MERRIMACK COLLEGE
Department of Civil Engineering

CEN 5024: SEISMOLOGICAL AND GEOTECHNICAL ASPECTS OF EARTHQUAKES

Course Syllabus, Spring 2018

I. Course Information

Instructor:
Name: James Kaklamanos, Ph.D. ("Professor Kaklamanos")
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Course details:
Name: CEN 5024: Seismological and Geotechnical Aspects of Earthquakes (4 cr.)
Class meeting times and location: Tuesday, 6–9:45 p.m.; Mendel 140
Prerequisites: CEN 3020 (Geotechnical Engineering) and MTH 2220 (Differential Equations)
Course website: <https://blackboard.merrimack.edu>

Course description (catalog): Study of the characterization of earthquake hazards, incorporating principles from engineering seismology, soil dynamics, and geotechnical earthquake engineering. Earthquake fundamentals, including plate tectonics, fault rupture mechanisms, and characterization of seismic sources. Theory of wave propagation and vibratory motion. Ground-motion models and probabilistic seismic hazard analysis. Dynamic soil behavior and influence of geologic materials on ground motions. Assessment of geotechnical effects of earthquakes, including site response, liquefaction, and seismic slope stability.

Course learning objectives:
Upon successful completion of this course, the student will be able to:
1. Apply the fundamental principles of seismology, physics, and soil mechanics to the characterization of earthquake hazards.
2. Describe significant earthquakes that have occurred throughout history and their implications.
3. Explain the causes of earthquakes and their effects.
4. Characterize seismic sources using parameters for earthquake magnitude and frequency.
5. Construct and explain seismic response spectra for simple structures.
6. Calculate ground motion parameters for an acceleration time series.
7. Interpret and predict ground motion parameters from ground motion models.
8. Assess the seismic hazard at a site using deterministic and probabilistic seismic hazard analyses.
9. Compute dynamic soil properties and the response of soil to cyclic loading.
10. Explain the influence of geologic materials on ground motions, and predict site-specific ground motions using site response analyses and design codes.
11. Evaluate the susceptibility of a site to seismically induced liquefaction and landslides.
12. Exemplify enhanced communication and research skills by completing a research project in engineering seismology or geotechnical earthquake engineering.

Topical outline:	*Number of two-hour sessions:*
1. Seismology and earthquakes	4 sessions
2. Vibratory motion and system response	4 sessions
3. Ground motion	4 sessions
4. Seismic hazard analysis	4 sessions
5. Soil dynamics and site response	5 sessions
6. Liquefaction and slope stability	5 sessions

Required course materials:

- **Textbook:** *Geotechnical Earthquake Engineering*, by Steven L. Kramer (1996). Prentice Hall: Upper Saddle River, New Jersey. ISBN: 978-0133749434.
- **Calculator:** A scientific/engineering calculator will be necessary for out-of-class assignments and in-class examinations. On exams in this course, you will be required to reset the calculators (clearing all memory) prior to using them in the exam room.
- **Additional materials:** An engineer's scale (or ruler), compass, and protractor are required.

II. Policies

Attendance:
Attendance at all class meetings is strongly recommended and will be rewarded, but attendance at class meetings is not mandatory. When present in class, you must arrive on time and behave in a professional manner (see the Professionalism section below); late arrivals and/or unprofessional behavior will result in a decreased course grade, as described in the Assessment section of the syllabus. If you miss class for any reason, you will be expected to confer with a classmate to obtain notes, announcements, and/or assignments that you miss.

Professionalism:
Professional behavior is expected in all aspects of this course, as professionalism is an essential characteristic of your future as a practicing engineer. Unprofessional behavior may negatively detract from the classroom environment and the learning experience of other students in the course, and will not be tolerated. Examples of unprofessional behavior may include, but are not limited to:

- Arriving late or leaving the classroom while class is in session (except for emergencies).
- Using mobile technology or personal electronic devices (e.g., cell phones, tablets, laptops, etc.) during class sessions. (Turn your cell phone off and place it out of sight before the beginning of the session, unless you receive my prior consent due to an extenuating circumstance.)
- Using derogatory, vulgar, or insulting language.
- Unsolicited talking in class.
- Sleeping in class.

Consequences for unprofessional behavior are described in the Assessment section of the syllabus. Remember that professional behavior extends to electronic communication as well. I will not reply to any emails that are unprofessional and/or lack a subject, salutation, body, and signature.

