

CIV E 698 Petroleum Geomechanics

Winter 2026 - January 05 to April 15

Class time: Tuesday, Thursday 14:00-15:20 Location: BS B-121

Instructor:

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Office Hours:

Course Description:

*3 (fi) (either term, 3-0-0) Application geotechnical engineering principles to petroleum engineering problems. Principles of thermo-poroelasticity are reviewed. Borehole stability, hydraulic fracturing, subsidence/heave, sand production, formation damage and reservoir-geomechanical modelling are the major topics for the course. Special attention is given to geomechanical influences on reservoir flow processes.

Prerequisites: consent of Instructor

Course synchronous and asynchronous content delivery schedule:

Synchronous delivery. Potential for recorded lectures to be provided if situation warrants.

Land Acknowledgment:

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

Course Objectives & General Content:

This course will introduce geoscience concepts related to our use of the subsurface as a “solution space” for developing both our hydrocarbon resources as well as technologies deployed as part of the energy transition. It is designed for students from a wide range of backgrounds including geotechnical, petroleum, chemical and mechanical engineering, earth science students (e.g., geology, geophysics, integrated petroleum geoscience).

This course will introduce the main fundamental aspects of reservoir geomechanics (deformation, strength, in situ stress) as background to explore their application in wellbore stability, mechanical earth models, hydraulic fracturing, multiphase flow and poroelasticity. Application areas for these topics will include carbon capture and storage (CSS), geothermal, tight oil and gas, SAGD, underground hydrogen storage, compressed air energy storage, and shallow geothermal applications such as thermal piles and borehole heat pumps.

Energy Transition Context

This updated course recognizes the critical role of geomechanics in achieving net-zero targets and supporting the energy transition. Students will develop skills applicable across traditional and emerging energy sectors, with emphasis on:

- Transferable skills across energy applications
- Containment assurance and risk management
- Sustainable operations and environmental stewardship
- Digital workflows and modern tools
- Multidisciplinary integration

Geoscience Workforce

The course acknowledges the current geoscience skills shortage and aims to prepare students for diverse career pathways in:

- Carbon capture and storage
- Hydrogen economy
- Geothermal energy
- Wind and renewable energy
- Oil and gas (lower emissions operations)
- Mining and mineral resources
- Environmental consulting

Learning Outcomes:

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

Marking Scheme:

Activity	(A)Synchronous	Due/Scheduled	Weight
Assignments	Asynchronous	Due throughout term	40%
Quizzes	Synchronous	Three throughout term	60%

The Faculty recommended grade point average for a 600 level course is 3.3. 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.

Text and References (Mandatory):

There is no required textbook for this course.

Extensive set of notes will be provided throughout the course as well as additional related to topics that are covered.

Text and References (Recommended):

The following books are good resources for current understanding of topics covered in CIVE 698.

- Fjaer, E., Holt, R.M., Horsrud, P, Raaen, A.M., and Risnes, R. (2008). Petroleum Related Rock Mechanics, 2nd Edition, Elsevier, Amsterdam, 491 p.
- Zoback, M. (2007) Reservoir Geomechanics. Cambridge University Press, 505 p.
- Ameen, M.S. (2018). Operational Geomechanics: A Rock Based Science for Environmental, Energy and Engineering Applications. EAGE Publications, 538 p.
- Davis, T.L., Landrø, M., and Wilson, M. (2019). Geophysics and Geosequestration. Cambridge University Press.
- Selected papers from ARMA, SPE, and academic journals (provided during course)

Website:

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!

Lecture Topics

1. Introduction

- Schedule
- Structure of the Course
- Overview of Subsurface Energy Applications
- Energy Transition and Net Zero Context
- Geoscience Workforce and Career Pathways

1 Geomechanics in the Life Cycle of a Reservoir

- 1.1 Intro to Exploration, Drilling, Completions
- 1.2 Reservoir / Well Dynamics / Facilities
- 1.3 Framework for integration in mechanical earth modeling in 1^D, 2^D and 3^D

2 Deformation, Failure and Strength

- 2.1 Principles of Soil Mechanics
- 2.2 Principles of Rock Mechanics (Intact)
- 2.3 Principles of Rock Mechanics (Fractured – Rock Mass Approaches)

3 Determination of Mechanical Properties

- 3.1 Core-Based Methods
- 3.2 Log-Based Methods
- 3.3 In Situ Methods

4 In Situ Stress and Pore Pressure Prediction

- 4.1 Geological Setting and Stress Tensor (Andersson, etc.)
- 4.2 Indirect Evidence
- 4.3 Borehole Based Evidence
 - 4.3.1 Breakouts
 - 4.3.2 Drilling Induced Tensile
 - 4.3.3 Geophysics
 - 4.3.4 Pressuremeter
- 4.4 Direct Measurement Techniques
 - 4.4.1 Core-based Methods (ASR, DSA, USBM, etc.)
 - 4.4.2 Pressurized Fracturing (LOT, XLOT, DFIT, step-rate-test, minifrac, FIT)
- 4.5 Seismic-based Techniques
- 4.6 Pore Pressure Prediction Techniques

5 Mechanical Earth Model Workflow including Seismic

- 1D, 3D, Uncertainty, Ensemble and Digital Twin Concepts

6 Poroelasticity including Thermal Effects

7 Wellbore Stability and Integrity

8 Hydraulic Fracturing and Stimulation

9 Subsurface Integrity and Containment

- 9.1 Containment Framework
- 9.2 Overburden Characterization
- 9.3 Caprock/Top-Seal Assessment
- 9.4 Fault and Fracture Sealing
- 9.5 Induced Seismicity

