## GRS PY 895 Seminar: Special Topics in Theoretical Physics

**Course Title:** Advanced Topics in Statistical Mechanics: Disordered Systems and Renormalization Group

Preferred Times: MW 9:30-11 or T Th 9:30-11

This course will cover advanced topics in statistical physics. In the first half of the course, we will study the renormalization group. We will start by introducing the main ideas of the renormalization group by analyzing the transition to the chaos and calculation of the Feigenbaum number. We will then move on to study spin systems, starting with a review of phase transitions and scaling functions. We will then move on to study real-space renormalization methods before proceeding to discuss Wilsonian RG in momentum space. The focus of both portions of the course will be to give students general intuitions and tools that can be used to solve a wide variety of problems across systems in physics ranging from high-energy, to CMT, to biophysics and machine learning. The second half of the course will concentrate on the statistical physics of disordered systems. We will start by introducing the basic theoretical tools to analyze disordered systems such as the replica method, the cavity method, and Random Matrix Theory. We will then use these tools to analyze a wide variety of systems including spin glasses, attractor neural networks, ecological dynamics, computational algorithms, and disordered quantum systems. Finally, we will try to combine these two topics by discussing some works on RG in disordered systems.

Books and Resources:

<u>Renormalization Group:</u>

- Creswick, Richard J., Horacio A. Farach, and Charles P. Poole. *Introduction to renormalization group methods in physics* (out-of-print) but pdfs are floating around on internet.
- Cardy, John. *Scaling and renormalization in statisticalphysics*. Vol. 5. Cambridge university press, 1996.
- Goldenfeld, Nigel. *Lectures on phase transitions and the renormalization group*. CRC Press, 2018.
- Kadanoff, Leo P. *Statistical physics: statics, dynamics and renormalization*. World Scientific, 2000.

<u>Disordered Systems</u>

- Mézard, Marc, Giorgio Parisi, and Miguel Angel Virasoro. *Spin glass theory and beyond: An Introduction to the Replica Method and Its Applications.* Vol. 9. World Scientific Publishing Company, 1987.

- Nishimori, Hidetoshi. *Statistical physics of spin glasses and information processing: an introduction*. No. 111. Clarendon Press, 2001.
- Amit, Daniel J., and Daniel J. Amit. *Modeling brain function: The world of attractor neural networks*. Cambridge university press, 1989.
- Mezard, Marc, and Andrea Montanari. *Information, physics, and computation*. Oxford University Press, 2009.