Short Course on

DYNAMIC SOIL-STRUCTURE INTERACTION

Pavia, March 2-6, 2015

![Diagram showing the total solution, kinematic interaction, and inertial interaction.](image)
• **OBJECTIVES OF THE COURSE**

The objective of this short course is to provide graduate students - both at MSc and PhD levels - and practicing engineers with the fundamental concepts and theory of dynamic soil-structure interaction (SSI), with special focus on the numerical tools currently available to model such problems in earthquake engineering practice. Although the course touches upon all aspects of the theory and the numerical modeling for seismic problems, emphasis will be on the basic concepts, including elements of vibration theory, wave propagation in the ground and wave interaction with foundations and structures, earthquake source mechanisms, wave amplification in soft soil deposits and the interaction of small and large-scale foundations and buildings erected on compliant soil. Both linear and non-linear aspects of modeling will be covered.

The course will include both theoretical lectures and hands-on solutions by the attendees of practical problems obtained via simple Matlab programs.

The course is taught by **Prof. Eduardo Kausel**, from the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology, and by **Dr. Glenn J. Rix**, Principal Engineer at Geosyntec Consultants, Inc. and formerly a Professor of Civil and Environmental Engineering at the Georgia Institute of Technology.

• **PARTICIPATION**

In addition to UME School students, a maximum of 20 external participants may be accepted to the course, under the payment of a 500€ fee. Special financial conditions are, however, in place for University researchers or students, to whom a fee of not more than 300€ is requested. Those wishing to attend the course should contact the UME School Secretariat.

• **CONTACTS**

UME School Secretariat
c/o EUCENTRE Foundation - Via Adolfo Ferrata, 1 - 27100 Pavia, Italy
Phone (+39) 0382.5169867/851 - E-mail: secretariat@umeschool.it
Web-site: www.umeschool.it


**Dr. Eduardo Kausel**

earned his first professional degree in 1967 from the University of Chile. After some post-graduate studies in 1969 at the Technical University of Darmstadt in Germany he moved to the United States, and earned his MS (1972) and ScD (1974) degrees from the Massachusetts Institute of Technology. Following graduation Dr. Kausel worked in the industry at Stone and Webster Engineering Corporation in Boston, and then joined the MIT faculty in 1978, where he is currently a Professor of Civil and Environmental Engineering. He is a registered Professional Engineer in the state of Massachusetts and has extensive experience as consulting engineer. Among the distinctions he has received are a 1992 Honorary Faculty Membership in Epsilon Chi (of only 2 in his department), the 1994 Konrad Zuse Guest Professor at the University of Hamburg in Germany, the Humboldt Prize from the German Government in 2000, and the 2001 MIT-CEE Award for Conspicuously Effective Teaching. Dr. Kausel is best known for his work on Dynamic Soil-Structure Interaction, and for the very successful Green’s functions he developed for the dynamic analysis of layered media, which are now incorporated in several well-known and widely used programs. Dr. Kausel is the author of some two hundred technical papers and reports in the areas of structural dynamics, earthquake engineering, and computational mechanics. Among these is his recent (2006) book “Fundamental Solutions in Elastodynamics” published by Cambridge University Press.

**Dr. Glenn J. Rix**

earned his Bachelors degree in civil engineering from Purdue University in 1982 and his Master of Science and Doctoral degrees in civil engineering from the University of Texas at Austin in 1984 and 1988, respectively. Dr. Rix joined Geosyntec Consultants, Inc. as a Principal Engineer in 2013 after a distinguished 24-year career as a Professor in the School of Civil and Environmental Engineering at the Georgia Institute of Technology specializing in soil dynamics and geotechnical earthquake engineering. At Geosyntec, Dr. Rix is focused on the areas of geotechnical earthquake engineering and engineering seismology (particularly for the eastern and central U.S.), seismic hazard assessment and risk mitigation for civil infrastructure at both the component and system scales, and advanced near-surface geophysics investigations and interpretations across a range of applications. Dr. Rix has authored or co-authored more than 50 refereed publications, and delivered more than 70 technical presentations at national and international conferences on the topics listed above, and he is a co-author of “Surface Wave Methods for Near-Surface Site Characterization” that was recently published (2014) by CRC Press.
### COURSE SCHEDULE March 2-6, 2015