Late assignments:

- Homework submissions are due prior to the beginning of class on the due date; once class has begun, you will not be allowed to submit your work. Late homework submissions will not be accepted in this course, as they are usually not accepted in engineering practice. In the case of bids on contracts, late bids are rejected if even one minute late, resulting in the loss of employment opportunities for a firm and perhaps the subsequent loss of individual employment.

- The research paper submission is the only course assignment that will be accepted after the due date, although I hope you plan your time and efforts to avoid this. A late penalty will be applied to your submission grade according to the following schedule: 0-24 hours late = reduction of one full letter grade; 24-48 hours late = reduction of two full letter grades; 48-72 hours late = reduction of three full letter grades. Research paper submissions will receive zero credit if submitted more than 72 hours after the original due date.
- All assignments should be submitted in hard copy unless otherwise requested.

Class honor code:

- Canon 6 of the American Society of Civil Engineers (ASCE) Code of Ethics states that "Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession." This means that acts of academic dishonesty are unprofessional, unacceptable, and will not be tolerated whatsoever.
- It is unacceptable to copy the work of another student, whether on exams or assignments; such behavior will be grounds for academic disciplinary action, including, but not limited to: zero credit for the assessment in question, a failing grade for the course, suspension from the College, or dismissal from the College. It is also unacceptable to look at prior students' work or solutions to assignments or exams that have not been made directly available by the instructor. Now or in the future, you are not allowed to distribute any instructor-provided course materials to others.
- Collaboration is allowed on homework assignments, but all assignments must be written up independently by each student. If you consult with any of your classmates or anyone else, you must indicate their names at the end of the relevant problem(s).
- Students must carefully review the Merrimack College Academic Integrity Code (AIC) posted on Blackboard and available at <http://www.merrimack.edu/about/offices_services/office-of-the-provost/academic-integrity-code.php>. You will be required to sign an Academic Integrity Pledge during the first week of class, after you have reviewed the Academic Integrity Code and course policies.

Communication: Course announcements will be made in class and via email. Students are expected to be reachable through their Merrimack email address, and are responsible for receiving all course announcements, both inside and outside of class.

Americans with Disabilities (ADA) Policy: Merrimack College provides reasonable accommodations for students with documented disabilities. Students who have, or think they may have, a disability are invited to contact the Accessibility Services Office. Students are encouraged to contact the office as soon as possible to ensure adequate time to meet and create a plan; accommodations cannot be made retroactively. Additional information about the office and the process for requesting accommodations can be found at <http://www.merrimack.edu/accessibility>.

General comments: I look forward to working with you throughout the semester, and I encourage you to ask questions and be engaged in the course. Please do not hesitate to drop by office hours, call me, or send me an email if you ever have any questions or concerns. Throughout the semester, please inform me of any personal circumstances or issues that I should know about.

III. Assessment

Grading: To earn a grade in the C range, you will need to successfully memorize the basic material and correctly apply it to problems similar to those we have covered. To earn a grade in the B range, you will also need to show evidence of understanding the material well enough to explain the intuition behind the problems. To earn a grade in the A range, you will also need to be able to correctly apply the material to new problems and explain the intuition behind the underlying theory. Grades of D and F represent below average and failing performance, respectively. Throughout the semester, students are responsible for being aware of their current course averages. The weights for your final course grade are as follows:

60% Exams *
- 25% Midterm Examination
- 35% Final Examination

40% Assignments
- 20% Homework Assignments (12)
- 20% Research Project (Paper and Presentation)

* In order to pass this course, you must demonstrate mastery of the material presented in class. This means that your weighted exam average must be greater than 60%, regardless of your grades on other assignments. In addition, your final weighted course average (encompassing all exams, projects, and homework) must be greater than 60%.

Letter grades will be computed from your final numerical course average using the following scale: A: 93 and above, A−: 90–92, B+: 87–89, B: 83–86, B−: 80–82, C+: 77–79, C: 73–76, C−: 70–72, D+: 67–69, D: 63–66, D−: 60–62, F: 0–59. Numerical averages will be rounded to the nearest whole number. Graduate students will earn a grade of F for final course averages below 70; per College policy, grades in the D range cannot be assigned to graduate students.

Exams: There will be two (2) exams: (1) a Midterm Examination, during class on Tues., Mar. 20; and (2) a cumulative Final Examination, on Tues., May 8, from 6–9:45 p.m. (the date and time established by the Registrar). The format and coverage of each exam will be discussed in class, with sufficient notice. Exams will assess your understanding of concepts covered in class, homework, and the assigned reading. No make-ups will be allowed for exams except in the case of a medical emergency with appropriate documentation.

