

Western University
Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9577– Rock Mechanics

COURSE OUTLINE Winter 2024

DESCRIPTION

The objective of the course is for students to develop an understanding of the fundamental concepts and principles in rock mechanics. Topics include stress-strain-strength behaviour of rocks, rock failure theories, in-situ stresses in rock, the role and analysis of joints and discontinuities, and the engineering of rock masses.

ENROLLMENT RESTRICTIONS

Enrollment in this course is restricted to graduate students in Civil and Environmental Engineering, as well as any student that has obtained special permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

INSTRUCTOR CONTACT INFORMATION

Course instructor: Bing Li
Email address: bing.li@uwo.ca
Office: SEB 3010C
Office hours: After weekly lecture

COURSE FORMAT

In-person

TOPICS

Topic #	Description	Learning Activities	Tentative timeline
Assignment 1 Posted			
1: Introduction (Chapter 1-2 in Hudson & Harrison)	Geological considerations: - What is rock mechanics? - Effect of water, heat, temperature, stress - Jointed vs intact rock - Anisotropy - Time effects	<ul style="list-style-type: none">• Powerpoint lectures• Assignment 1 (written problem set)• Zoom office hours	Week 1
2: Stress-strain (Chapter 3, 5 in Hudson & Harrison; chapter 2 in Jaeger-Cook-Zimmerman)	- Scalar vs vector vs tensor - Force -> stress - Stress rotation (no shear on surface) - Mohr's circle	<ul style="list-style-type: none">• Chalk and talk lectures• Assignment 1 (written problem set)• Zoom office hours	Week 2

	<ul style="list-style-type: none"> - Principal stress - Stress invariants - Normal and shear stress/strain 		
3: In-situ stress (Chapter 4 in Hudson & Harrison)	<ul style="list-style-type: none"> - Why in-situ stress? - $k = \sigma_h/\sigma_v$ - Stress measurement: flatjack, hydraulic fracturing, USBM, CSIRO - World stress map 	<ul style="list-style-type: none"> • Chalk and talk lectures • USBM demonstration • Assignment 2 (written problem set) • Zoom office hours 	Week 3
Assignment 1 Due, Assignment 2 Posted			
4: Intact rock strength and rock fracture mechanics (Chapter 6 in Hudson & Harrison; chapter 4, 6 in Jaeger-Zimmer-Cook)	<ul style="list-style-type: none"> - Mohr-Coulomb - Hoek-Brown - Mode I, II, III - Griffith's criterion - Intact testing (UCS) - Tensile strength testing 	<ul style="list-style-type: none"> • Chalk and talk lectures • Assignment 2 (written problem set) • Zoom office hours 	Week 4
5: Wave propagation in rocks and rock physics (Chapter 13 in Hudson & Harrison; chapter 11 in Jaeger-Zimmerman-Cook)	<ul style="list-style-type: none"> - P-wave, S-wave, Surface wave - Effects of density, porosity, pore pressure, clay 	<ul style="list-style-type: none"> • Powerpoint lectures • Assignment 3 (written problem set with lab component) • Zoom office hours 	Week 5
Assignment 2 Due, Assignment 3 Posted			
6: Joint statistics and joint strength (Chapter 7 in Hudson & Harrison; chapter 3 in Jaeger-Zimmer-Cook; Chapter 5 in Wyllie)	<ul style="list-style-type: none"> - What is a "joint"? - Joint spacing - Joint aperture - Joint persistence - Joint roughness - JRC - RQD - Shear box testing 	<ul style="list-style-type: none"> • Powerpoint lectures • Assignment 3 (written problem set) • Zoom office hours 	Week 6
Reading week, no class			
7: Empirical rock quality criterion (Chapter 7, 12 in Hudson & Harrison)	<ul style="list-style-type: none"> - CHILE vs DIANE materials - JRC - RMR - Q - GSI 	<ul style="list-style-type: none"> • Powerpoint lectures • Assignment 3 (written problem set) • Zoom office hours 	Week 7
8: Stereonets	<ul style="list-style-type: none"> - What is a stereonet? - Great circles 	<ul style="list-style-type: none"> • Chalk and talk lectures + demo 	Week 8

(Appendix B in Hudson & Harrison; chapter 2, 4, Appendix I in Wyllie)	- Small circles - Poles - Intersection of planes - Vector bisectors - Rotation	<ul style="list-style-type: none"> • Assignment 4 (written problem set with stereonet and software components) • Zoom office hours 	
Assignment 3 Due, Assignment 4 Posted			
Take-home midterm exam, covering material up to topic 7.			
9: Instability mechanisms in jointed rock (Chapters 17-19 in Hudson & Harrison; Chapters 7, 8, 10 in Wyllie)	- Rockfall - Slope stability - Toppling - Wedge stability	<ul style="list-style-type: none"> • Chalk and talk lectures • Assignment 4 (written problem set with stereonet and software components) • Zoom office hours 	Week 9
10: Fluid-rock interactions (Chapter 9 in Hudson & Harrison; chapter 7, 12 in Jaeger-Cook-Zimmerman, chapter 6 in Wyllie)	- Definitions - Flow through single fracture - Flow through fracture networks - Corrosion	<ul style="list-style-type: none"> • Chalk and talk lectures • Assignment 5 (written problem set with software component) • Zoom office hours 	Week 10
Assignment 4 Due, Assignment 5 Posted			
11: Rock engineering (Chapters 15, 16 in Hudson & Harrison; chapters 13-14 in Wyllie)	- Rock bolt support - Blasting - Grouting	<ul style="list-style-type: none"> • Powerpoint lectures • Assignment 5 (written problem set with software component) • Zoom office hours 	Week 11
12: Risk analysis (Chapter 14 in Hudson & Harrison)	- Interaction matrix - Sensitivity analysis - Probabilistic analysis - Monte Carlo simulation	<ul style="list-style-type: none"> • Powerpoint lectures • Assignment 5 (written problem set with software component) • Zoom office hours 	Week 12
Assignment 5 Due			
Take-home final exam			

