GE 481/681
INTRODUCTION TO GEOMECHANICS
4 credits, Fall 2024

Lecture M, W, F 12:00 PM - 12:50 PM, Laxalt Mineral Engineering 415

Laboratory W 3:00-5:00 PM
LMR 275, door code 8541

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Office Hours: Monday 11:00-11:50 or by appointment

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Course Description

This course is an introduction to the continuum mechanics used in Earth science and engineering. Course topics are split equally between heat conduction, fluid mechanics, and solid mechanics. During the course we will work with fundamental physical processes important to the transport of energy, mass, and momentum in the Earth and on Earth's surface. Solutions for each problem will be derived from first principles, including conservation and flux laws. We will explore continuum mechanics applied to geological problems through a mix of lectures, demonstrations, discussion, readings, laboratories, and writing assignments. Example applications: heat flow and temperatures in the crust, shallow geothermal energy, groundwater flow, flow of water and sediment in rivers, elasticity, rock fracture and failure, landslide initiation and runout, rock mass strength. The mandatory computer laboratory component provides a hands-on introduction to procedural computer programming in which students will write computer codes in Python to solve equations, complete analysis, plot results, and visualize data across a range of applied problems introduced in the lecture component.

Course Prerequisites

MATH 181 - Calculus I (or equivalent)
PHYS 180 - Physics for Scientists and Engineers I (or equivalent)

Required Texts, Course Materials

Mechanics in the Earth and Environmental Sciences by Middleton and Wilcock

Course Objectives

Understanding continuum mechanics is a critical skill for a wide range of professionals in Earth sciences and engineering. Hence, this course aims:

1. To develop your skills in applying continuum mechanics and basic physical principles to either solve geological problems or to explain basic features of natural phenomena in a quantitative and generalizable manner.
2. To improve your understanding of the mathematics behind the behavior and motion of natural materials and phenomena.
3. To help you understand technical and scientific literature that relates to geomechanics.
4. To develop your basic procedural programming skills to solve diverse problems efficiently.

Relationship of Course Goals to ABET Student Learning Outcomes

ABET Student Learning Outcomes	Corresponding Course Objectives
1) Fundamental Background and Problem Solving - an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	1,2,3,4
2) System and Process Design - an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	1,4
3) Communication - an ability to communicate effectively with a range of audiences	1,2,3,4
4) Ethics, Broad Education, and Social Awareness - an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	1,3
5) Teamwork - an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	1
6) Experimental Design / Data Analysis - an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	1,2,3,4
7) New Knowledge - an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	1,2,3,4
8) Field Competency - the application of geologic field proficiency to engineering practice	

Student Learning Outcome

1. Students will demonstrate, through analytical papers and laboratory reports, that they can speak the mathematical language of continuum mechanics and apply this knowledge to solve diverse geological problems.
2. Students will be able to organize, approach, and solve multi-step Earth science and geological engineering problems. In general, this means that students will be able to derive useful equations from fundamental governing equations and constitutive equations, list needed assumptions, and solve specific geological problems by specifying appropriate initial and boundary conditions.
3. Students will demonstrate they have developed a useful scientific/engineering computing skill set that can be used throughout professional practice by writing basic procedural programming scripts to solve equations, complete analysis, plot results, and visualize data across a range of geological problems.

Required Work and Grading

No plus/minus grading will be used below a B-.

100%-93% = **A**; 92.9%-90% = **A-**; 89.9%-87% = **B+**; 86.9%-84% = **B**; 83.9%-80% = **B-**; 79.9%-70% = **C**; 69.9%-55% = **D**; 54.9% or below = **F**

GE 481

Laboratory exercises	40%
Analytical papers	50%
Class Participation	10%

GE 681

Final Oral Exam	10%
Analytical papers	40%
Laboratory exercises	40%
Class Participation	10%

Analytical papers

During the semester you will prepare 3 short (typically ~10 page) analytical papers. These papers will combine discussion, calculation, and analysis of a particular kind of mechanical behavior and its applications to geological problems. The purpose of these papers is to help you deepen your understanding of the concepts while practicing technical writing.

Laboratory

Labs will be held every Wednesday 3:00-5:00 PM. Due dates for each lab assignment will be specified in the web campus assignment. All labs will be typed up in Jupyter Notebook and must follow the format specified in the separate handout titled “Lab Book Guide”. All labs will involve some element of computer programming in Python to solve equations, do analysis, and plot data and results.

Readings

Short readings from the textbook or technical literature (typically 10-30 pages) will sometimes be assigned and should be completed by the following class, when we will review them. I may sometimes ask you to prepare a summary of the key points in these readings.

Exams

No exams will be given for GE 481. A final oral exam will be given for GE 681.

Class participation

Willingly contribute to the class discussion, participate during small breakout sections and take short quizzes.

DGSE Code of Conduct: In this course we will follow the DGSE Code of Conduct. There will be zero tolerance for harassment, microaggressions, or academic misconduct of any kind.

Difference between GE 481 and 681

Graduate students will be expected to achieve a deeper understanding of the material presented in lecture and lab by completing additional readings assigned throughout the semester, answering in-depth challenge questions on the analytical papers and laboratory assignments and completing an additional oral final examination. These extra assignments are meant to be difficult enough to encourage additional independent study as well as interaction with the other graduate students, the teaching assistant, and the professor. The oral final exam is designed as a synthesis experience as well as to provide practice for comprehensive exams required for graduate school. Graduate students will be evaluated independent from undergraduates in both analytical papers and laboratory assignments and held to a higher standard in terms of quality of writing, presentation of results, and depth of discussion.

Late work

It is crucial that ALL assignments be handed in on time, so that (1) you're prepared to discuss them in class, (2) we can grade them promptly, and (3) you don't fall behind. Therefore, I will deduct 10% per day that papers are late.