**Monday 2**

<table>
<thead>
<tr>
<th>Time</th>
<th>Course</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>09:00</td>
<td>Vibration Theory, Part I (Rix):</td>
<td>Fundamental principles; 1-DOF systems. Free vibration; Impulse response function and convolution; Frequency response functions; Fourier methods; Exponential window method; Energy dissipation.</td>
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<td>14:00</td>
<td>Vibration Theory, Part II (Kausel):</td>
<td>MDOF systems and continuous systems; Properties of normal modes; Modal superposition for seismic problems; Numerical integration; Method of weighted residuals (finite elements); Lagrange's equations and their application to continuous systems via the Assumed Modes Method.</td>
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**Tuesday 3**

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<thead>
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<tbody>
<tr>
<td>09:00</td>
<td>Wave Propagation, Part I (Rix):</td>
<td>Waves in unbounded media; Waves in rods, beams, deep water, beam on elastic foundation, beam on elastic half-space; Phase and group velocity; Wavenumber spectra.</td>
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<tr>
<td>14:00</td>
<td>Wave Propagation, Part II (Kausel):</td>
<td>Dispersion; Guided waves in layered media, including Rayleigh and Love waves; Normal modes; Reflection, refraction and diffraction; Geometric and material attenuation; Conditions for radiation; Fundamental solutions.</td>
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**Wednesday 4**

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<tbody>
<tr>
<td>09:00</td>
<td>Earthquakes and their effects (Rix):</td>
<td>Types of faulting; Measures of earthquake strength; Magnitude recurrence relationships; Ground motion prediction equations; Spatial variability and correlation of ground motions; Basin and topographic effects</td>
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<tr>
<td>14:00</td>
<td>Site response &amp; in-situ measurement of soils (Rix):</td>
<td>Dynamic soil properties and site response analysis; Shear modulus and material damping ratio in soils; Simple nonlinear constitutive models; Laboratory and in-situ measurement of low and intermediate-strain soil properties; Amplification of vertically propagating shear waves; Control motion within and at rock outcrop; Impedance contrast as a measure of radiation damping; Waves in vertically heterogeneous soils.</td>
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**Thursday 5**

09:00 – 12:00  **Inelastic effects (Kausel):**
Non-linear behavior of soils; Simple inelastic models for shear; Masing’s rule, and its simulation with Ivan’s model; Seed-Idriss iterative method; Inelastic response under multiaxial states of stress (general overview).

14:00 – 17:00  **Soil-Structure Interaction, Part I (Kausel):**
Fundamental superposition theorem; Free-field response; Kinematic interaction; Inertial interaction; Piled foundations; Modeling strategies; Modal synthesis in frequency domain.

**Friday 6**

09:00 – 12:00  **Soil-Structure Interaction, Part II (Kausel):**
Stiffness of foundations; Response of foundations to wave passage; Iguchi’s method; Dynamic stresses underneath foundations.

14:00 – 17:00  **Numerical models for SSI (Kausel):**
Direct approach with finite elements; Transmitting boundaries; Perfectly matched layers; Internal vs. external excitation; Complex models.
The European Commission has approved and financed within the Erasmus Mundus II the Masters on Earthquake Engineering and Engineering Seismology (MEEES), coordinated by the UME School as part of the ROSE programme and featuring also the participation of the University of Grenoble Joseph Fourier (France), the University of Patras (Greece) and the Middle East Technical University (Turkey), which aim to enhance quality in European higher education and to promote intercultural understanding through co-operation with third countries, a relatively large number of scholarships are available for both non-European as well as European students. Interested applicants are invited to visit the MEEES website (www.meees.org) for detailed information and instructions on financial conditions and application procedures.