GEOL 314
Engineering Geology

Fall 2016

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Office hours: MW 11 am - 12 pm, or by arrangement.

Introduction

GEOL 314 focuses on the core activities of engineering geologists – site characterization and geologic hazard identification and mitigation. Through lectures, labs, and case study examination you will learn to couple your geologic expertise with the engineering properties of rock and unconsolidated materials in the characterization of geologic sites for civil work projects and the quantification of processes such as rock slides, soil-slope stability, settlement, and liquefaction.

Engineering geology is an applied geology discipline that involves the collection, analysis, and interpretation of geological data and information required for the safe development of civil works. Engineering geology also includes the assessment and mitigation of geologic hazards such earthquakes, landslides, flooding; the assessment of timber harvesting impacts; and groundwater remediation and resource evaluation. Engineering geologists are applied geoscientists with an awareness of engineering principles and practice—they are not engineers. In states that require professional licensing (e.g., Washington, Oregon, and California) these practitioners become Licensed Engineering Geologists (LEGs), not Professional Engineers (PEs) like geological engineers and geotechnical engineers

Course Structure

We will focus on the mechanics of Earth materials and how they respond to forces and stresses. In the first half of the course we will discuss rock mechanics, and how to characterize the susceptibility of rock mass sites to failure. You will learn how to assess rock-mass quality, perform kinematic analyses, and analyze rock-slope stability (sliding and topples). In the second half of the course we will cover the mechanics of unconsolidated materials (soils) as applied to processes such consolidation/settlement, subsidence, liquefaction, compaction, and soil slope stability. You will also be introduced to common methods used in geotechnical engineering such as the Unified Soil Classification System and the American Society for Testing Materials (ASTM) standards (e.g., Atterberg limits and Proctor tests). Please see the lecture topics below.

To convey these concepts we will have a combination of lectures (3 hours per week;) and labs (2 hours per week). The labs will emphasize material testing and analysis, employ ArcGIS techniques for site characterization, and utilize a software package called Rocscience for analyzing rock masses, rock slope stability, consolidation and settlement, and soil-slope stability. Please see the lab topics below.

My **course outcomes and learning objectives** for GEOL 314 outlined on the last page of the syllabus.

Reading Material

There is not a required textbook for the course. Some recommended engineering geology textbooks include:

Geological Engineering, Luis I. González de Vallejo and Mercedes Ferrer, CRC Press, 2011

Engineering Geology: An Environmental Approach, Perry H. Rahm, 2nd Ed, Prentice Hall, 1996.

Geotechnical Engineering: Principles and Practice, Donald P. Coduto et al., 2nd Ed, Pearson, 2011.

Some online resources include:

Geotechnical Engineering Circular No. 5: Evaluation of Soil and Rock Properties, P.J. Sabatini, R.C. Bachus, P.W. Mayne, J.A. Schneider, T.E. Zettler. Report No. FHWA-IF-02-034.

Geotechnical Design Manual, Washington State Department of Transportation, Pub. No. M 46-03.10.

Engineering Geology Field Manual, U.S. Bureau of Reclamation.

Assessment

Labs and Problem Sets

There will be weekly two-hour labs that will include a mix of ArcGIS exercises, material testing and data analysis, software applications using Rocscience, and case studies presented by local professionals. The lab topics are listed below. In addition to the lab exercises you will be given problem sets that are very much like those encountered in physics, only they have geological meaning. The lab exercises and problem sets enforce the theory and develop problem solving skills and critical thinking. I do not require the memorization of equations; therefore, I provide an equation sheet that is updated throughout the quarter for exercises and exams. Labs and problem sets turned in after class on the due date will be deducted 5%, and 10% for each day they are late.

Exams

I give two exams during the quarter and a comprehensive final exam. The exams represent 75% of the grade. I expect you to understand a concept both conceptually and quantitatively, therefore, my exams tend to be a mix of concept description and problem solving using equation identification and manipulation. I provide an equation sheet with each exam, which is the same version of the one used for the problem sets, so your familiarity with the equation sheet becomes essential. I also provide a study guide prior to an exam summarizing the essential concepts I expect you to understand.

You will be required to take all exams at the scheduled times. Make-up exams will be given only in the case of official prearranged absences or emergencies. An excused absence form from the office of Student Affairs is required.

The grading break down will be as follows:

Lab and Problem Sets…25 %
Exam 1……..25%
Exam 2……..25%
Final Exam……25% (Thursday, December 8, 8:00-10:00am)

A grading scale will be as follows (a curve is possible but not certain):
100-93 = A, 92-90 = A-, 89-88 = B+, 87-83 = B, 82-80 = B-, 79-78 = C+, 77-73 = C, 72-70 = C-, 69-68 = D+, 67-63 = D, 62-60 = D-, 60 or below = F

Academic honesty is an important part of every course at WWU. For students, academic integrity means challenging yourself, striving for excellence, taking risks and learning from your mistakes, doing your own work, and giving credit whenever you use the work of others. It boils down to caring about your schoolwork and always being honest in carrying it out.

I begin with the assumption that you come to Western and this class with integrity. However, academic integrity and honesty can be challenging due to such things as ignorance, confusion, stress, bad advice, and bad choices. So to help you keep your integrity and good reputation intact, I have resources for you (meaning, by the way, that ignorance will not be an excuse):

- WWU's Integrity Website http://www.wwu.edu/integrity/ provides all the information you need, including why integrity is important, how to promote it, as well as types of academic dishonesty and how to avoid them, particularly plagiarism. It also includes WWU's policy and procedures on academic honesty (appendix D of the WWU Catalog).

- See me if you have any concerns or questions about academic integrity regarding yourself or your classmates. An ounce of prevention is worth a pound of cure, especially where penalties and one's reputation are at stake. I am here to help. Please read the Integrity section

Attendance is not required but it is expected. It is your responsibility to get notes for the classes you miss. I encourage you to visit my office for help and clarification, but do not use my office hours to obtain lecture material that you miss (unless you have an excused absence).

Your academic success and support services

Please feel free to talk to me about your performance in the course or possible ways you can improve. You can meet with me during my scheduled office hours, MW 10:00-11:00 a.m., or by appointment at another meeting time, which you can request in class or by email. *Please be aware that I will NOT read or reply to student emails outside of Monday-Friday between the hours of 9 a.m. and 5 p.m.*

If you need disability-related accommodations, please notify Disability Resources for Students at 650-3083 (phone); 650-3725 (TTY); email drs@wwu.edu; or on the web at http://www.wwu.edu/depts/drs/. Reasonable accommodation for persons with documented disabilities should be established within the first week of class and arranged through Disability Resources for Students.

Western encourages students to seek assistance and support at the onset of an illness, difficulty, or crisis.

- In the case of a medical concern or question, please contact the Health Center: 650-3400 or visit http://www.wwu.edu/chw/student_health/
- In the case of an emotional or psychological concern or question, please contact the Counseling Center: 650-3400 or visit http://www.wwu.edu/counseling/
- In the case of a health and safety concern, please contact the University Police: 650-3555 or visit http://www.wwu.edu/ps/police/
- In the case of a family or personal crisis or emergency, please contact the Dean of Students: 650-3450 or visit http://www.wwu.edu/depts/dos/
- To seek confidential support related to sexual violence, please contact Consultation & Sexual Assault Support (CASAS): 650-3700 or visit http://www.wwu.edu/pws/about_casas.shtml, or contact the Student Health Center, and/or the Counseling Center.
- To report sexual violence, please contact University Police, Bellingham Police, and/or the Title IX Coordinator in Western's Equal Opportunity Office: 650-3307 or visit

http://www.wwu.edu/depts/eoo/. Faculty are responsible employees who are required to report sex discrimination, including sexual violence that they learn about to the Title IX Coordinator.

Cellphones and texting

Please turn off all cellphones during class time – this includes text messaging. Under NO circumstances should a cell phone or pager ring or be answered during class. Under NO circumstances should you use your cell phone (i.e., text messaging, internet surfing) during class or exams.

If you are waiting for an important call, please let me know, but recognize that I may ask you to wait for your call outside. If your work situation requires that you be on call, please discuss this with me prior to class. If you use your cell phone during class FOR ANY REASON you will be asked to leave.

Other appropriate classroom conduct

During lecture, if you choose to talk with others outside of an instructor-led group discussion, you will be asked to leave. ***This means I will stop whatever I am doing, address you directly, and let you know that if you choose to continue talking, you will need to exit the classroom***. This is a learning environment where your classmates are making a huge investment in their future. Discourteous and disrespectful attitudes and behaviors toward me or your classmates will not be tolerated. If for whatever reason you must arrive late or leave early, please do so quietly and courteously. If you have to be late, take the first available seat you can find. If you have to leave early, select the least disruptive seat possible for your departure when you arrive. I WILL have a problem and address you directly if you consistently arrive late or leave early.

I am committed to establishing and maintaining a classroom climate that is inclusive and respectful for all students. Learning includes being able to voice a variety of perspectives, and classroom discussion is encouraged. While students' expressed ideas may vary and/or be opposed to one another, it is important for all of us to listen and engage respectively with each other.

I, and Western, are committed to an environment free of discrimination and harassment. Federal and State laws, as well as University policies, protect students, faculty and staff against discrimination based on the following legally protected characteristics: Race, Color, Creed, Religion, National Origin, Sex (including pregnancy and parent status), Age, Disability, Marital Status, Sexual Orientation, Gender Identity and Expression, Genetic Information and Veteran Status. (See Equal Opportunity and Western's Policies on Providing Equal Opportunity and Nondiscrimination and Preventing Sexual Harassment.)

Please note: I reserve the right to change the syllabus as required throughout the term to better meet the instructional needs of the class.

Geology 314 (Engineering Geology) provides information for the following degree/program outcomes:

	B.A. Geology	B.S. Geology	B.S. Geophysics	GUR
Outcomes	*2. Earth's surface is affected by dynamic processes on a range of timescales.* *3. Earth's composition varies and these compositions provide the raw materials for the rock cycle.* *4. Earth's interior is dynamic and drives plate tectonics* *5. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.* *6. Geology and society are fundamentally inter-related.* *7. Graduates have developed their observational, analytical and quantitative skills (field, lab, computer, and classroom)*	*2. Earth's surface is affected by dynamic processes on a range of timescales.* *3. Earth's composition varies and these compositions provide the raw materials for the rock cycle.* *4. Earth's interior is dynamic and drives plate tectonics* *5. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.* *6. Geology and society are fundamentally inter-related.* *7. Graduates have developed their observational, analytical and quantitative skills (field, lab, computer, and classroom)* *8. Graduates can create maps and understand what they tell us about the Earth.* *9. Graduates will be able to apply physics, chemistry, and mathematic concepts to the study of Earth.*	*2. Earth's surface is affected by dynamic processes on a range of timescales.* *3. Earth's composition varies and these compositions provide the raw materials for the rock cycle.* *4. Earth's interior is dynamic and drives plate tectonics* *5. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.* *6. Geology and society are fundamentally inter-related.* *7. Graduates have developed their observational, analytical and quantitative skills (field, lab, computer, and classroom)* *8. Graduates can create maps and understand what they tell us about the Earth.* *9. Graduates will be able to apply physics, chemistry, and mathematic concepts to the study of Earth.* *11. Graduates will be able to demonstrate general proficiency with concepts and quantitative problems involving Newtonian mechanics, energy and momentum.*	*1. Analyze and communicate ideas effectively in oral, written, and visual forms.* *3. Use quantitative and scientific reasoning to frame and solve problems.*

GEOL 314 - Engineering Geology Lecture Topics

Course Design: Lectures and Labs will follow this general sequence, subject to modification as needed.

WEEK/CONCEPT	LECTURE TOPIC	LAB TOPIC
Week 1 – 9/23 Introduction and Terrain Analysis	Introduction – definition of engineering geology Site Characterization	Lab 1 – 9/23 ArcGIS exercise: site characterization
Week 2 – 9/26 Rock Mechanics I	Bulk properties of rock—porosity, bulk density, unit weight, moist density 1-D stress and strain—compression and tension Geostatic stress and Bulk Modulus	Lab 2 – 9/30 Rock mass quality analysis and RQD data
Week 3 – 10/3 Rock Mechanics II	Mining room and pillar analysis—introduction of the factor of safety (FS) Shear stress and strain Elastic properties and seismic velocities	Lab 3 – 10/7 Stereographic projection
Week 4 – 10/10 Mass Movement I	Translational slides—forces & FS Translational slides—stresses & FS Translational slides—engineered slopes Translational slides—road cuts Topples—moments	Lab 4 – 10/14 Kinematic analysis
	EXAM 1	
Week 5 – 10/17 Soil Mechanics I – Soil Texture and Soil Moisture	Soils introduction Soil classification—coarse fraction & the Unified Soil Classification System (USCS) Engineering properties of clays (sensitivity—quick clays) Soil classification—fine fraction, plasticity & Atterberg Limits	Lab 5 – 10/21 USCS coarse fraction classification
Week 6 – 10/24 Soil Mechanics II – Engineering Properties	Induced Stress Effective Stress Consolidation—settlement and compression index (C_c) Consolidation—rates (permeability)	Lab 6 – 10/28 USCS fine fraction classification
Week 7 – 10/31 Soil Mechanics III – Engineering Properties	Liquefaction Compaction Soil shear strength—triaxial test and Mohr's circles	Lab 7 – 11/4 Consolidation & Sediment
	EXAM 2	
Week 8 – 11/7 Week 9 – 11/14 Mass Movement II	Infinite slopes Rotational slides—moments Rotational slides—method of slices Rotational slides—vegetation and triggers Rotational slides—mitigation	Lab 8 – 11/11 ArcGIS Exercise: Infinite Slope Lab 9 – 11/18 Rotational Failures
Week 10 – 11/21 Week 11 – 11/28 Seismic Risk	Earthquake ground shaking and NEHRP data Role of the Geoscientist in Disaster Risk Reduction	Lab 10 – 12/2 Seismic Design Categories

GEOL 314 - Engineering Geology Lab Topics

1. ArcGIS exercise: introduction to site characterization and geologic hazards in Whatcom County, WA.

2. I-90 Design Sector VI rock mass quality analysis using intact rock, core recovery, and rock quality designation (RQD) data.

3. I-90 Design Sector VI stereographic projection of discontinuity data using Rocscience Dips software.

4. I-90 Design Sector VI kinematic analysis using discontinuity data and slope face orientations and Rocscience Dips software.

5. Soil classification and the Unified Soil Classification System –determining the group symbol and group name of the course fraction resulting from sieve analyses.

6. Soil classification and the Unified Soil Classification System – determining the plastic and liquid limit (Atterberg Limits) of the fine fraction of a soil.

7. Consolidation and Settlement – case study examples and using Rocscience Settle3D software.

8. ArcGIS exercise: using model builder in ArcGIS to examine infinite slope landslide susceptibility in the Smith Creek basin in the Lake Whatcom watershed.

9. Analysis of the Jones Creek deep-seated rotational Landslide in Whatcom County using Rocscience Slide software.

10. Seismic Design Categories – use USGS web tools and DNR maps to examine the seismic design categories of site in Washington State.

GEOL 314 - Engineering Geology Course Outcomes and Objectives

Course Outcomes	Course Objectives
Students will understand:	Students will be able to:
1. Site characterization and how to collect, analyze, and report geologic data using standards in engineering practice (e.g., ASTM methods).	1.1 Use ArcGIS to examine geology, soil, geologic hazard, and NEHRP data to characterize a geologic site.
2. The fundamentals of the engineering properties of Earth materials and fluids.	2.1 Calculate the bulk properties of rocks and unconsolidated sediments such as density, void ratio, water contents, and unit weights. 2.2 Estimate rock strength from stress, stain, and elastic quantities from unconfined compression or tension test.
3. Rock mass characterization and the mechanics of planar rock slides and topples.	3.1 Evaluate rock-mass quality and perform a kinematic analysis. 3.2 Apply the factor of safety equation to solve planar rock slide and toppling problems.
4. Soil characterization and the Unified Soil Classification System.	4.1 Perform a grain-size analysis, determine plastic and liquid limits, and classify soils using the Unified Soil Classification System.
5. The mechanics of soils and fluids and their influence on settlement, liquefaction, and soil slope stability.	5.1 Calculate soil consolidation magnitudes and rates under induced stress conditions. 5.2 Determine soil strength parameters from in situ tests. 5.3 Apply the method of slices and factor of safety equation to solve rotational slide problems.