DESCRIPTION
This course develops understanding of the concepts, theories and procedures of geotechnical earthquake engineering. The students will learn to analyze the ground response during earthquake, assess the liquefaction potential and seismic stability of slopes and retaining walls.

ENROLLMENT RESTRICTIONS
This course is intended for graduate students enrolled in civil and environmental engineering. It is expected that students will have basic understanding of soil mechanics and geotechnical engineering obtained by taking suitable courses at either the undergraduate or graduate level. Students without a suitable background in soil mechanics should discuss this with the instructor prior to registering for the course.

INSTRUCTOR CONTACT INFORMATION
Course instructor: Kareem Embaby
Email address: Kembaby@uwo.ca
Office: TBD
Office hours: Weekly office hours (TBD) are held via zoom.

COURSE FORMAT
The course will be delivered in-person.

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</td>
<td>Introduction</td>
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<tr>
<td></td>
<td>Introduction</td>
<td>1.1. Seismology and earthquakes</td>
<td>One Lecture (In-person)</td>
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<td>1.2. Seismic waves</td>
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<td>1.3. Size of earthquake</td>
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<td>1.4. Ground motion parameters</td>
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<td>2</td>
<td>Wave Propagation</td>
<td>2.1. One dimensional wave propagation</td>
<td>One Lecture (In-person)</td>
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<td></td>
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<td>2.2. Multi-dimensional wave propagation</td>
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<td>2.3. Surface and multi-layered soil wave systems</td>
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<tr>
<td>Topic #</td>
<td>Description</td>
<td>Learning Activities</td>
<td>Tentative timeline</td>
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<tr>
<td>3</td>
<td><strong>Dynamic Soil Properties</strong></td>
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</tbody>
</table>
| 3.1. Field Tests | 3.1.1. Seismic refraction  
3.1.2. Continuous surface wave test  
3.1.3. Spectral analysis of surface waves  
3.1.4. Multichannel analysis of surface waves  
3.1.5. Seismic downhole test (and SCPT)  
3.1.6. Seismic cross-hole test (SCHT) | ● Two Lectures (In-person) | Weeks 3-4 |
| 3.2. Laboratory Tests | 3.2.1. Resonant column test  
3.2.2. Bender element test  
3.2.3. Cyclic triaxial test  
3.2.4. Shear box test | | |
| 3.3. Cyclic stress-strain behavior | 3.3.1. Constitutive models  
3.3.2. Equivalent linear analysis | | |
| 4 | **Ground Response Analysis** | | |
| Ground Response Analysis | 4.1. Objectives of site response analysis  
4.2. Types of site response analysis  
4.2.1. One-dimensional analysis  
4.2.2. Two-dimensional analysis  
4.2.3. Dynamic finite element analysis  
4.2.4. Dynamic soil-structure interaction | ● Two Lectures (In-person) | Weeks 5-6 |
| | **Reading Week (no lectures)** | | |
| 5 | **Liquefaction** | | |
| 5.1. Introduction | 5.1.1. Liquefaction case histories  
5.1.2. Liquefaction process/factors  
5.1.3. Effects on built environment | ● Two Lectures (In-person) | Weeks 7-8 |
| 5.2. Liquefaction assessment | 5.2.1. Cyclic stress approach  
5.2.2. Cyclic strain approach  
5.2.3. Liquefaction resistance | | |
| 5.3. Post liquefaction | 5.3.1. Residual strength  
5.3.2. Liquefaction settlement  
5.3.3. Lateral spreading | | |
| 5.4. Mitigation | 5.4.1. Foundation options  
5.4.2. Ground improvement | | |
| 6 | **Seismic Slope Stability** | | |
| 6.1. Introduction | 6.1.1. Introduction  
6.1.2. Basic Mechanism of seismic effects  
6.1.3. Evaluation of seismic slope stability | ● Two Lectures (In-person) | Weeks 9-10 |
<table>
<thead>
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<th>Description</th>
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<th>Tentative timeline</th>
</tr>
</thead>
</table>
| 6.2. Static Slope Stability | 6.2.1. Limit equilibrium analysis  
6.2.2. Stress-deformation analysis | | |
| 6.3. Seismic Slope Stability | 6.3.1. Analysis of inertial instability  
6.3.1.1. Pseudo static approach  
6.3.1.2. Homogeneous wedge approach  
6.3.1.3. Newmark sliding block analysis  
6.3.1.4. Probabilistic Newmark analysis  
6.3.2. Analysis of weakening instability  
6.3.2.1. Analysis of stability  
6.3.2.2. Analysis of deformations  
6.3.3. Finite element analysis stability | | |
| 7 | Seismic Design of Retaining Walls | 7.1. Dynamic response of retaining walls | Two Lectures (In-person)  
Weeks 11-12 |
| | 7.2. Seismic Earth Pressure | 7.2.1. Mononobe -Okabe Method  
7.2.2. Effect of water on wall pressure  
7.2.3. Seismic pressures on basement walls | |
| | 7.3. Seismic Displacement | 7.3.1. Richard-Elms/deterministic method  
7.3.2. Wu-Prakash/deterministic method  
7.3.3. Whitman-Liao/statistical method | |
| | 7.4. Seismic Design | 7.4.1. Design based on seismic pressures  
7.4.2. Performance-based design  
7.4.3. Design of mechanically stabilized earth (MSE) walls | |

