MECH\_ENG 495: THEORY OF HETEROGENEOUS MATERIALS

**Quarter Offered:**

Winter: MWF 9:00-9:50; Tech L160 V. Lefèvre

**Prerequisites:**

The course will be self-contained but will rely on continuum-based descriptions of the physical behavior of solids (CIV\_ENV 417-1, or equivalent) as well as standard computational methods in Solid Mechanics (MECH\_ENG 327, or equivalent).

**Course Description:**

Heterogeneous materials appear pervasively in Nature (e.g., polycrystals, wood, bone, blood, …), physical systems (e.g., (un)stable colloidal suspensions, …), or in engineering applications (e.g., fiber-reinforced materials for aircraft structures, reinforced rubber in car tires, …). They usually exhibit remarkable physical properties, in general superior to the properties of their individual components. Despite being comprised at the microscopic length scale of multiple domains with different physical properties, these materials behave from a macroscopic perspective as homogeneous materials and can therefore be assigned macroscopic (or effective) physical material-like properties for practical purposes.

The course will cover classical and more recent analytical and numerical methods for the computation of various physical properties (viscous/thermal/dielectric, elastic, viscoelastic, thermoelastic, piezoelectric, electrostrictive) of heterogeneous materials that exhibit (non)linear and/or coupled behaviors.

**Course Outline:**

1. **Introduction**

Review of Continuum Mechanics, Problem description and setting, Classical Voigt and Reuss bounds

1. **2-scale asymptotic expansion**

Composites with periodic microstructures

1. **Construction of solutions for exact microstructures**

Checkerboards, Laminated materials, Coated assemblages, Iterated dilute homogenization

1. **Comparison medium methods**

Eshelby inclusion problem, Hashin-Shtrikman variational principles and bounds, Self-consistent estimates

1. **Beyond linear composites**

Viscoelastic composites, Hyperelastic composites, Thermoelastic composites, Elastic dielectrics