximum horizontal stress determination*
    - *In-situ stress directions*
    - *Pore pressure assessment*
6. *Hydraulic fracturing*
    - *Fracture geometry (1 session)*
        - *Fracture modes*
        - *Fracture initiation and formation breakdown*
        - *Fracture orientation, growth and confinement*
        - *Fracture length and height; PKN and KGD models*
        - *Stiffness, permeability, and thermal effects on fracturing pressure and propagation*
        - *Microseismic map as a measure of fracture growth*
    - *Rock fracability (1 session)*
        - *Brittleness Index*
        - *Fracability Index*
    - *Perforation for Hydraulic Fracturing (1 session)*
        - *Perforation direction, diameter and phasing*
        - *Promoting transverse fracture*
    - *Stress shadow in multi-stage fracturing (1 session)*
    - *Proppant Selection and Micro-proppants (1 session)*
7. *Wellbore stability during drilling (2 sessions)*
    - *Borehole failure criteria*
    - *Borehole breakouts*
    - *Stability of vertical and slanted wells*
    - *Lost circulation*

- *Mud window*
- *Interaction between shale and drilling fluid*

8. *Sand production (2 sessions)*
    - *Forces on sand grains*
    - *Sandstone failure*
    - *Critical drawdown for the onset of sanding*
    - *Sanding rate assessment*
    - *Sand transport*
    - *Sand control*
9. *Geomechanics of geothermal and carbon storage reservoirs (1 session)*
10. *SAGD Geomechanics and caprock Integrity mechanisms (1 session)*
    - *SAGD Geomechanics*
    - *Integrity of SAGD caprock*
    - *Integrity of caprock during and after CO2 injection*
11. *Wellbore integrity mechanisms, completion integrity, casing and cement sheath integrity, fault reactivation, integrity of older wells (1 session)*

University and faculty policies

Respect and professionalism

The Faculty of Engineering is committed to fostering and protecting an equitable, inclusive, and respectful work and study environment in line with University of Alberta policies and professional engineering industry standards.

The faculty prepares students to uphold industry standards to become a Professional Engineer (P.Eng). Therefore, respect, professionalism, and accountability must be upheld within the Faculty of Engineering and the University of Alberta.

Academic integrity and student conduct

The University of Alberta is committed to the highest standards of academic integrity and honesty, as well as maintaining a learning environment that fosters the safety, security, and the inherent dignity of each member of the community, ensuring students conduct themselves accordingly. Students are expected to be familiar with the standards of academic honesty and appropriate student conduct, and to uphold the policies of the University in this respect.

Students are particularly urged to familiarize themselves with the provisions of the Student Academic Integrity Policy and the Student Conduct Policy, and avoid any behaviour that could

potentially result in suspicions of academic misconduct (e.g., cheating, plagiarism, misrepresentation of facts, participation in an offence) and non-academic misconduct (e.g., discrimination, harassment, physical assault). Academic and non-academic misconduct are taken very seriously and can result in suspension or expulsion from the University.

All students are expected to consult the Academic Integrity website for clarification on the various academic offences. All forms of academic dishonesty are unacceptable at the University. Unfamiliarity of the rules, procrastination or personal pressures are not acceptable excuses for committing an offence. Listen to your instructor, be a good person, ask for help when you need it, and do your own work -- this will lead you toward a path to success. Any academic integrity concern in this course will be reported to the College of Natural and Applied Sciences. Suspected cases of non-academic misconduct will be reported to the Dean of Students. The College, the Faculty, and the Dean of Students are committed to student rights and responsibilities, and adhere to due process and administrative fairness, as outlined in the Student Academic Integrity Policy and the Student Conduct Policy. Please refer to the policy websites for details on inappropriate behaviours and possible sanctions.

The College of Natural and Applied Sciences (CNAS) has created an Academic Integrity for CNAS Students eClass site. Students can self-enroll and review the various resources provided, including the importance of academic integrity, examples of academic misconduct & possible sanctions, and the academic misconduct & appeal process. Students can also complete assessments to test their knowledge and earn a completion certificate.

"Integrity is doing the right thing, even when no one is watching." -- C.S. Lewis

The Faculty of Engineering expects an environment free of harassment, discrimination, and bullying. We encourage you to talk to the Office of Safe Disclosure and Human Rights about experiences, questions, or concerns. Additional resources and support for students are attached below.

Engineering students studying in the province of Alberta must also follow the Code of Ethics set by the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Course outline policies, course requirements, evaluation and grading information can be found in the University Calendar.

Safety during learning activities

In all Faculty of Engineering courses, labs, seminars or other learning activities, safety is of paramount importance. In some cases, laboratory work in a program requires high standards for risk management to keep potential hazards safely under control.

Anyone found to be unable to function safely in the class, lab, seminar or other learning activity may be asked to leave or be removed for their and the safety of other participants and instructors in alignment with the Student Academic Integrity Policy and Student Conduct Policy. As members, or prospective members, of the engineering profession, it is your responsibility to identify and inform the proper authorities of unsafe work.

