## Independent Study at SIEN lab

## Soft Matter and Biological Lubrication

At SIEN we aim to understand the molecular lubrication mechanisms of soft matter and use this knowledge to design novel biomaterials as soft tissue implants. The following projects are related to this vision.

1) **Visualization of soft matter contacts during mechanical loading**

   Since the frictional response of soft materials including hydrogels, biomimetic cell-membrane systems and articular cartilage is dependent on the contact area, it is crucial to have the capability to experimentally measure contact areas during mechanical loading.

   **The student will be involved in:**

   - Extending a nano-indenter with a high-speed camera for cross-sectional imaging of the contact during indentation and scratch tests.
   - Preparing hydrogels with different microstructure and performing indentation experiments to measure the contact area.
   - Evaluating the results with the help of existing contact mechanic models.

   **Preferred background:**

   Preferable for students with a past experience in materials science and mechanical labs. Grades will be taken into account.

2) **Investigating stress relaxation behavior of bi-phasic materials**

   Strongly hydrated crosslinked polymeric networks known as hydrogels are viscoelastic, due to their polymeric component and poroelastic because of their biphasic structure. This project is aimed to comprehend viscoelastic and poroelastic components to hydrogel relaxation.

   **The student will be involved in:**

   - Preparing hydrogels with different microstructures
   - Developing a protocol for stress-relaxation measurements of hydrogels with a nanoindenter.
   - Evaluating the effect of experimental parameters to probe and to decouple the visco and poro-elastic hydrogel relaxations.

   **Preferred background:**

   Interest and basic knowledge of polymers and polymer physics. Past experience of working in a materials chemistry lab would be helpful. Grades will be taken into account.

3) **Modeling force-indentation curves using contact mechanics theories (Coding project)**

The atomic force microscopy (AFM) is an important tool to determine interfacial mechanical properties of complex materials such as biological cells, hydrogels and cartilage. Like any other indenter, the AFM can perform indentation measurements to which contact mechanics models can be applied to extract key properties, for instance the elastic modulus, and interfacial energy. Depending on the type of material and its mechanical response several contact mechanical models can be applied for e.g. the Hertz model – for non-adhesive elastic contacts, the Johnson-Kendall-Roberts (JKR) – for adhesive contacts, and multiple others.

The student will work on developing a processing tool with the help of MATLAB to apply multiple contact mechanics models to the indentation curves measured by AFM.

**Preferred background:**

Knowledge of MATLAB programming. Interest in applying mathematical models to data.

Contact Person: Prof. Rosa M. Espinosa-Marzal (rosae@illinois.edu)

Website: https://publish.illinois.edu/rosaespinosamarzal/