# Course Syllabus: Sediments: Properties and Processes - ERPE 220

| | |
|---|---|
| **Division** | Physical Science and Engineering Division |
| **Course Number** | ERPE 220 |
| **Course Title** | Sediments: Properties and Processes |
| **Academic Semester** | Spring |
| **Academic Year** | 2018/2019 |
| **Semester Start Date** | 01/27/2019 |
| **Semester End Date** | 05/23/2019 |
| **Class Schedule** (Days & Time) | 04:00 PM - 05:30 PM \| Sun Mon |

## Instructor(s)

| Name | Email | Phone | Office Location | Office Hours |
|---|---|---|---|---|
| Juan Carlos Santamarina | Carlos.Santamarina@kaust.edu.sa | +966128087262 | 3218, 5, Al-Kindi (bldg. 5) | |

## Teaching Assistant(s)

| Name | Email |
|---|---|

## Course Information

| | |
|---|---|
| **Comprehensive Course Description** | Description: (1) Fundamental concepts (Geological history. Governing laws. Biological considerations. Water. Sediment formation and diagenesis). (2) Particulate media (Interparticle forces and effective stress. Fabric. Classification). (3) GeoMechanics (Effective stress. Numerical micromechanics. Strain regimes. Deformation and failure. Biot, Terzaghi, Skempton. Repetitive loading). (4) Coupled Bio-Thermo-Hydro-Chemo-Mechanical Processes (Mixed fluids. Conduction phenomena. Diffusion Phenomena. Thermal properties. Couplings). (5) Localizations, scales and spatial variability. (6) Implications in energy geo-engineering, infrastructure and environmental solutions. |
| **Course Description from Program Guide** | Fundamental concepts (Geological history. Governing laws. Biological considerations. Water. Sediment formation and diagenesis). Particulate media (Interparticle forces and effective stress. Fabric. Classification). GeoMechanics (Effective stress. Numerical micromechanics. Strain regimes. Deformation and failure. Biot, Terzaghi, Skempton. Repetitive loading). Coupled Bio-Thermo-Hydro-Chemo-Mechanical Processes (Mixed fluids. Conduction phenomena. Diffusion Phenomena. Thermal properties. Couplings). Localizations, scales and spatial variability. Implications in energy geo-engineering, infrastructure and environmental solutions. |
| **Goals and Objectives** | To learn the fundamentals of granular materials, and to anticipate their response to hydro-thermo-chemo-bio-mechanical processes. |
| **Required Knowledge** | Fundamentals of physics, mechanics, chemistry and biology |
| **Reference Texts** | -Santamarina, J.C., Klein, K. and Fam, M. (2001). *Soils and Waves*, J. Wiley and Sons, 488 pages<br>(Chapters 1-5 and contents from several other chapters)<br>-Complementary publications (to be provided/assigned)<br>-Class notes<br>-Selected readings |
| **Method of evaluation** | **40.00**% - Course Project(s)<br>**20.00**% - Homework /Assignments<br>**40.00**% - Tests |
| **Nature of the assignments** | Weekly, written analyses due every Sunday. Individual submission (but encouraged to solve with others - Duplication: not acceptable).<br>Project:<br>A 2000 word state-of-the-art review with deep insight into fundamentals of behavior.<br>Final presentation: “youtube” type 8 min lecture (selected ones will be uploaded in our website) |

| | |
|---|---|
| **Course Policies** | -This course will be conducted under the guidelines of KAUST's Academic Honor Code.<br>-Cheating of any kind is unethical and unacceptable.<br>-Do not cut and paste any part of your homework or lab reports. Quote and attribute any words that are not your own.<br>-Wireless communication system of all kinds must be turned off while in the classroom, including cell phones. |
| **Additional Information** | |

