



## Course Syllabus: Sediment Properties and Behavior - ErSE 390B

<b>Division</b>	Physical Science and Engineering Division
<b>Course Number</b>	ErSE 390B
<b>Course Title</b>	Sediment Properties and Behavior
<b>Academic Semester</b>	Spring
<b>Academic Year</b>	2016/2017
<b>Semester Start Date</b>	01/22/2017
<b>Semester End Date</b>	05/18/2017
<b>Class Schedule</b> (Days & Time)	04:00 PM - 06:00 PM   Sun Thu

### Instructor(s)

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### Teaching Assistant(s)

Name	Email
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### Course Information

<b>Comprehensive Course Description</b>	Sediments are multiphase particulate materials. Their unique macroscale properties and behavior reflect intricate grain/pore-scale processes and phenomena. Implications affect all forms of engineering, from infrastructure and energy to the environment.
<b>Course Description from Program Guide</b>	
<b>Goals and Objectives</b>	Particle and pore scale processes in sediments Sediment macroscale properties Engineering
<b>Required Knowledge</b>	Fundamentals of physics, mechanics, chemistry and biology
<b>Reference Texts</b>	Santamarina, J.C., Klein, K. and Fam, M. (2001). <i>Soils and Waves</i> , J. Wiley and Sons, 488 pages Large number of scientific papers
<b>Method of evaluation</b>	40.00% - Tests 20.00% - Homework /Assignments 40.00% - Course Project(s)
<b>Nature of the assignments</b>	Weekly, written analyses
<b>Course Policies</b>	Wireless communication system of all kinds <u>must be turned off</u> while in the classroom, including cell phones.
<b>Additional Information</b>	