Homework:
- Homework assignments will assess material covered in class and the assigned reading. Many assignments will require written responses in addition to calculations. Homework problems provide you with practice using the methods covered in class and are essential for you to become proficient with these methods. Homework also provides an opportunity to assign more complex and/or thought-provoking problems than those that may be assigned during a timed exam. Remember that the primary purpose of homework is to facilitate learning, not just to produce a solution as the end result.
- Assignment due dates are specified in the course schedule in this syllabus; submissions must be made prior to the start of class. Homework assignments must follow the prescribed format in the "Guidelines for Homework Submissions" section at the end of this syllabus. Unless otherwise noted, all homework assignments will be weighted equally when determining your final homework average, and your lowest homework grade will be dropped.
- Homework solutions will not be posted; the burden is on you to make sure you find out how to solve the problems by getting help before they are due, or asking about them after they have been handed in. However, the beginning of class on the day prior to the due date will be dedicated as a problem session, where you will have the opportunity to ask questions about the homework assignment. You are expected to attempt all homework problems prior to this problem session, so that you may contribute to group discussions about these problems.
- Your grades on homework assignments will be primarily based on whether all problems have been completed accurately, and that an honest attempt has been made. In order to receive full credit on an assignment, the following conditions must be met: (a) all parts of the problem must be completed, (b) at least three-fourths of the problem must be solved correctly, and (c) your work must follow the prescribed format guidelines. Note that instructor feedback will be more detailed on exams and projects than on homework assignments.
- On each homework submission, you will be allowed to earn 1 point of extra credit by submitting an outline or study guide of the assigned reading material. To receive full credit, an outline should not only be well-written and complete in its coverage, but it should also link the textbook to the material in your class notes. Note that each assignment will usually have 10 possible points, so a perfect score with extra credit would be 11/10.

Research Project: During the semester, you will perform a research project on a current topic of interest in engineering seismology, soil dynamics, or geotechnical earthquake engineering. The research project will culminate in a term paper and presentation, and will be completed individually by each student. The term paper should be of sufficiently high quality so that it could potentially be submitted to an engineering conference. However, the topic should be limited in scope so as not to involve a herculean research effort. Research project topics must be approved by Professor Kaklamanos, and further details of the project deliverables will be discussed in class.

Reading: In the course schedule provided in this syllabus, reading assignments from the textbook are listed for each class session. Reading assignments are to be done before the class for which they are listed, so that you may take an active role in the class and ask any questions to clarify the reading. Class sessions are intended to highlight or clarify concepts in the assigned reading, not to cover every concept for which you are responsible. If I do not cover a concept that needs clarification, please bring it up during class. Homework assignments and exam questions will be drawn heavily from the reading.

Professionalism: Professional or unprofessional behavior will result in adjustments to your final course average: professional behavior throughout the term will result in a numerical increase, and unprofessional behavior will result in a numerical decrease.

- Students who exhibit exemplary attendance, punctuality, and participation will be rewarded. At the end of the semester, students who have no more than one unexcused absence, no more than one unexcused late arrival, do not engage in any unprofessional behavior (including usage of personal electronics), and who actively participate in class throughout the semester, will receive one bonus point added to their final course average.
- Usage of personal electronics during class, arriving to class late (on more than two occasions), and/or engaging in other disruptive, disrespectful, or unprofessional behavior (examples of which are given in the course policies above) will result in automatic reductions of a student's final course average. On each instance that you engage in unprofessional behavior, I will immediately deduct one or more points off your final course average. Continued unprofessional behavior may result in dismissal from the class.

IV. Class Schedule (Tentative)

Notes:

- Each session is assumed to represent two hours of class time. Class meetings lasting four hours will cover two sessions.
- The reading assignments correspond to sections from Kramer (1996). Required supplemental readings outside the textbook will be assigned at times during the semester.
- Due to the Presidents' Day holiday, note that a Monday class schedule will be followed on Tuesday, Feb. 20.

Session No.	Session Title	Date	Textbook Reading	Assignment Due
Module 1: *Seismology and Earthquakes*				
1	Overview of Earthquake Engineering	Tue. Jan. 23	1.1–1.4	
2	Earthquake History and Case Studies	Tue. Jan. 23	1.5	
3	Plate Tectonics and Faults	Tue. Jan. 30	2.1–2.6, 5.1–5.3	HW 1
4	Earthquake Size and Location	Tue. Jan. 30	2.7–2.10	

