**Executive Summary: Sensor Optimization by Adjusting Volume Fractions of Superparamagnetic Nanoparticles in Hydrogel**

My project addresses the question of how to optimize a recently-developed sensor, which employs simple chemical reactions and magnetics to detect environmental changes. The sensor is composed of a water-based gel in which magnetic nanoparticles are embedded. The hydrogel changes volume as the conditions to which it is sensitive to (the specific condition or stimuli depend on the hydrogel in question) change. The nanoparticles move with the gel as it swells or shrinks, altering the magnetic properties of the ferrogel as a whole, which can be externally detected. From there it is a simple matter to convert the magnetic change back into the original change and report it. The sensor as a whole is referred to as a “ferrogel.”

I first used a modified version of the Bruggeman Effective Medium Approximation (EMA, or just equation), which I altered to solve for magnetic instead of electric properties, to predict a design. I then synthesized my ferrogel in accordance with prior literature that had initially proposed the sensor. After that, I measured both the magnetic and physical properties of the ferrogels, and compared the results with the concentration of iron-in-gel. From this comparison, I determined the two directly opposing factors that influenced effectiveness: concentration of iron and degree of hydrogel reaction. Through further measurement and usage of the Bruggeman equation, I realized that the latter factor had far greater influence on overall effectiveness and thus maximized it to ensure that the sensor was optimized.

Ultimately, this means that, for optimal effectiveness, a ferrogel sensor should minimize its concentration of nanoparticles to best allow the hydrogel to react to external stimuli. This optimized sensor may be applied to a wide variety of disciplines across multiple fields.