Course Outline

Introduction: What is a continuum?
Conservation equations: mass, momentum, and energy

Thermal

The heat equation
Steady solutions to conduction problems and geothermal gradients
Role of radioactivity in the crust
Introduction to non-steady problems
Thermal profiles driven by oscillating surface temperatures
Instantaneous heating and cooling problems
Groundwater flow through porous media: One of the many applications of the diffusion equation

Fluids

Introduction to fluids and rheology
Introduction to the material derivative
Derivation of the Navier-Stokes equation
Poiseuille-Couette Flow: An example use of the Navier-Stokes equation
Solving the general Poiseuille-Couette flow equation for different boundary conditions
Non-dimensionalizing governing equations
Fluid mechanics problems
Dimensional analysis
Open channel flow

Solids

Landslides, hillslope stability, and runout dynamics
Strength, deformation, failure, facture
Stress and strain
Deformation and failure of ideal materials
Stress in 1D and 2D
Effective stress and friction
Rock mass strength and rock mass rating systems

University Policies

Statement on Academic Dishonesty

The University Academic Standards Policy defines academic dishonesty, and mandates specific sanctions for violations. See the University Academic Standards policy: UAM 6,502.

Generative AI use is permitted

In this course you are welcome to use generative artificial intelligence/large language model tools (such as ChatGPT, DALL-E, Gemini, Perplexity, etc.). Using these tools aligns with the course learning outcomes/student goals.Please be aware that many AI companies collect and store personal information. Please do not enter your confidential information as part of a prompt.
Also, please note that some of these large language models may "make up" or "hallucinate" information. These tools may reflect misconceptions and biases of specific data. Students are responsible for checking facts, finding reliable sources for, and making a critical examination of any work that is submitted.

All use of AI tools or content must be acknowledged or cited. If you do not acknowledge or cite your use of an AI tool, what you submit will be considered a form of cheating, as outlined in UNR Academic Integrity Policy (UAM 6,502).
Please make sure to use the appropriate guidelines for acknowledging/citing generative AI in your assignments.

- UNR MLA Citation Guide
- UNR APA Citation Guide

Additional Considerations

- Generative AI for Research

Statement on Student Compliance with University Policies

In accordance with section 6,502 of the University Administrative Manual, a student may receive academic and disciplinary sanctions for failure to comply with policy, including this syllabus, for failure to comply with the directions of a University Official, for disruptive behavior in the classroom, or any other prohibited action. "Disruptive behavior" is defined in part as behavior, including but not limited to failure to follow course, laboratory or safety rules, or endangering the health of others. A student may be dropped from class at any time for misconduct or disruptive behavior in the classroom upon recommendation of the instructor and with approval of the college dean. A student may also receive disciplinary sanctions through the Office of Student Conduct for misconduct or disruptive behavior,

including endangering the health of others, in the classroom. The student shall not receive a refund for course fees or tuition.

Statement of Disability Services

Use either the traditional or online statement, in addition to the last sentence regarding third party materials.

For Traditional and Seated Classrooms:

Any student with a disability needing academic adjustments or accommodations is requested to speak with me or the Disability Resource Center (Pennington Achievement Center Suite 230) as soon as possible to arrange for appropriate accommodations.

Statement on Audio and Video Recording

Student-created Recordings

Surreptitious or covert video-taping of class or unauthorized audio recording of class is prohibited by law and by Board of Regents policy. This class may be videotaped, or audio recorded only with the written permission of the instructor. In order to accommodate students with disabilities, some students may have been given permission to record class lectures and discussions. Therefore, students should understand that their comments during class may be recorded.

Instructor-created Recordings

Class sessions may be audio-visually recorded for students in the class to review and for enrolled students who are unable to attend live to view. Students who participate with their camera on or who use a profile image are consenting to have their video or image recorded. If you do not consent to have your profile or video image recorded, keep your camera off and do not use a profile image. Students who un-mute during class and participate orally are consenting to have their voices recorded. If you do not consent to have your voice recorded during class, keep your mute button activated and only communicate by using the "chat" feature, which allows you to type questions and comments live.

Statement on Maintaining a Safe Learning and Work Environment

The University of Nevada, Reno is committed to providing a safe learning and work environment for all. If you believe you have experienced discrimination, sexual harassment, sexual assault, domestic/dating violence, or stalking, whether on or off campus, or need information related to immigration concerns, please contact the University's Equal Opportunity & Title IX office at 775-784-1547. Resources and interim measures are available to assist you. For more information, please visit the Equal Opportunity and Title IX page.

Statement on Campus Closures or Delays

In the event of class cancelations or delays caused by inclement weather conditions, fire/smoke conditions, or other unforeseen emergencies, the safety and well-being of

students are the University's top priority. Official notifications will be disseminated through the University website and other official channels with details related to any campus delays or closures.

In the event of a campus closure, you will be informed as to whether the class will be offered remotely or if it will be canceled. If the class is cancelled, you will receive information on how to address any missed course content.

Students facing significant impacts due to these events are encouraged to communicate with their instructor for potential accommodations.

Additional Information

- If you are sick, please do not come to class. If you must miss class due to illness, please contact me to make arrangements for any missed work or lecture materials.

- Your student fees cover usage of the University Math Center (https://www.unr.edu/university-math-center), (775) 784-4433; University Tutoring Center (https://www.unr.edu/tutoring-center), (775) 784-6801; and University Writing & Speaking Center (https://www.unr.edu/writing-speaking-center), (775) 784-6030. These centers support your classroom learning; it is your responsibility to take advantage of their services. Keep in mind that seeking help outside of class is the sign of a responsible and successful student.