PHYS 431 – PHYSICS OF IMAGING

Syllabus: Description of physical principles underlying the spin behavior in magnetic resonance imaging and Fourier imaging in multi-dimensions. Introduction of conventional, fast, and chemical-shift imaging techniques. Spin echo, gradient echo, and variable flip-angle methods. Projection reconstruction and sampling theorems. Bloch equations, T1 and T2 relaxation times, RF penetration, diffusion and perfusion. Flow imaging, MR angiography, and functional brain imaging. Sequence and coil design.

Goals: The engineering physics and technical goals are to understand the connections between the precession of a nuclear magnetic moment (in the presence of a combination of magnetic fields) and the rich variety of signals generated in a modern MRI experiment. The target is for finishing students to have a good understanding of much of the latest literature. A general goal is to show that MRI leads to a more general appreciation of signal and image processing and electromagnetic phenomena, allowing the student to understand a greater vista of basic and industrial applications. An educational goal is for the instructors themselves to look for an increase in teaching effectiveness by utilization of methods such as the use of cooperative study groups.

Prerequisites: A standard engineering/science core of courses including introductions to differential equations, complex variables, Fourier analysis, statistics, electronics laboratory, and electromagnetism.

Typical Semester Schedule:

1. Introduction to magnetic moments, precession, magnetization and Bloch eqns. (2 weeks)
2. Connections to quantum mechanics and thermal physics (1 week)
3. Signal concepts, spin and gradient echoes, Fourier imaging in multi-dimensions (2 weeks)
4. Sampling, aliasing, filtering, and resolution, discrete Fourier transforms (2 weeks)
5. Projection reconstruction, signal, contrast, and noise (1 week)
6. Chemical shifts, fast imaging, and image distortion (2 weeks)
7. Diffusion and other parameter measurements (1 week)
8. Motion (1 week)
9. Tissue magnetic properties; sequence design (1 week)
10. MR coil design (1 week)