**EE 591: Magnetic Resonance Imaging and Reconstruction**  
**Spring 2015 Syllabus**

**Instructor:** Prof. Krishna Nayak  
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OH: TBD

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**Grader:** TBD

**Lectures:** Fridays 1:00 - 3:50pm  
Location TBD

**Website:** [http://ee-classes.usc.edu/ee591/](http://ee-classes.usc.edu/ee591/)  
Handouts and Homework will be posted here  
[https://piazza.com/usc/spring2015/ee591/home](https://piazza.com/usc/spring2015/ee591/home)  
Discussion and Q/A will happen here

**Prerequisites:**  
Required: EE 483 (digital signal processing)  
Required: Familiarity with MATLAB

Magnetic resonance imaging (MRI) is an incredibly powerful and widely used technique for imaging structure, function, and other properties of soft tissues within the human body. Roughly 80 million clinical MRI scans are performed each year. MRI is also used extensively in biomedical and neuroscience research. The acquisition and reconstruction of images is rooted in Fourier transforms and linear systems. The first half of the course will cover the physics of MRI, selective excitation, image acquisition, linear image reconstruction, image contrast, volumetric imaging, and various system imperfections. The second half will cover advanced topics such as ultra-fast imaging, contrast manipulation, RF pulse design, application of compressed sensing, image artifact correction, the patent landscape, and unique features of the MRI industry. At the end of the course, you will know precisely how 95% of all MRI’s are obtained, and will be able to follow the latest trends in the field. Coursework will be motivated by current clinical and research applications that include brain, spine, musculoskeletal, and cardiac imaging. Class will meet once per week for three hours, there will be weekly homework, two exams, and a final project.

**Required Text:**  
- DG Nishimura, *Principles of Magnetic Resonance Imaging*  
  [http://tinyurl.com/usc-ee591-text](http://tinyurl.com/usc-ee591-text)  

**Additional References:**  
- EM Haacke et al., *Magnetic Resonance Imaging: Physical Principles and Sequence Design*, Wiley  
- RN Bracewell, *The Fourier Transform and it’s Applications*, McGraw Hill
Software:
- MATLAB™ Mathworks, Inc., South Natick, MA
- SpinBench™ http://www.spinbench.com/ (Mac OSX only)

Grading:
- Homework 40%
- Project 20%
- Exams 40%

TOPICS:

PHYSICS, ACQUISITION, RECONSTRUCTION
Classical description of NMR “spins”
- Polarization, precession, relaxation and the Bloch Equation
- Magnetic fields used in MRI
- k-space
- Selective Excitation (small-tip approximation)
- Pulse sequence design, resolution and field of view
- Bloch Simulation in MATLAB and SpinBench
- Basic Image Reconstruction in MATLAB
- Image Contrast based on tissue relaxation properties
- Imaging Considerations: Flow and Motion; System Imperfections
- Noise in MRI
- 3D Imaging

ADVANCED TOPICS
- Innovation and Entrepreneurship in MRI
- Parallel Imaging Reconstruction
- Non-Cartesian k-space reconstruction
- Constrained and Model-based Reconstruction
  - Partial k-space
  - Fat-Water separation
- Spoiled Gradient Echo Imaging
- Steady-State Free Precession Imaging
- Excitation k-space, 2D pulses, spectral-spatial pulses
- Shinnar-LeRoux RF pulse design
- Adiabatic RF pulses

SUGGESTIONS

My primary interest is that you learn as much as possible, that you find the material interesting, and that you finish the course wanting to know more about this subject. There are a few important things you can do: (i) ask questions, (ii) actively respond to questions posed in class, (iii) make use of office hours, (iv) read about applications of the course material, (v) learn to use MATLAB and SpinBench, (vi) remember that exams, grades, and degrees are a means to an end and not an end in itself.

STUDENTS WITH DISABILITIES:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is
located in STU 301 and is open 8:30 a.m. – 5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

ACADEMIC INTEGRITY:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A: [http://www.usc.edu/dept/publications/SCAMPUS/gov/](http://www.usc.edu/dept/publications/SCAMPUS/gov/). Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: [http://www.usc.edu/student-affairs/SJACS/](http://www.usc.edu/student-affairs/SJACS/).