BCH 6741C
Magnetic Resonance Imaging and Spectroscopy in Living Systems

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Office hours: Tuesdays and Thursday, 4:30 to 5:30 pm by appointment
Course web site: UF E-Learning in Canvas (http://lss.at.ufl.edu)

Course Objective: To provide students with knowledge necessary to apply modern methods of MR imaging and spectroscopy in vivo to solve research problems.

Course Goals: Lectures will provide a detailed treatment of theory of nuclear magnetic resonance imaging and spectroscopy necessary to understand current methods for visualizing the structure of cells, tissues, whole animals, and humans with a focus on living systems. Also current methods will be discussed which allow the monitoring of biochemical processes in cells suspensions, whole animals, and humans using in vivo MR spectroscopy. In addition, the lab will provide the student with practical experience in sample preparation, operation of the instrumentation, data analysis and construction of simple MR radio frequency coils.

Registration: A student can register for the lecture portion of the course of two-credit hours, or both the lecture and lab for three-credit hours or just the lab portion for 1 hour credit. The best option is registration for both the lecture and lab portions, which reinforce each other.

Lectures (1-hour class twice a week on Tuesday and Thursday during 4th period):
Week 1: Behavior of magnetic moments in an applied magnetic field (Chap. 2)
Week 2: RF coils, magnetic field gradients and the rotating reference frame (Chap. 3)
Week 3: Relaxation and magnetic-field-strength dependence (Chap. 4)
Week 4: Signal detection and Fourier transformation (Chaps. 7, 8)
Week 5: Multiple RF pulses, echoes, and one-dimensional imaging (Chaps. 9, 10)
Week 6: Imaging in multiple dimensions (Fourier imaging) and slice selection (Chaps. 10)
Week 7: Rapid imaging methods: FLASH, Echo Planar, Spiral, and RARE (Chaps. 19)
Week 8: Image contrast: SNR, relaxation, and flow (Chap. 8, Sect 3 & Chaps.15, 22-24)
Week 9: Diffusion weighted imaging (Chap. 21)
Week 10: Functional magnetic resonance imaging (Chap. 25)
Week 11: Basic quantum description of NMR (Chaps. 5-6 and class notes)
Week 12: Chemical shift and scalar coupling (class notes)
Week 13: Chemical-shift-selective and spectroscopic imaging (Chap. 10 & class notes)
Week 14: Localized MR spectroscopy and adiabatic excitation (class notes)
Week 15: Measurement of physiological parameters: pH and reaction rates (class notes)
Laboratory (3-hour class; once a week for 5 weeks at appropriate times during the term):

1. RF magnetic field coils and construction
   - Coil circuit elements and radio-frequency response
   - Coil construction
   - Effect of the number of turns on apparent inductance

2. Basic image processing
   - Fourier transformation, scaling and image display
   - T1 and T2 relaxation time calculation
   - Analyzing dynamic contrast enhanced images

3. MR imaging *in vivo*
   - Lab Safety
     - Effects of static magnetic fields
     - Biological effects of the magnetic resonance process
   - NMR Instrumentation
     - Overview of hardware and software systems
     - Sample loading and RF coil tuning
     - Shimming and RF pulse-power calibration
     - $^1$H NMR imaging (quantification of T1 and T2 relaxation times)
   - Samples for labs; Vegetable or fruit (e.g. apple, kiwi, or orange) or grocery store hen's egg, each no more than 4 cm wide.

4. Diffusion weighted image processing
   - Diffusion tensor image calculation
   - Analysis of rate of diffusion and diffusion anisotropy
   - Fiber track mapping

5. P-31 NMR spectroscopy and the measurement of physiological processes
   - NMR spectroscopy processing (e.g. Fourier transformation, phase correction)
   - Measurement of pH and reaction rates
**Class attendance**: Class attendance is not required, but without regular attendance the student will miss a great deal of important discussion and interaction. In addition, some of the material covered will only be available in class notes.

**Missed assignments and make-up exams**: Assignments cannot be turned in late unless prior arrangements have been made with the instructor. Making up the quizzes or final exam is possible with prior approval of the instructor. Special arrangements can be made in case of a documented emergency.

**Grading**: A grade for the lecture portion of the course will be based on the results from graded homework (30%), mid-term exam (30%), and a final exam (40%). For the laboratory portion of the course, grade will be based on participation and graded lab reports. For students registered for both the lecture and laboratory portion of the course, a combined grade will be assigned with 2/3 of the grade from the lecture portion and 1/3 from the lab portion.

**Textbook and Journal Articles**:

Textbook (see below): Magnetic Resonance Imaging: Physical Principles and Sequence Design, by E. M. Haacke, R. W. Brown, M. R. Thompson, and R. Venkatesan, John Wiley & Sons, Inc, 1999. *The book is expensive so I have designed the course to use this book as complementary reading. You can get by without purchasing this book, but reading the book is very, very helpful. It is a good reference and you might be able to find a used copy.*

Journal articles: Early literature on the basics of MR and recent literature (1990-2010) published in the journals, such as Journal of Magnetic Resonance, Magnetic Resonance in Medicine, and Magnetic Resonance Imaging.

**Students with Disabilities**: Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation.