COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

Department of Civil Engineering and Engineering Mechanics
Soil Mechanics CIEN 3141: Spring 2015

CLASS SESSIONS
Lecture: Tuesday and Thursday, 11:40 – 12:55pm, TBA
Lab Session: Monday OR Wednesday, 1:10-2:25pm 233 Mudd

INSTRUCTOR
Professor: Dr. Steve WaiChing Sun, 614 Mudd, wsun@columbia.edu
Office Hour: Friday 2:00-4:00PM or by appointment

TEACHING ASSISTANTS
Mr. SeonHong Na, 641 Mudd, sn2605@columbia.edu
TBA or by appointment

TEXTBOOK
We will use the textbook written by Holtz, Kovacs and Sheahan as textbook.

[HK] *An Introduction to Geotechnical Engineering*, R.D. Holtz, W.D. Kovacs, T.C. Sheahan, Prentice Hall, 2nd edition, 2010

The other two textbooks listed below are highly recommended but not required.

[W] *Soil Mechanics*, T.H. Wu, Allyn & Bacon, 2nd edition, 1976
[LW] *Soil Mechanics*, T.W. Lambe and R.V. Whitman, John Wiley & Sons, 1979

COURSE DESCRIPTION
The objective of this course is to present the fundamental principles of soil mechanics that are essential for engineering practice and to prepare students for more advanced study on geotechnical engineering and geomechanics. We will cover a selected number of topics, including but not limited to index properties, soil classification, compaction, shear strength of dry and saturated soil, one dimensional consolidation and slope stability.

PREREQUISITES
ENME E3133 or equivalent course(s). Basic understanding on linear algebra.

COURSE LEARNING OBJECTIVES
Students who successfully complete this course will be able to:
- Develop a basic understanding of the engineering properties of soils as multiphase materials.
- Learn and apply basic analytical methods and techniques through a series of exercises.
- Understand and appreciate the techniques and approximation used by practicing engineers.
- Master the essential skills to conduct laboratory tests and interpret experiential data.

ASSESSMENT AND GRADING POLICY
Student grades will be based on:
Laboratories 20%
Homework 20%
Two Midterm Exams 30%
Final Exam 30%

COURSE OUTLINE

- Overview and brief history of geotechnical engineering
    - Historical background
    - Basic definition
    - Index and classification properties of soil
    - Compaction
- Hydraulic properties of soil
    - Permeability and seepage of porous media
    - Darcy's law
    - Permeability estimation
    - Flow nets
- Mechanical properties of soil
    - Mohr's circle, Stress at a point
    - Shear strength of drained soil
    - Mohr-Coulomb failure criteria
    - Lateral pressures and retaining structures
- Hydro-mechanical properties of soil
    - Effective stress theory
    - One-dimensional consolidation
    - Undrained responses of soil
    - Slope Stability

LABORATORY SESSIONS

Laboratories will be held in Mudd 233. Lab reports from each individual student will be due exactly one week after the lab session. Lab attendance is compulsory. Students are required to attend one of the two lab sessions on Monday OR Wednesday. Fail to attend any of the lab session and/or submit lab report will result in a failing grade. No made-up lab session will be given.

1. Grain size analysis
2. Atterberg limits
3. Constant head permeability test
4. Drained shear test
5. Undrained triaxial compression test

EXAMINATION

Two mid-term exams will be given. Each of them will weight 15% of the total grades. A comprehensive three-hour final exam will be given during the final week. All exams will be closed book.

HOMEWORK

One homework assignment will be given (approximately) every two weeks. There will be 7 homework assignments. They will be due in class exactly one-week after the assignment is given. Late homework and lab reports will receive a 50% penalty if submitted within one week after deadline, and will not be accepted thereafter under any circumstance.

POLICIES AND EXPECTATIONS

Academic Integrity
Students are required to adhere to the Codes of Conduct, Community Standard and Academic Integrity, available online at http://apam.columbia.edu/files/seasdepts/applied-physics-and-applied-math/pdf-files/SEAS_conduct.pdf

Disability Access
In order to receive disability-related academic accommodations, students must first be registered with the Office of Disability Services (ODS). Students who have, or think they may have a disability are invited to contact ODS for a confidential discussion at 212.854.2388 (V) 212.854.2378 (TTY), or by email at disability@columbia.edu. If you have already registered with ODS, please speak to your instructor to ensure that s/he has been notified of your recommended accommodations by Lillian Morales (lm31@columbia.edu), the School's liaison to the Office of Disability Services.

COURSE SCHEDULE

Session 1 – Introduction
Topic: motivation; brief history of soil mechanics; soil formation, phase diagram, phase relationships Assignment: None Suggested Reading: W: 1.1; H:1.1-1.3

Session 2 – Soil Composition, index properties and classification
Topic: index properties; grain size distribution, Atterberg limits, soil classification Assignment: Homework 1 Suggested Reading: W: 1.2-1.6, 1.8-1.9; H:2.1-2.8

Session 3 – Compaction
Topic: relative density, soil improvement, compaction tests Lab Session: Grain size analysis Suggested Reading: W: 1.7, H:5.1:5.7

Session 4 – Dry soil as single-phase materials

Topic: Stress at a point, general state of stress, principal stress, elasticity, tests to measure stress-strain properties, shear strength of cohesion-less soil

Assignment: Homework 2
Suggested Reading: W: 4.1, 4.4, 4.5, 8.1-8.4; H:10.1-10.6

Session 5 – Lateral earth pressure

Topic: types and usages of retaining walls, Rankine theory, wall friction

Assignment: Homework 3

Suggested Reading: W: 9.1-9.3, 10.1-10.5

Session 6 – Effective stress and capillarity

Topic: effective stress principle, hydrostatic stress, saturated and unsaturated porous media, capillary pressures

Assignment: Homework 4

Suggested Reading: W: 2.1-2.3, 2.7-2.9; H:7.5-7.6

Session 7 – Hydraulic properties of soil

Topic: One-dimensional flow, concepts of potential head

Lab Session: Atterberg limits

Suggested Reading: W: 3.1-3.5; H:7.1-7.4

Session 8 – Darcy'a law

Topic: Darcy's law, hydraulic test to estimate effective permeability, Laplace's equation

Midterm 1

Session 9 – Flow net and factors that affects permeability

Topic: graphical method for Laplace's equation, Kozeny-Carman relation, porosity-permeability relation, fabric changes, empirical relations, relative permeability

Lab Session: Constant head permeability test

Session 10 – Poro-elasticity

Topic: three-dimensional elastic consolidation theory, Centrifuge Lab Tour

Assignment: Homework 5

Suggested Reading: Poro-elasticity notes; W:4.6

Session 11 – Consolidation

Topic: one-dimensional consolidation, consolidation curve, compression index, swelling index, pre-consolidation stress, secondary compression

Assignment: Homework 6

Suggested Reading: W:5.1-5.7; H:8.1-8.12

Session 12 – Shear strength of undrained soil

Topic: effective stress-strain behavior, undrained shear strength, stress paths of undrained soils, excess pore pressure

Lab Session: Direct shear test

Midterm 2

Suggested Reading: W:8.6-8.13; H:11.5

Session 13 – Estimation of deign shear strength in practice

Topic: Factors that affect shear strength of saturated clay, anisotropy, rate effect, an overview of common methods to estimate shear strength

Assignment: Homework 7

Suggested Reading: W: 8.13; H:11.6-11.8

Session 14 – Slope Stability and retaining wall revisited

Topic: Slope stability, earth retaining structure and earth slopes with undrained conditions, review session

Lab Session: Triaxial compression test

Suggested Reading: W:9.9-9.11, 10.7-10.9