Course Information

Course Number:	PETE 689
Course Title:	Fundamentals of Fluids and Geomechanics
Sections:	602/702 (online) The course will be taught online, both synchronously and asynchronously.
Time:	2:20 p.m. – 3:35 p.m.
Location:	RICH 1009
Credit Hours:	3

Instructor Details

Instructor:	Dr. Wencheng Jin
Office:	Richardson 401F
Phone:	979-458-7672
Email:	wencheng.jin@tamu.edu
Office Hours:	W/R 3:35 pm – 4:30 pm

Course Description

Reservoir fluids and rocks and their physical behavior; porous media and fracture flow models; constitutive modeling; influence of rock deformability, fluid pressure and temperature, stress, pore pressure, effective stress, poroelasticity; Applications to wellbore stability, hydraulic fracturing, and reservoir compaction.

Course Prerequisites

PETE311

Course Learning Outcomes

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

1. Define fluid properties, flow behavior, and non-Newtonian effects relevant to porous media and drilling.
2. Explain the fundamental concepts of stress, pore pressure, strain, and displacement in subsurface systems, including their scalar, vector, and tensor representations.
3. Compute stress states, pore pressure profiles (hydrostatic, lithostatic, overpressure), and effective stress (Terzaghi and Biot formulations) using geophysical log data and field conditions.
4. Perform stress tensor transformations, stress projections, and Mohr circle analyses to determine principal stresses, normal and shear stresses, and stress regimes (normal, strike-slip, reverse).
5. Derive Cauchy's equations of equilibrium, strain–displacement relations, and Navier's equation for linear elasticity, and solve basic boundary-value problems analytically.
6. Evaluate elastic parameters (Young's modulus, bulk modulus, Poisson's ratio, Lamé constants) from laboratory measurements or seismic velocity data, and interpret their geomechanical significance.
7. Develop coupled poroelastic models to predict subsurface deformation, including 1D Terzaghi consolidation and Mandel's problem, and interpret results for engineering applications.
8. Apply yield criteria (Mohr–Coulomb, Drucker–Prager, Hoek–Brown) to identify failure conditions, and analyze stress paths leading to wellbore breakout, fault slip, or reservoir compaction.
9. Differentiate between elastic, plastic, viscoelastic, and viscoplastic deformation behaviors, and predict brittle–ductile transition under varying stress, temperature, and strain rate conditions.

10. Assess the potential for fracture propagation and natural fracture/fault reactivation under fluid injection, using linear elastic fracture mechanics (stress intensity factor, energy release rate, toughness) and Mohr-circle-based stability analysis.
11.

Textbook and/or Resource Materials

The main source of material for the course will be a series of notes and slides handed out to the students. Suggested complementary textbooks are:

- **McCain, William D., Jr.** *Properties of Petroleum Fluids (3rd Edition).* PennWell, 2017.
- **Zoback, M. D.** *Reservoir Geomechanics.* Cambridge University Press, 2007.
- **Detournay, E., & Cheng, A. H.-D.** *Fundamentals of Poroelasticity.* Elsevier, 1993.
- **Jaeger, J. C., Cook, N. G. W., & Zimmerman, R. W.** *Fundamentals of Rock Mechanics*. 4th Edition. Wiley-Blackwell, 2007

Grading Policy

Grading items

	Weight [%]
Homework	30
Midterm Exam-1	20
Midterm Exam-2	20
Final Exam	30
Total	100

Grading scale

A	>= 90%
B	80% - 89.9%
C	70% - 79.9%
D	60% - 69.9%
F	< 59%

Homework (30%):

- There will be 10 homework assignments for the total 5 modules.
- All homework will be graded; each homework will be a worth of 3% of the course grade.
- Assigned problems will be made available through the Canvas coursework website and homework solutions must be submitted electronically.

Midterms I & II (each 20%)**:**

- Exams are closed book, closed notes
- A letter-sized cheat sheet is allowed for writing equations or anything the students think it is appropriate.
- No phones, headphones, computers, etc. allowed.