Session No.	Session Title	Date	Textbook Reading	Assignment Due
Module 2: *Vibratory Motion and System Response*				
5	Vibrations and Waves	Tue. Feb. 6	A.1–A.3	HW 2
6	Single-Degree-of-Freedom (SDOF) Systems	Tue. Feb. 6	B.1–B.4	
7	Response of Linear SDOF Systems	Tue. Feb. 13	B.5	HW 3
8	Response Spectra, Damping, and Nonlinear Response	Tue. Feb. 13	B.6–B.8	Research Proposal
Module 3: *Ground Motion*				
9	Ground Motion Measurement and Parameters	Tue. Feb. 27	3.1–3.3	HW 4
10	Probability and Statistics Review	Tue. Feb. 27	C.1–C.7	
11	Ground-Motion Models	Tue. Mar. 6	3.4–3.6	HW 5
12	The Next Generation Attenuation of Ground Motions (NGA) Project	Tue. Mar. 6	Handouts	
Module 4: *Seismic Hazard Analysis*				
13	Earthquake Source Characterization; Deterministic Seismic Hazard Analysis	Tue. Mar. 13	4.1–4.3	HW 6
14	Probabilistic Seismic Hazard Analysis	Tue. Mar. 13	4.4–4.5	Res. Prog. Report 1
15	Probabilistic Seismic Hazard Analysis (Cont.)	Tue. Mar. 20	4.4–4.5	HW 7
16	**Midterm Examination**	Tue. Mar. 20		Midterm
Module 5: *Soil Dynamics and Site Response*				
17	Dynamic Soil Properties	Tue. Apr. 3	6.1–6.3	HW 8
18	Dynamic Soil Behavior	Tue. Apr. 3	6.4, 6.6	Res. Prog. Report 2
19	Characteristics of Site Response	Tue. Apr. 10	8.1–8.2	HW 9
20	Site Response Analysis	Tue. Apr. 10	7.1–7.2, 7.6, Handouts	
21	Design Codes	Tue. Apr. 17	8.3–8.4, 8.6, Handouts	HW 10
Module 6: *Liquefaction and Seismic Slope Stability*				
22	Liquefaction Characteristics and Susceptibility	Tue. Apr. 17	9.1–9.3, 9.4 (pp. 351–355), 9.6 (pp. 397–408)	

Session No.	Session Title	Date	Textbook Reading	Assignment Due
23	Liquefaction Triggering Analysis	Tue. Apr. 24	9.5 (pp. 368–389, 396–397), 9.7	Research Paper
24	Seismic Slope Stability	Tue. Apr. 24	10.1–10.5, 10.6 (pp. 433–445), 10.7	HW 11
25	Research Project Presentations	Tue. May 1		Research Presentation
26	Course Conclusion	Tue. May 1		HW 12
—	**Final Examination**	Tue. May 8, 6–9:45 p.m.		Final Exam

V. Guidelines for Homework Submissions

Format:

- Homework assignments should be neat, clear, and accurate. All work is to be done on 8½×11 engineering paper (single sided) and stapled together. The use of engineering paper is required for all assignments, except for problems that involve typed responses.
- On the first page of a homework assignment, please include your name, date, course number (CEN 5024), assignment number and name, and the total number of pages (e.g., "Page 1 of *n*"). On successive pages, include your name (or initials) and page number in the upper right corner.
- Use straightedges, protractors, and/or compasses for all diagrams, sketches and graphs; write legibly and unambiguously in a sequential format down the page.
- Leave an appreciable space (at least 1 inch) between problems or start each problem on a new page.
- Acknowledge collaboration with fellow students.

Problem-solving procedure:

- **Given** and **Find**: Restate the problem in your own words, including the information that is given and what is to be found. The reader should not have to refer to the textbook or problem assignment.
- **Sketch**: Include a sketch of the system, using straightedges where appropriate.
- **Solution**: Solve the problem (algebraically and/or numerically) to obtain your answer. Provide written explanations to help explain your thought process. State the fundamental equations and/or principles necessary to solve the problem, as well as any assumptions.
- **Answer**: Enclose your final answer with a box. Include units and remember the number of significant figures that are appropriate. If necessary, discuss your results and the assumptions used. Check your answer for reasonableness and confirm the consistency of your units.

General comments:

- Neatness and legibility is a requirement for an assignment to be graded. Homework that does not follow these guidelines or that is illegible may be returned with a grade of zero.
- Organization and neatness will be considered in grading, along with procedures and final answer. Show enough equations, sources of information, assumptions and intermediate steps so that your work can be followed both by a grader and by you when you later use the homework for review.
- Your homework submissions should reflect the diligence and thoroughness required in engineering. Consider your homework a professional submittal to your boss. What will happen if he/she cannot read or understand it?