Fall 2019

CE 645-101: Rock Mechanics

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CIVIL AND ENVIRONMENTAL ENGINEERING

NJIT New Jersey Institute of Technology

CE 645 – Rock Mechanics **Fall 2019**
Section: 101

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Office Hours: Mondays, Tuesdays 4.30pm-6pm

Prerequisite: CE 342. Restriction: approved undergraduate course in soil mechanics within last five years or permission of instructor. Theoretical and experimental aspects of rock mechanics and rock engineering. Review of laboratory and field rock testing; empirical and analytical methods for describing strength, deformability and conductivity of intact rock and rock masses. Fracture mechanics and mechanics of discontinuous media, including flow through discontinuous media and hydraulic fracturing. Design and analysis of rock slopes, underground structures in rock and foundations on rock. Includes a term paper/design project.

Required Textbook

Goodman, R. E. (1989), Introduction to Rock Mechanics, 2nd Edition, John Wiley and Sons, ISBN#: 978-0-471-81200-5

Other Recommended Texts & Reading

Jaeger, J.C., Cook, N.G.W., Zimmerman, R.W. (2007), Fundamentals of Rock Mechanics, 4th Edition, Blackwell Publishing, ISBN#: 978-0-632-05759-7

Hoek, E., Bray, J.W. (1981), Rock Slope Engineering, 3rd Edition, ISBN#: 978-0-419-16010-6

Willey, D., (2018) Rock Slope Stability: Civil Applications, 5th Edition, CRC Press, ISBN#: 978-1498786270

Course Description *(from NJIT's course catalog)*

Theoretical and experimental aspects of rock mechanics and rock engineering. Review of laboratory and field rock testing; empirical and analytical methods for describing strength, deformability and conductivity of intact rock and rock masses. Fracture mechanics and mechanics of discontinuous media, including flow through discontinuous media and hydraulic fracturing. Design and analysis of rock slopes, underground structures in rock and foundations on rock.

Course Objectives (General)

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

Properties of intact rock and rock masses: Distinguish between intact rock and rock masses. Prescribe laboratory and field tests to determine strength, deformability, permeability and state of stress of intact rocks and rock masses.

Rock fractures: Prescribe field and laboratory tests to estimate the roughness and attitude of rock fractures. Use stereographic projection to represent fractures.

Rock slope stability: Identify failure mechanisms and determine safety of rock slopes and design measures to stabilize them.

Underground openings: Design underground openings in rock, including grouting, rock bolts and anchors.

POLICIES & PROCEDURES

Academic Integrity: It is expected that NJIT's University Code on Academic Integrity will be followed in all matters related to this course. Refer to NJIT's Dean of Students website to become familiar with the Code on Academic Integrity and how to avoid Code violations.
https://www.njit.edu/policies/sites/policies/files/academic-integrity-code.pdf

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. **Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university.** If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu

Communication: All communications by the instructor will be during the class and via e-mail. It is your responsibility to check your e-mail regularly. If you prefer to use a private e-mail account, please inform the instructor.

Lectures/Class: Attendance to all lecture/class periods is expected. Absence of 3 or more classes will result in a failing grade for the course. During the class instructor will often ask you to work on a problem or brainstorm ideas with the people next to you and you will be called on to provide one or more of your answers. The goal of this in-class work is to get you started on a problem (not necessarily finish) that will then be discussed. Please turn off your cell phones during class.

Homework: It is expected that all homework be presented in an organized manner; use green, yellow or white engineering paper, one side of each page (clear side, not grid side); begin each problem on a new page and number all pages; staple all homework pages together and have your name written clearly on the front page. Some homework assignments will also require tracing paper.

Homework Format: Homework questions will be graded in terms of a ten point scheme based on three categories of format, concept, and execution. All homework questions will be equally weighted in determining your final homework grade.

Format

One (1) point will be awarded if the solution is formatted with a problem statement and a statement on what is required in the solution

One (1) additional point will be awarded if the engineering solution is presented in an organized and neat fashion that is easy to follow along.

One (1) additional point will be awarded if the solution is completed with a boxed-in answer, including a properly formatted drawing if it is requested in the problem statement.

Concept

One (1) point will be awarded if the solution has major errors in the conceptual basis of the solution.

Two (2) points will be awarded if the solution has minor errors in the conceptual basis of the solution.

Three (3) points will be awarded if the solution has no errors in the conceptual basis of the solution.

Execution

One (1) point will be awarded if the solution has two or more math or execution errors.

Three (3) points will be awarded if the solution has one math or execution error.

Four (4) points will be awarded if the solution has zero math or execution errors.

Late Homework: Homework will be due at the beginning of class on the date it is due. Late Homework will be accepted up to two days after the due date with a 10% reduction for each day that it is late. After that time they will not be accepted. The late homework should be turned in to the Instructor by 5pm.

Homework Solutions: Homework solutions will be posted two days after the homework is due. It is your responsibility to make sure you understand how to solve the problems by attending office hours with the instructor and/or asking questions in class. As with many engineering problems, multiple solutions may be possible. This means that all rational solutions to the assignments will be accepted.

Exams: There will be one midterm exam held during class time and one comprehensive final exam as scheduled by the University Registrar.