SPECIFIC LEARNING OUTCOMES

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	40%	<ul style="list-style-type: none"> • Assignments • Examinations 	<ul style="list-style-type: none"> • Understanding of advanced concepts and theories • Awareness of important current problems in the field of study • Understanding of computational and/or empirical methodologies to solve related problems
Application of knowledge	40%	<ul style="list-style-type: none"> • Assignments • Examinations 	<ul style="list-style-type: none"> • Ability to apply knowledge in a rational way to analyze a particular problem

			<ul style="list-style-type: none"> Ability to use coherent approach to design a particular engineering system using existing design tools
Professional capacity / autonomy	5%	<ul style="list-style-type: none"> Assignments 	<ul style="list-style-type: none"> Awareness of academic integrity Ability to implement established procedures and practices in the coursework Defends own ideas and conclusions Integrates reflection into his/her learning process
Awareness of limits of knowledge	15%	<ul style="list-style-type: none"> Assignments Examinations 	<ul style="list-style-type: none"> Awareness of the need of assumptions in complex scientific analyses and their consequences Understanding of the difference between theoretical and empirical approaches Ability to acknowledge analytical limitation due to complexity of practical problems

ASSESSMENTS

Assessment Type	Material Covered	Tentative Due Date	Weight
Assignment 1 (written problem set)	Topics 1-2	26 Jan 2024	7%
Assignment 2 (written problem set)	Topics 3-4	8 Feb 2024	7%
Assignment 3 (written problem set)	Topics 5-7	8 Mar 2024	12%
Assignment 4 (software component)	Topics 8-9	22 Mar 2024	12%
Assignment 5 (software component)	Topics 10-12	5 Apr 2024	12%
Midterm exam (take-home, open book)	Topics 1-7	10 March 2024	20%
Final exam	All	Exam period	30%

Activities in which collaboration is permitted:

- Students are permitted to discuss and solve assignments in groups; however, they should complete and submit their final solutions and reports individually.
- Students will conduct the experiments for assignment 3 in groups, and are permitted to discuss and solve the problems together. However, they should complete and submit their final solutions individually.

Activities in which students must work alone (collaboration is not permitted):

- Midterm (open book)
- Final (open book)

Contact policy:

- Contact instructor via email (above) or through messages in OWL
- Weekly Office hours are held after the lecture
- A general FAQ section on the ‘forums’ section of OWL will be used for students to pose course-related questions so that all have the same information.

REQUIRED TEXTBOOK

None – chapters noted under “Topics” above are for reference only.

OPTIONAL COURSE READINGS

- Hudson, & Harrison, J. P. (1997). Engineering rock mechanics: an introduction to the principles (1st ed.). Pergamon.
- Wyllie. (2017). Rock slope engineering: civil applications (Fifth edition.). Taylor & Francis, CRC Press. <https://doi.org/10.4324/9781315154039>
- Jaeger, Cook, N. G. W., & Zimmerman, R. W. (2007). Fundamentals of rock mechanics (4th ed.). Blackwell Pub.

All three textbooks are available at the Allyn & Betty Taylor Library, or short-term from the instructor's office.

COURSE CONTENT

Powerpoint slides will be made available the night before lectures, all lectures will be delivered synchronously. The lecture notes, online lecture videos, assignments, and exams are copyrighted to the instructor and legally protected. Do not post these materials on any other website or online forums. The recording of the live/synchronous sessions of the course without the permission from the instructor is prohibited. The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

CHEATING, PLAGIARISM/ACADEMIC OFFENCES

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence at the following website: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

CONDUCT

Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

HEALTH/WELLNESS SERVICES

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services

to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at <http://www.health.uwo.ca/>.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Faculty of Engineering has a Student Wellness Counsellor. Information on how to schedule an appointment with the counsellor is available at:

<https://www.eng.uwo.ca/undergraduate/academic-support-and-accommodations/Student-Wellness-Counselling.html>

Students who are in emotional/mental distress should refer to Mental Health@Western: <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

SICKNESS

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Students who are not able to meet certain academic responsibilities due to medical, compassionate or other legitimate reason(s), could request for academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at:

<https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.html>

ACCESSIBLE EDUCATION WESTERN (AEW)

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction. on regarding an accommodation.