Final Exam (30%)**:**

- Exams are closed-book, closed notes.
- Two letter-sized cheat sheet is allowed for writing equations or anything the students think it is appropriate.
- No phones, headphones, computers, etc. allowed.

Course Policies

Attendance: It is the students' responsibility to attend the class. Attendance and active participation in class are expected.

Late Submission: In case of Late submissions, the following penalties apply: homeworks and project will be assigned a late penalty of 20% for each 24-hour period after the due date and time. Work submitted by a student as makeup work for an excused absence is not considered late work and is exempt from the late work policy (Student Rule 7).

Work Quality: A Neat, legible, systematic, and complete presentation is required in homework and examinations for full credit. Units and explanations must be written wherever appropriate for the answers.

Exams: Exams are not optional. Make-up exams will be given only for university excused absences. It is the student's responsibility to notify the instructor within 24 hours of the absence to make arrangements. ***All exam grades are final one week after being posted on Canvas.***

Feedback: After Midterm exam, I will be asking you to give me feedback on your learning in informal ways so we can create a better learning experience. Feel free to contact me anytime with feedback, concerns, suggestions, etc.

Academic Dishonesty: Collaboration on exams is forbidden except when specifically authorized. Students violating this policy may be given an F in the course. See http://www.tamu.edu/aggiehonor

Course Schedule

Week	Module/Topic
1	**I. Introduction.** • Motivation: Subsurface engineering-related flow and geomechanics **II. Fundamentals of Fluids** • Density, viscosity, compressibility, surface tension • Real-gas behavior, Z-factor, PVT relationships
2	• Phase diagram for reservoir fluids (e.g., water, methane, oil, CO2) • Capillarity and wettability effects in porous systems • Continuum assumption and derivation of the Navier–Stokes equations • Laminar vs turbulent flow, Reynolds number • Homework-1, 3% of total score
3	• Analytical solutions for Poiseuille flow and Couette flow • Non-Newtonian behavior: Power-law and Bingham fluids (relevance to drilling muds) • Homework-2, 3% of total score **III. Fundamentals of Stress and Pore Pressure** • Scalar, vector, tensors in the subsurface (e.g., pore pressure, displacement/velocity, stress/strain/stiffness/compliance)
4	• Math operations to scalar, vector and tensor (Eigenvalues and eigenvectors, derivative, gradient, divergence, curl, Laplacian) • Stress and pore pressure in vertical direction (lithostatic gradient, on-/off-shore hydrostatic pressure, 1D effective stress)

	• Origins of non-hydrostatic pore pressure (overpressure and underpressure) • Homework-3, 3% of total score
5	• Pore pressure estimation methods from geophysical logs • Stress tensor, rotation of stress tensor, and stress projection on a plane: 2D & 3D (normal & shear stress at a fracture/fault surface) and principal stresses • Stress invariants, 3D effective stress (Terzaghi's and Biot' Effective Stress, Biot coefficient determination) • Homework-4, 3% of total score
6	• Mohr Circle representation of stress • Stress paths in p-q and principal stress spaces (Lab: isotropic compression, uniaxial compression, triaxial compression; Field: depletion, injection) • Subsurface stress regimes (normal, strike-slip, reverse), measuring in situ stress (mini fracking), and implication for hydrofracking fracture directions
7	**Midterm Exam 1: Topics include Module II & III**, 20% of total score **IV. Fundamentals of Continuum Mechanics** • Derivation of Cauchy's equations in stress equilibrium

8	• Concept of displacement, strain tensor
	• Constitutive models – stress-strain relationships
	  ○ Generalized Hooke's law
	  ○ Voigt Notation of stress, stiffness, and strain relationship
	• Homework-5, 3% of total score

9	• Constitutive models – stress-strain relationships
	  ○ Definition of linear isotropic and transversely isotropic elasticity, modulus equivalence (Young's modulus, Bulk Modulus, Constraint Modulus, Poisson's ratio, shear modulus, Lamé constants) and their relationship with seismic velocity
	  ○ Multiphysics impact: poro-mechanical and thermo-mechanical model
	• Derivation of Navier's equation and its solution
	• Homework-6, 3% of total score