## Tentative Course Schedule

*(Time, topic/emphasis & resources)*

| Week | Lectures | Topic |
|---|---|---|
| 1 | Sun 01/27/2019 | Introduction. Geological history. History of geotechnical engineering. Failures. Sustainability. Geo-environmental. Energy geotechnology. |
| 1 | Mon 01/28/2019 | Governing laws. Newtonian mechanics (continuum mechanics and elasticity). Electromagnetism. Thermodynamics. Conservation principles. |
| 2 | Sun 02/03/2019 | Water. The water molecule. Properties. Water and electrolytes. Diffusion and osmosis. Dry and wet sediments. Counter ion cloud - double later thickness. Phase transformation (evaporation, freezing, hydrates). Molecular dynamics. |
| 2 | Mon 02/04/2019 | Water. The water molecule. Properties. Water and electrolytes. Diffusion and osmosis. Dry and wet sediments. Counter ion cloud - double later thickness. Phase transformation (evaporation, freezing, hydrates). Molecular dynamics. |
| 3 | Sun 02/10/2019 | Sediment formation. Minerals, rocks and sediments. Grain formation and size (mechanical, chemical, biological). Transported and residual sediments. Transportation agents and effects. Clay minerals. |
| 3 | Mon 02/11/2019 | Sediment formation. Minerals, rocks and sediments. Grain formation and size (mechanical, chemical, biological). Transported and residual sediments. Transportation agents and effects. Clay minerals. |
| 4 | Sun 02/17/2019 | A single particle. Properties of a single particle (mineralogy, size, shape, specific surface, mechanical, thermal, chemical and electrical properties). Determination. |
| 4 | Mon 02/18/2019 | A single particle. Properties of a single particle (mineralogy, size, shape, specific surface, mechanical, thermal, chemical and electrical properties). Determination. |
| 5 | Sun 02/24/2019 | Characteristics of particulate media. Sediments as particulate materials. Complementary views: grain mass, grain surface, pores. Macro and microproperties. Phases and phase relations. |
| 5 | Mon 02/25/2019 | Characteristics of particulate media. Sediments as particulate materials. Complementary views: grain mass, grain surface, pores. Macro and microproperties. Phases and phase relations. |
| 6 | Sun 03/03/2019 | Fabric. 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. |
| 6 | Mon 03/04/2019 | Fabric. 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. |
| 7 | Sun 03/10/2019 | Sediment Classification. Underlying concepts. Index properties. Schofield chart. Limitations. |
| 7 | Mon 03/11/2019 | Sediment Classification. Underlying concepts. Index properties. Schofield chart. Limitations. |
| 8 | Sun 03/17/2019 | State of stress. 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). |
| 8 | Mon 03/18/2019 | State of stress. 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). |
| 9 | Sun 03/24/2019 | Spring Break |
| 9 | Mon 03/25/2019 | Spring Break |
| 10 | Sun 03/31/2019 | Interparticle interaction. Fundamental contact theories. Hertz and Mindlin. Numerical micromechanics: Discrete element methods. DEM. |
| 10 | Mon 04/01/2019 | Interparticle interaction. Fundamental contact theories. Hertz and Mindlin. Numerical micromechanics: Discrete element methods. DEM. |
| 11 | Sun 04/07/2019 | Small strain Shear Stiffness. Controlling parameters. Effective stress, capillarity and cementation. Truss model. |
| 11 | Mon 04/08/2019 | Small strain Shear Stiffness. Controlling parameters. Effective stress, capillarity and cementation. Truss model. |
| 12 | Sun 04/14/2019 | Volume change during loading. Compressibility (isotropic and zero-lateral strain conditions). Contractive and dilative tendencies. Fabric evolution during loading. Micromechanics. Inherent and stress induced anisotropy. Poisson's ratio. |
| 12 | Mon 04/15/2019 | Volume change during loading. Compressibility (isotropic and zero-lateral strain conditions). Contractive and dilative tendencies. Fabric evolution during loading. Micromechanics. Inherent and stress induced anisotropy. Poisson's ratio. |

| | | |
|---|---|---|
| 13 | Sun 04/21/2019 | Strength. Friction and internal shear strength (fine and coarse sediments). Mohr, coulomb and the failure line. Critical state sediment behavior. Load-deformation behavior: drained and undrained deviatoric loading. Normalized behavior. |
| 13 | Mon 04/22/2019 | Strength. Friction and internal shear strength (fine and coarse sediments). Mohr, coulomb and the failure line. Critical state sediment behavior. Load-deformation behavior: drained and undrained deviatoric loading. Normalized behavior. |
| 14 | Sun 04/28/2019 | Repetitive loading. Ratcheing. Terminal densities. |
| 14 | Mon 04/29/2019 | Repetitive loading. Ratcheing. Terminal densities. |
| 15 | Sun 05/05/2019 | Mixed fluids: Immiscible fluids. 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. |
| 15 | Mon 05/06/2019 | Mixed fluids: Immiscible fluids. 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. |
| 16 | Sun 05/12/2019 | Conduction phenomena. 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. |
| 16 | Mon 05/13/2019 | Conduction phenomena. 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. |
| 17 | Sun 05/19/2019 | Final Exam Week |
| 17 | Mon 05/20/2019 | Final Exam Week |

**Note**

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