Term Paper: There will be a term paper that should be done in groups of two students, and should have 12-15 pages, in addition to the reference list. Figures must be used to clarify written concepts and explanations. The term paper must discuss an engineering failure related to Rock Mechanics (e.g. failure of dam foundation, rock slope, mine, tunnel). The purpose of the term paper is to 1) provide the students with the opportunity to treat thoroughly a limited subject and to present their work in a clearly understandable and technically well-founded manner, 2) give the students the opportunity and experience in integrating their knowledge of several areas, 3) develop the ability of the student in critically judging source material and 4) supplement the general information provided by the lectures with detailed information on a related subject.

Calculation of Course Grade: A weighted average grade will be calculated as follows:

25% - Homework
20% - Term paper
10% - Class Participation
20% - Midterm
25% - Final

The minimum requirements for final letter grades are as follows:

A = 90.0%, B+ = 85.0%, B = 80.0%, C+ = 75.0%, C = 70.0%, D = 65.0%, F < 60.0%

Grades are not curved in computing the final grade.

Instructor Commitment: You can expect the Instructor to be courteous, punctual, organized, and prepared for lecture and other class activities; to answer questions clearly; to be available during office hours or to notify you beforehand if office hours are moved; to provide a suitable guest lecturer or pre-recorded lecture when they are traveling or unavailable; and to grade uniformly and consistently.

Students with Documented Disabilities: NJIT is committed to providing students with documented disabilities equal access to programs and activities. If you have, or believe that you may have, a physical, medical, psychological, or learning disability that may require accommodations, please contact the Coordinator of Student Disability Services located in the Center for Counseling and Psychological Services, in Campbell Hall, Room 205, (973) 596-3414. Further information on disability services related to the self-identification, documentation and accommodation processes can be found on the webpage. at: (http://www.njit.edu/counseling/services/disabilities.php)

Course Schedule:

Week	Topic
1	Introduction and Index properties of rocks
2	Strength and deformability of intact rocks
3	Strength and deformability of intact rocks
4	Representation of fractures using stereographic projection
5	Fractures and discontinuities
6	Measuring properties of fractures and discontinuities
7	Midterm Examination

8	Properties of Rock Masses
9	Measuring Properties of Rock Masses
10	Rock Slope Stability
11	Rock Slope Stability
12	Design of Underground Openings
13	Methods of rock stabilization: bolts, anchors, grouting
14	Review class
15	Final Exam

CE 645 – Rock Mechanics

Strategies, Actions, Assignments	Assessment Measures	ABET Student Outcomes (1-7)	Program Educational Objectives
Student Learning Outcome 1: Interpret and prescribe laboratory and in-situ tests to determine rock and rock mass properties of interest to specific projects			
Students will learn intact rock behavior concepts, including its strength, deformability and permeability	Class/group discussions, homework and examinations.	1, 6, 7	
Students will learn rock mass behavior concepts, including its strength, deformability and permeability	Class/group discussions, homework and examinations.	1, 6, 7	
Students will apply concepts of intact rock and rock mass behavior to prescribe appropriate project-specific laboratory and in-situ tests	Homework and examinations.	1, 2, 6, 7	
Student Learning Outcome 2: Use stereographic projection to represent fractures/joints and calculate their poles and intersection lines			
Students will learn the principles of stereographic projection to represent rock joints	Homework and examinations.	1	
Students will use stereographic projection to represent rock joints and identify joint sets	Homework and examinations.	1, 2	
Student Learning Outcome 3: Apply principles of rock mechanics in the evaluation of the stability of rock slopes and underground openings and design measures to stabilize them			
Students will use rock mechanics concepts in the assessment of rock slope stability	Class discussion, homework, term paper and examinations.	1, 2, 4, 6, 7	
Students will use rock mechanics concepts in the design of underground openings	Class discussion, homework, term paper and examinations.	1, 2, 4, 6, 7	
Students will design methods to stabilize rock slopes and underground openings, including grouting, bolting and anchoring	Class discussion, homework, term paper and examinations.	1, 2, 3, 4, 5, 6, 7	

CEE Mission, Program Educational Objectives and Student Outcomes

The mission of the Department of Civil and Environmental Engineering is:

- to educate a diverse student body to be employed in the engineering profession
- to encourage research and scholarship among our faculty and students
- to promote service to the engineering profession and society

Our program educational objectives are reflected in the achievements of our recent alumni:

1 – Engineering Practice: Alumni will successfully engage in the practice of civil engineering within industry, government, and private practice, working toward sustainable solutions in a wide array of technical specialties including construction, environmental, geotechnical, structural, transportation, and water resources.

2 – Professional Growth: Alumni will advance their skills through professional growth and development activities such as graduate study in engineering, research and development, professional registration and continuing education; some graduates will transition into other professional fields such as business and law through further education.

3 – Service: Alumni will perform service to society and the engineering profession through membership and participation in professional societies, government, educational institutions, civic organizations, charitable giving and other humanitarian endeavors.

Our Student Outcomes are what students are expected to know and be able to do by the time of their graduation:

1. an ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics
2. 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
3. an ability to communicate effectively with a range of audiences
4. 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
5. 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
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Revised: 2/13/18