10	**V. Fundamental of Poromechanics** • Single phase flow in rigid porous media: Darcy's law, mass conservation equation • Transient pressure diffusion: wellbore drawdown test and its solution • Coupled flow and deformation: From constitutive models towards governing equations • Homework-7, 3% of total score
11	• Terzaghi 1D consolidation; Mandel's 2D consolidation • Coupled multiphase flow and deformation **Midterm Exam 2: Topics include Module IV & V**, 20% of total score
12	**VI. Yield and Failure of Geomaterials** • Motivation: Examples of inelastic deformation in subsurface (e.g., wellbore breakout, reservoir compaction, fracturing, natural fracture reactivation) • Strain decomposition, yield surface, incremental plastic strain direction, associate versus non-associate flow rules, perfect plasticity, stress hardening/softening • Homework-8, 3% of total score
13	• Tensile & shear yield criteria: Mohr-Coulomb, Drucker-Prager, Hoek-Brown

	• Compression yield cap: Compaction band from pore collapse • Brittle-ductile transition, Visco-elastoplastic deformation • Homework-9, 3% of total score
14	• Basics of fracture mechanics: Mode-I/II/III fracture propagation, stress intensity factor, toughness, energy release rate • Natural fracture / fault reactivation due to fluid injection (Mohr circle analysis) • Homework-10, 3% of total score
15	**Final Exam: All Modules**, 30% of total score

Non-Traditionally Delivered Course

The in-person and online versions of this course are intended to be the same, except as noted below. The course is offered face-to-face, and via distance learning (synchronous or asynchronous online).

- Online students will take the course during the semester the course is being taught face to face. While face-to-face students have 10 days to complete each course, online students have 20 days.
- Synchronous online students will zoom in during the regular class time. Asynchronous online students will access the course recordings outside of the regular class time.
- Videos of the lectures will be provided on CANVAS. As such, the contact hours are the same as for the face-to-face students.
- The instructor will schedule zoom meetings to answer questions for face-to-face, online synchronous, and online asynchronous students.
- Assignments will be submitted by a combination of email and uploading to CANVAS. Exams will be administered through the CANVAS site.

University Policies

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See Student Rule 24.)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" (Section 20.1.2.3, Student Rule 20).

You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Notice of Nondiscrimination

Texas A&M University is committed to providing safe and non-discriminatory learning, living, and work environments for all members of the University community. The University provides equal opportunity to all employees, students, applicants for employment or admission, and the public regardless of race, color, sex (including pregnancy and related conditions), religion, national origin, age, disability, genetic information, or veteran status. Texas A&M University will promptly, thoroughly, and fairly investigate and resolve all complaints of discrimination, harassment (including sexual harassment), complicity and related retaliation based on a protected class in accordance with System Regulation 08.01.01, University Rule 08.01.01.M1, Standard Administrative Procedure (SAP) 08.01.01.M1.01, and applicable federal and state laws. In accordance with Title IX and its implementing regulations, Texas A&M does not discriminate on the basis of sex in any educational program or activity, including admissions and employment. The following person has been designated to handle inquiries and complaints regarding the non-discrimination policies: Jennifer M. Smith, TAMU Associate VP & Title IX Coordinator at YMCA Ste 108, College Station, TX 77843, 979-458-8407, or email civilrights@tamu.edu. For other reporting options, visit https://ocrcas.ed.gov/contact-ocr to locate the address and phone number of the office that serves your area, or call 1-800-421-3481.

Civil Rights, Free Speech, and Title IX Policies

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit discrimination and harassment based on an individual's race, color, sex, (including pregnancy and related conditions), religion, national origin, age, disability, genetic information, veteran status, or any other legally protected characteristic. This includes forms of sex-based violence, such as sexual assault, sexual harassment, sexual exploitation, dating/domestic violence, and stalking.

Students can report discrimination/harassment, access supportive resources, or learn more about their options for resolving complaints on the University's Civil Rights & Title IX webpage.