Audio and video recording

Audio or video recording, digital or otherwise, of lectures, labs, seminars or any other teaching environment by students is allowed only with the prior written consent of the instructor or as a part of an approved accommodation plan.

Student or instructor content, digital or otherwise, created and/or used within the context of the course is to be used solely for personal study and is not to be used or distributed for any other purpose without prior written consent from the content author(s).

Only those items specifically authorized by the instructor may be brought into the exam facility. Students must not bring any unauthorized electronic device into an examination room, including cell phones or other devices.

Student services and support

Health & Wellness Support

Counselling and Clinical Services

Free, short-term, appointment-based counselling and psychiatric services. Also offers drop-in workshops. Book an initial consultation. Visit uab.ca/CCS to learn more.

Wellness Supports Social Workers

Free one-on-one support for students in the areas of housing, finances, academics, personal wellness, life skill development, family dynamics, system navigation, and any area of life where there is a desire to invite change. Visit uab.ca/wellness to learn more.

Sexual Assault Centre

Free, anonymous, and confidential drop-in counselling. Visit uab.ca/UASAC to learn more.

The Office of Safe Disclosure & Human Rights (OSDHR)

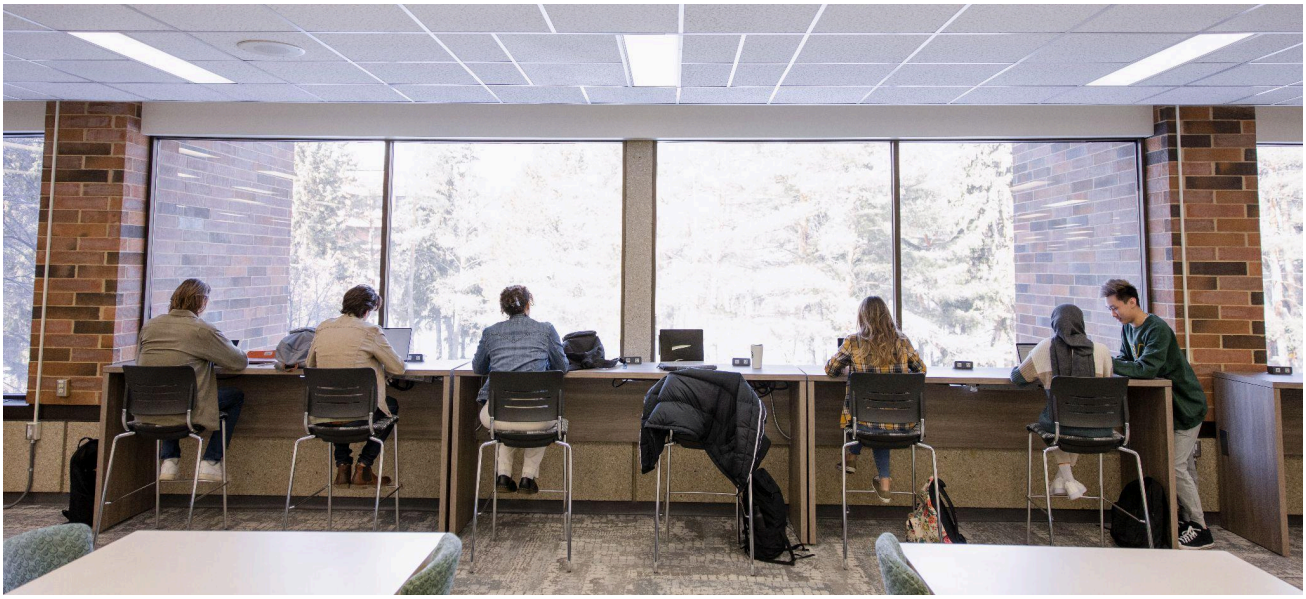
The OSDHR advises confidentially on sensitive issues you may not feel comfortable solving on your own. Contact the OSDHR if you want to get help or to make a report while keeping your privacy. Visit uab.ca/OSDHR to learn more.

HIAR (Helping Individuals at Risk)

If you're worried about someone, contact HIAR, who can help assess risk and connect individuals to support. Learn more at uab.ca/HIAR.

Immediate External Supports

Health Link Alberta: 811
Suicide Crisis Helpline: 988



Academic support

Academic Success Centre
Access to a variety of services to maximize your academic success. Learn more at uab.ca/ASC.

Accessibility Resources
Connects students with disabilities to accommodations. Learn more at uab.ca/Access under accommodations + accessibility.

Decima Robinson Support Centre
Academic support for 100- or 200-level introductory calculus, linear algebra and statistics courses. Visit uab.ca/DSC to learn more.

Engineering Student Success Centre
The Faculty of Engineering provides drop-in tutoring for first-year courses. Visit uab.ca/ESSC to learn more.

Office of the Student Ombuds
Call for complex problems and conflict mediation. Learn more at uab.ca/ombuds.

Financial support

Student Service Centre

For awards and other funding support. Learn more at uab.ca/ask.

Campus Food Bank

The Campus Food Bank Society is an independent charity supporting University of Alberta students, faculty, staff, and alumni for up to five years. For additional information visit their website at campusfoodbank.com.