## Tentative Course Schedule

*(Time, topic/emphasis & resources)*

Week	Lectures	Topic
1	Sun 01/22/2017 Thu 01/26/2017	<p><u>Introduction</u>. Geological history. History of geotechnical engineering. Failures. Sustainability. Geo-environmental. Energy geotechnology.</p> <p><u>Governing laws</u>. Newtonian mechanics (continuum mechanics and elasticity). Electromagnetism. Thermodynamics. Conservation principles.</p> <p><u>Biological considerations</u>. Introductory concepts. Microorganisms, dimensions, properties. Conditions for life. Bio-mediated geo-processes: bio-gas, bio-cementation, bio-clogging.</p>
2	Sun 01/29/2017 Thu 02/02/2017	<p><u>Water</u>. The water molecule. Properties. Water and electrolytes. Diffusion and osmosis. Dry and wet sediments. Counter ion cloud - double layer thickness. Phase transformation (evaporation, freezing, hydrates). Molecular dynamics.</p> <p><u>Sediment formation</u>. Minerals, rocks and sediments. Grain formation and size (mechanical, chemical, biological). Transported and residual sediments. Transportation agents and effects. Clay minerals.</p> <p><u>Diagenesis</u>. Dissolution (modes). Re-precipitation (pore habit).</p>
3	Sun 02/05/2017 Thu 02/09/2017	<p><u>A single particle</u>. Properties of a single particle (mineralogy, size, shape, specific surface, mechanical, thermal, chemical and electrical properties). Determination.</p> <p><u>Characteristics of particulate media</u>. Sediments as particulate materials. Complementary views: grain mass, grain surface, pores. Macro and microproperties. Phases and phase relations.</p> <p><u>Interparticle forces and effective stress</u>. Electrical and mechanical. Terzaghi's effective stress principle. Summary of pore pressure sources. Modified effective stresses principles (electrical forces, capillary, locked sediments) or multidimensional space?</p>
4	Sun 02/12/2017 Thu 02/16/2017	<p><u>Fabric</u>. Fine-grained sediments (pH and c). Coarse-grained sediments (Cu and shape). Mixtures. The effect of mica and platy particles. Fines in coarse grained sediments: Critical fine fraction. Grain size and pore size.</p> <p><u>Sediment Classification</u>. Underlying concepts. Index properties. Schofield chart. Limitations.</p>
5	Sun 02/19/2017 Thu 02/23/2017	<p><u>State of stress</u>. Stress history. In situ stress: Coefficient of lateral earth pressure at rest. Hydrostatic conditions. Induced stress (1D, 2D, 3D). Drained loading. Stress paths. Effective stress (defined at boundary)</p> <p><u>Interparticle interaction</u>. Fundamental contact theories. Hertz and Mindlin. Numerical micromechanics: Discrete element methods. DEM.</p> <p><u>Strain regimes</u>. Small-strain and large-strain regimes. Threshold strains.</p>
6	Sun 02/26/2017 Thu 03/02/2017	<p><u>Small Strain Shear Stiffness</u>. Controlling parameters. Effective stress, capillarity and cementation. Truss model.</p> <p><u>Volume change during loading</u>. Compressibility (isotropic and zero-lateral strain conditions). Contractive and dilative tendencies (<math>s'-e</math> or <math>p'-e</math> space). Fabric evolution during loading. Micromechanics. Inherent and stress induced anisotropy. Poisson's ratio.</p> <p><u>Saturated sediments</u>. Poroelasticity. Biot, Terzaghi, Skempton. Undrained isotropic loading. Induced pore pressure. Special Phenomena. (e.g., Mandel-Cryer).</p>
7	Sun 03/05/2017 Thu 03/09/2017	<p><u>Strength</u>. Friction and internal shear strength (fine and coarse sediments). Mohr, coulomb and the failure line (<math>t-s'</math> or <math>q-p'</math> space). Critical state sediment behavior. Load-deformation behavior: drained and undrained deviatoric loading. Normalized behavior.</p>
8	Sun 03/12/2017 Thu 03/16/2017	<p><u>Mixed fluids: Immiscible fluids</u>. Surface tension and contact angle. Laplace and Kelvin equations. Sediment-water characteristic curve (van Genuchten). Preliminary implications on small and large strain behavior. Implications: sediment compaction, collapsible sediments, desiccation cracks.</p>
9	Sun 03/19/2017 Thu 03/23/2017	<p><u>Conduction phenomena</u>. Different forms of conduction. Seepage (Bernoulli, Pascal, Laplace, Darcy). Hydraulic and electrical conduction at the microscale. Non-linear flow. Numerical solution: network models. Fines migration: Clogging and filters.</p>
10	Sun 03/26/2017 Thu 03/30/2017	<p><u>Diffusion Phenomena</u>. Pressure diffusion: consolidation. Chemical diffusion. Numerical solution.</p>
11	Sun 04/02/2017 Thu 04/06/2017	<p><u>Scales and Spatial Variability</u>. Internal spatial scales in sediments. Phenomena and temporal scales. Morphology of heterogeneity. Properties (Upper bounds and lower bounds; effective media models). Emerging phenomena.</p>
12	Sun 04/09/2017 Thu 04/13/2017	<p><u>Thermal properties</u>. Specific and latent heat. Heat conduction at the particle level. Diffusion. Frozen ground. Lenses. Hydrates.</p>
13	Sun 04/16/2017 Thu 04/20/2017	<p><u>Coupled Processes</u>. Quasi-static coupled processes (constant fabric and coupled gradients related to fabric changes). Dynamic energy coupling (Stochastic resonance. Friction and noise. AC transport chemical, thermal).</p>
14	Sun 04/23/2017 Thu 04/27/2017	<p><u>Time-related sediment response</u>. Strain rate effects. Natural (aging, thixotropy, dissolution/cementation). Man-made (engineered, surface modified sediments, ground modification).</p>
15	Sun 04/30/2017 Thu 05/04/2017	<p><u>Localization</u>. Shear bands and progressive failure. Compression bands. Hydraulic fracture in sediments. Freezing and lensing. Piping (hydromechanical, chemical)</p>

16	Sun 05/07/2017 Thu 05/11/2017	<u>Repetitive loading</u> . Ratcheting. Terminal densities.
17	Sun 05/14/2017 Thu 05/18/2017	<u>Engineering Implications</u>
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**Note**

The instructor reserves the right to make changes to this syllabus as necessary.