Students should be aware that all university employees (except medical or mental health providers) are mandatory reporters, which means that if they observe, experience or become aware of an incident that they reasonably believe to be discrimination/harassment alleged to have been committed by or against a person who was a student or employee at the time of the incident, the employee must report the incident to the university.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact the Disability Resources office on your campus (resources listed below)

Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.
To request academic accommodations, contact the designated ADA office based on your location:

- Texas A&M University, College of Nursing, College of Dentistry, Irma Lerma Rangel College of Pharmacy College Station, College of Medicine, School of Public Health, Institute of Biosciences and Technology, EnMed Program, Bush School in Washington DC, Mays Business School – CityCentre, TAMU Engineering Academies, Texas A&M University Higher Education Center at McAllen and Texas A&M University at Galveston should contact Disability Resources at (979) 845-1637 or disability@tamu.edu.
- Texas A&M University School of Law should contact the Office of Student Affairs at (817) 212-4111 or law-disability@law.tamu.edu to request accommodations.
- Irma Lerma Rangel College of Pharmacy in Kingsville should contact the Disability Resource Center at Texas A&M University - Kingsville at (361) 593-3024 or drc.center@tamuk.edu to request accommodations.
- Texas A&M University College of Veterinary Medicine & Biomedical Sciences in Canyon should contact the Office of Student Accessibility at West Texas A&M University – Canyon at (806) 651-2335 or osa@wtamu.edu.
- Texas A&M University at Qatar (TAMUQ) should contact the campus psychologist, Dr. Steve Wilson +974-4423-0047 or stephen.wilson@qatar.tamu.edu.

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If you are experiencing difficulties with your approved accommodations, contact the office responsible for approving your accommodations or the Texas A&M ADA Coordinator Julie Kuder at ADA.Coordinator@tamu.edu or (979) 458-8407.

Pregnancy Accommodations

Texas A&M provides reasonable accommodations to students due to pregnancy and/or related conditions, such as childbirth, recovery and lactation. Students should contact the University's Pregnancy Coordinator as soon as they become aware of the need for accommodation. Depending on the circumstances, accommodations could include extended time to complete assignments or exams, changes in course sequence, or modifications to the physical classroom environment. Texas A&M will also allow a voluntary leave of absence, ensure the availability of lactation space, and maintain grievance procedures to provide for the prompt and equitable resolution of complaints of sex discrimination. For information regarding pregnancy accommodations, email TIX.Pregnancy@tamu.edu.

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors influencing a student's academic success and overall wellbeing. Students are encouraged to engage in healthy self-care practices by utilizing the resources and services available through University Health Services on its mental health webpage. The TELUS Health Student Support app provides access to professional counseling in multiple languages anytime, anywhere by phone or chat, and the 988 Suicide & Crisis Lifeline offers 24-hour emergency support at 988 or 988lifeline.org.

Students needing a listening ear can contact University Health Services (979.458.4584) 24-hour emergency help is also available through the 988 Suicide & Crisis Lifeline (988) or at 988lifeline.org.

Statement on the Family Educational Rights and Privacy Act (FERPA)

FERPA is a federal law designed to protect the privacy of educational records by limiting access to these records, to establish the right of students to inspect and review their educational records and to provide guidelines for the correction of inaccurate and misleading data through informal and formal hearings. Currently enrolled students wishing to withhold any or all directory information items can do so within howdy.tamu.edu using the Directory Information Withholding Form. The complete FERPA Notice to Students and the student records policy is available on the Office of the Registrar webpage.

Items that can never be identified as public information are a student's social security number, citizenship, gender, grades, GPR or class schedule. All efforts will be made in this class to protect your privacy and to ensure confidential treatment of information associated with or generated by your participation in the class.

Directory items include name, UIN, local address, permanent address, email address, local telephone number, permanent telephone number, dates of attendance, program of study (college, major, campus), classification, previous institutions attended, degrees honors and awards received, participation in officially recognized activities and sports, medical residence location and medical residence specialization.