10 Multiphase Flow

11 Reservoir Geomechanics Applications

- 11.1 Permeability, relative permeability, capillary pressure
- 11.2 Depletion and stress changes
- 11.3 Thermal effects
- 11.4 Compaction and subsidence
- 11.5 Discontinuous/rock mass/fractures
- 11.6 CHOPS
- 11.7 CO₂ EOR/Geological Storage
- 11.8 Geothermal
- 11.9 Numerical modelling
 - 11.9.1 Uncoupled
 - 11.9.2 Sequentially or iteratively coupled
 - 11.9.3 Fully coupled

12 Reservoir Geomechanics Applications for Energy Storage

- 12.1 CO₂ Geological Storage
- 12.2 13.2 Hydrogen Storage
- 12.3 Compressed Air Energy Storage (CAES)
- 12.4 Geothermal Energy
- 12.5 Traditional Reservoir Applications
 - 12.5.1 Permeability Evolution
 - 12.5.2 Depletion and Stress Changes
 - 12.5.3 Compaction and Subsidence
 - 12.5.4 CHOPS and Sand Production
 - 12.5.5 Depletion-Drive Mechanisms

13 Geomechanics for Unconventional Developments

- 13.1 Introduction
- 13.2 Critical Geomechanical Aspects

14 Shallow Geotechnical Applications

- 14.1 Thermal Piles
- 14.2 Heated Foundations
- 14.3 Ground Heat Pumps

15 Case Histories

- 15.1 Joslyn/Primrose
- 15.2 UTF (Phase A & B)
- 15.3 ConocoPhillips – Eagle Ford
- 15.4 Aquistore

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.



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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.



CIVE 698 Petroleum Geomechanics – Winter 2020
Course Outline

Instructor: Dr. Rick Chalaturnyk, 6-222 ICE
(rjchalaturnyk@ualberta.ca)

Effective March 17, 2020, instructor will be available through emails or other forums such as Skype or ZOOM

~~Lecture Time: Tues/Thurs 11:00 – 12:20 am starting January 14
Place: NREF 2-016~~

Effective March 17, 2020, all remaining in-person lectures are cancelled. All course materials will be provided through eClass and project specific discussions will occur by email or through Skype/ZOOM platforms.

~~FINAL EXAM: TBD~~

Effective March 17, 2020, the Final Exam is cancelled and the weighting for the course will be Assignments based.

Evaluation: 1. Four Assignments 100%

Lecture Topic

1. Introduction
 - 1.1 Schedule
 - 1.2 Structure of the Course
 - 1.3 General discussions on application areas

- 2 Geomechanics in the Life Cycle of a Reservoir
 - 2.1 Exploration
 - 2.2 Drilling
 - 2.3 Completions
 - 2.4 Reservoir/Well Dynamics
 - 2.5 Surface Facilities
 - 2.6 IOR/EOR
 - 2.7 Framework for integration in mechanical earth modeling in 1^D, 2^D and 3^D

- 3 Deformation, Failure and Strength
 - 3.1 Principles of Soil Mechanics
 - 3.1.1 Formation Types (hard soils – soft rocks)
 - 3.1.2 Elastic/Plastic Behavior
 - 3.1.3 Effective Stress
 - 3.1.4 Failure Mechanisms

 - 3.2 Principles of Rock Mechanics (Intact)
 - 3.2.1 Formation Types
 - 3.2.2 Elastic/Plastic Behavior
 - 3.2.3 Failure Mechanisms

- 3.3 Principles of Rock Mechanics (Fractured – Rock Mass Approaches)
 - 3.3.1 Formation Types
 - 3.3.2 Elastic/Plastic Behavior
 - 3.3.3 Failure Mechanisms
- 4 Determination of Mechanical Properties
 - Vertical, Min. Horizontal and Max. Horizontal Stress
 - 4.1 Core-Based Methods
 - 4.1.1 Types of lab tests (soil and rock)
 - 4.1.2 Interpretation of Properties
 - 4.1.3 Coring Methods
 - 4.2 Log-Based Methods
 - 4.2.1 Types of Logs
 - 4.2.2 Formulas and Approaches
 - 4.3 In Situ Methods
 - 4.3.1 Pressuremeter
- 5 In Situ Stress and Pore Pressure Prediction
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 - 5.1 Seismic-based Techniques
 - 5.2 Pore Pressure Prediction Techniques
- 6 Mechanical Earth Model Workflow including Seismic
- 7 Poroelasticity including Thermal Effects
- 8 Wellbore Stability and Integrity
 - 8.1 Overview of Mechanisms
 - 8.2 Stresses around Openings
 - 8.3 Analytical Solutions
 - 8.4 Numerical Modeling
 - 8.5 Guidelines
- 9 Hydraulic Fracturing and Stimulation
 - 9.1 Overview (PKN, PN, KGD, Mode I, II and III, etc.)
 - 9.2 Operations Review
 - 9.3 Key Parameters that Control Geometry
 - 9.4 NFR Issues
- 10 Multiphase Flow and Geomechanics including Thermal
- 11 Geomechanics for Unconventional Developments
 - 11.1 Introduction
 - 11.1.1 Characteristics
 - 11.1.2 Challenges
 - 11.1.3 Stimulation Scenarios
 - 11.2 Reservoir Quality Evaluations
 - 11.2.1 Basic Concepts
 - 11.2.2 TOC, Porosity, NF's, pressure, mechanical properties
 - 11.3 Role of Natural Fractures/Weak Planes (DFN)
 - 11.4 Microseismicity

- 11.5 Hydraulic Fracturing Basics
- 11.6 Critical Geomechanical Aspects

12 Reservoir Geomechanics

13 Case Histories