Western University
Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9577– Rock Mechanics

COURSE OUTLINE Winter 2023

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.

PREREQUISITES
Bachelor’s degree in Civil, Mining, or Geological Engineering.

TOPICS

<table>
<thead>
<tr>
<th>Topic #</th>
<th>Description</th>
<th>Learning Activities</th>
<th>Tentative timeline</th>
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</thead>
<tbody>
<tr>
<td>1: Introduction (Chapter 1-2 in Hudson &amp; Harrison)</td>
<td>Geological considerations: - What is rock mechanics? - Effect of water, heat, temperature, stress - Jointed vs intact rock - Anisotropy - Time effects</td>
<td>• Powerpoint lectures • Assignment 1 (written problem set) • Zoom office hours</td>
<td>Week 1</td>
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<tr>
<td>2: Stress-strain (Chapter 3, 5 in Hudson &amp; Harrison; chapter 2 in Jaeger-Cook-Zimmerman)</td>
<td>- Scalar vs vector vs tensor - Force -&gt; stress - Stress rotation (no shear on surface) - Mohr’s circle - Principal stress - Stress invariants - Normal and shear stress/strain</td>
<td>• Chalk and talk lectures • Assignment 1 (written problem set) • Zoom office hours</td>
<td>Week 2</td>
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<tr>
<td>3: In-situ stress (Chapter 4 in Hudson &amp; Harrison)</td>
<td>- Why in-situ stress? - k = σh/σv - Stress measurement: flatjack, hydraulic fracturing, USBM, CSIRO - World stress map</td>
<td>• Chalk and talk lectures • USBM demonstration • Assignment 2 (written problem set) • Zoom office hours</td>
<td>Week 3</td>
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<tr>
<td>Assignment 1 Due, Assignment 2 Posted</td>
<td>4: Intact rock strength and rock fracture mechanics (Chapter 6 in Hudson &amp; Harrison; chapter 4, 6 in Jaeger-Zimmer-Cook)</td>
<td>- Mohr-Coulomb - Hoek-Brown - Mode I, II, III - Griffith's criterion - Intact testing (UCS) - Tensile strength testing</td>
<td>• Chalk and talk lectures • Assignment 2 (written problem set) • Zoom office hours</td>
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<tr>
<td>5: Wave propagation in rocks and rock physics (Chapter 13 in Hudson &amp; Harrison; chapter 11 in Jaeger-Zimmerman-Cook)</td>
<td>- P-wave, S-wave, Surface wave - Effects of density, porosity, pore pressure, clay</td>
<td>• Powerpoint lectures • Assignment 3 (written problem set with lab component) • Zoom office hours</td>
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<td>Assignment 2 Due, Assignment 3 Posted</td>
<td>6: Joint statistics and joint strength (Chapter 7 in Hudson &amp; Harrison; chapter 3 in Jaeger-Zimmer-Cook; Chapter 5 in Wyllie)</td>
<td>- What is a “joint”? - Joint spacing - Joint aperture - Joint persistence - Joint roughness - JRC - RQD - Shear box testing</td>
<td>• Powerpoint lectures • Assignment 3 (written problem set) • Zoom office hours</td>
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<tr>
<td>Reading week, no class</td>
<td>7: Empirical rock quality criterion (Chapter 7, 12 in Hudson &amp; Harrison)</td>
<td>- CHILE vs DIANE materials - JRC - RMR - Q - GSI</td>
<td>• Powerpoint lectures • Assignment 3 (written problem set) • Zoom office hours</td>
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<tr>
<td>8: Stereonets (Appendix B in Hudson &amp; Harrison; chapter 2, 4, Appendix I in Wyllie)</td>
<td>- What is a stereonet? - Great circles - Small circles - Poles - Intersection of planes - Vector bisectors - Rotation</td>
<td></td>
<td>• Chalk and talk lectures + demo • Assignment 4 (written problem set with stereonet and software components) • Zoom office hours</td>
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<tr>
<td>Assignment 3 Due, Assignment 4 Posted</td>
<td>9: Instability mechanisms in jointed rock (Chapters 17-19 in Hudson &amp; Harrison;</td>
<td>- Rockfall - Slope stability - Toppling - Wedge stability</td>
<td>• Chalk and talk lectures • Assignment 4 (written problem set with</td>
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<tr>
<td>Take-home midterm exam, covering material up to topic 7.</td>
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### Chapters 7, 8, 10 in Wyllie)
- Definitions
- Flow through single fracture
- Flow through fracture networks
- Corrosion