SPECIFIC LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Degree Level Expectation</th>
<th>Weight</th>
<th>Assessment Tools</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| Depth and breadth of knowledge | 15% | Assignments  
Project | 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 |
| Research & scholarship | 20% | Assignments  
Project | Ability to conduct critical evaluation of current advancements in the field of specialization  
Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment |
<table>
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<tr>
<th>Degree Level Expectation</th>
<th>Weight</th>
<th>Assessment Tools</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of knowledge</td>
<td>30%</td>
<td>• Assignments</td>
<td>• Ability to apply knowledge in a rational way to analyze a particular problem</td>
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<td>• Project</td>
<td>• 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>10%</td>
<td>• Assignments</td>
<td>• Awareness of academic integrity</td>
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<td>• Project</td>
<td>• Ability to implement established procedures and practices in the coursework</td>
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<td>• Defends own ideas and conclusions</td>
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<td>• Integrates reflection into his/her learning process</td>
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<tr>
<td>Communication skills</td>
<td>15%</td>
<td>• Project</td>
<td>• Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively</td>
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<tr>
<td>Awareness of limits of knowledge</td>
<td>10%</td>
<td>• Project</td>
<td>• Awareness of the need of assumptions in complex scientific analyses and their consequences</td>
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<td>• Understanding of the difference between theoretical and empirical approaches</td>
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<td>• 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>Homework Assignments (Five)</td>
<td>Topic 3 – 7</td>
<td></td>
<td>40%</td>
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<tr>
<td>Participation in class activities</td>
<td></td>
<td></td>
<td>10%</td>
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<tr>
<td>Project 1: Design Project</td>
<td>Topic 3 – 7</td>
<td></td>
<td>30%</td>
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<tr>
<td>Project 2: Presentation</td>
<td></td>
<td></td>
<td>20%</td>
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</table>

**Activities in which collaboration is permitted:**
- Analysis/calculations of assignments and project

**Activities in which students must work alone (collaboration is not permitted):**
- Writing reports of assignments and projects

**REQUIRED TEXTBOOK**
None

**OPTIONAL COURSE READINGS**
Any relevant books and scientific papers
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 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 at the following website: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

All required papers may be subject to submission for textual similarity review to the commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

CONDUCT
Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course 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 SERVICES
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 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. Faculty of Engineering has a Student Wellness Counsellor. To schedule an appointment with the counsellor, contact Kristen Edwards (khunt29@uwo.ca) via confidential email and you will be contacted by our intake office within 48 hours to schedule an appointment.

Students who are in emotional/mental distress should refer to Mental Health@Western: http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help.
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.

Students who are not able to meet certain academic responsibilities due to medical, compassionate or other legitimate reason(s), could request for academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at:
https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.html

ACCESSIBLE EDUCATION WESTERN (AEW)
Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program. Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW): http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.