### Stereonet and software components
- Zoom office hours

### 10: Fluid-rock interactions
(Chapter 9 in Hudson & Harrison; chapter 7, 12 in Jaeger-Cook-Zimmerman, chapter 6 in Wyllie)
- Rock bolt support
- Blasting
- Grouting

### 11: Rock engineering
(Chapters 15, 16 in Hudson & Harrison; chapters 13-14 in Wyllie)
- Interaction matrix
- Sensitivity analysis
- Probabilistic analysis
- Monte Carlo simulation

### Assignment 4 Due, Assignment 5 Posted
- Powerpoint lectures
- Assignment 5 (written problem set with software component)
- Zoom office hours

### 12: Risk analysis
(Chapter 14 in Hudson & Harrison)
- Powerpoint lectures
- Assignment 5 (written problem set with software component)
- Zoom office hours

### Assignment 5 Due

### Take-home final exam

### SPECIFIC LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Degree Level Expectation</th>
<th>Weight</th>
<th>Assessment Tools</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Depth and breadth of knowledge</td>
<td>40%</td>
<td>Assignments, Examinations</td>
<td>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</td>
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<tr>
<td>Application of knowledge</td>
<td>40%</td>
<td>Assignments, Examinations</td>
<td>Ability to apply knowledge in a rational way to analyze a particular problem, Ability to use coherent approach to design a particular engineering system using existing design tools</td>
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<tr>
<td>Professional capacity / autonomy</td>
<td>5%</td>
<td>Assignments</td>
<td>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</td>
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<tr>
<td>Awareness of limits of knowledge</td>
<td>15%</td>
<td>Assignments, Examinations</td>
<td>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</td>
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# ASSESSMENTS

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Material Covered</th>
<th>Tentative Due Date</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Assignment 1 (written problem set)</td>
<td>Topics 1-2</td>
<td>23 Jan 2023</td>
<td>7%</td>
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<tr>
<td>Assignment 2 (written problem set)</td>
<td>Topics 3-4</td>
<td>6 Feb 2023</td>
<td>7%</td>
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<tr>
<td>Assignment 3 (written problem set)</td>
<td>Topics 5-7</td>
<td>6 Mar 2023</td>
<td>12%</td>
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<tr>
<td>Assignment 4 (software component)</td>
<td>Topics 8-9</td>
<td>20 Mar 2023</td>
<td>12%</td>
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<tr>
<td>Assignment 5 (software component)</td>
<td>Topics 10-12</td>
<td>3 Apr 2023</td>
<td>12%</td>
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<tr>
<td>Midterm exam (take-home, open book)</td>
<td>Topics 1-7</td>
<td>8 March 2023</td>
<td>20%</td>
</tr>
<tr>
<td>Final exam (take-home, open book)</td>
<td>All</td>
<td>Exam period</td>
<td>30%</td>
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**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 INFORMATION

Course instructor: Bing Li
Email address: bing.li@uwo.ca

Contact policy:
- Contact instructor via email (above) or through messages in OWL
- Weekly Office hours are held via Zoom
- 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


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.

COMPUTING
The assignments will involve computer modelling of structures using the commercial programs Slope/W and Sigma/W from Geostudio. The full version of the programs is available at the PC lab in the Engineering building. Remote access to the computer lab and the software license servers will be provided. Instructions on how to remotely access the software license will be posted on course OWL site.

COURSE DELIVERY WITH RESPECT TO THE COVID-19 PANDEMIC
Although the intent is for this course to be delivered in-person, the changing COVID-19 landscape may necessitate some or all of the course to be delivered online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any assessments affected will be conducted online as determined by the course instructor.

When deemed necessary, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western’s Remote Proctoring website at: https://remoteproctoring.uwo.ca.

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 under “Assessments” 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 (see Western's scholastic discipline regulations for graduate students).
SYNCHRONOUS LEARNING ACTIVITIES
Students are expected to participate in synchronous learning activities as outlined in the course syllabus and/or described by the instructor. If you have issues that will impede your ability to participate in synchronous activities, please discuss with the course instructor at the beginning of the course.

CONDUCT
Students are expected to follow proper etiquette during synchronous and asynchronous activities to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in the synchronous and asynchronous learning activities and/or is not following the rules and responsibilities associated with the online learning 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
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 (remotely accessible) 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. Campus mental health resources may be found at http://www.health.uwo.ca/mental_health/resources.html https://www.uwo.ca/health/psych/index.html

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.

ACCESSIBILITY
Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at 661-2111 x 82147 or http://academicsupport.uwo.ca/accessible_education/index.html, for any specific question regarding an accommodation.