Spring 2017: MPHY8147 Advanced Physics of MRI

Days and Times 10-11:15 am, Tuesday and Thursday, Spring Semester 2017

Location Seminar room, Center for Magnetic Resonance Research (CMRR)

Credits 3 Cr. (two 75-minute lectures per week)

Instructor Patrick Bolan
2-138 CMRR
Office Hours – by appt
bola0035@gmail.com

Prerequisites Undergraduate level calculus and calculus-based physics; familiarity with linear algebra;basic familiarity with Matlab programming

Text *Principles of Magnetic Resonance Imaging* by Dwight G. Nishimura printed by www.lulu.com ($42.50)

Recommended References

Magnetic Resonance Imaging, by E Mark Haacke, Robert W. Brown, Michael R. Thompson, and Ramesh Venkatesan. Wiley and Sons

Handbook of MRI Pulse Sequences, edited by Matt A. Bernstein, Kevin F. King, and Xiaohong Joe Zhou. Academic Press.

Course Description:

Advanced Physics of MRI is a graduate/undergraduate senior level course that teaches the principles of nuclear magnetic resonance imaging (MRI) as used in biomedical research and clinical radiology. Students will learn about nuclear spin, radiofrequency pulses, spatial encoding, digital signal acquisition and processing, image reconstruction, image contrast, and advanced pulse sequences. Magnetic resonance spectroscopy (MRS), as used to measure metabolism in living systems, will also be covered. The course will include several guest lectures covering many of the specialized uses of MRI and MRS in biomedicine, including fMRI, diffusion imaging, and quantifying metabolite concentrations. Students will gain laboratory experience in acquiring MR images and spectra using one of the MRI scanners at the CMRR. There will also be a project, for which each student will select a landmark paper in MR to investigate and present to the class in a 15-minutes presentation.

Learning Objectives

After successfully completing this course, students should be able to:

- Explain the classical physics of NMR
- Identify the components of an MR system and describe their use
- Identify the components of an MRI pulse sequence, and be able to calculate their amplitudes & durations
- Use the Bloch equations to analytically describe the evolution of magnetization in an MR pulse sequence
- Perform basic reconstruction of MR images using Matlab

- Describe methods for measuring and encoding MR relaxation properties
- Assess and explain advanced topics in the MR literature

Tentative Course Schedule

Week	Date	Description	Instructor
1	1/17/17	Overview and Math Review	Bolan
1	1/19/17	Classical NMR Physics	Bolan
2	1/24/17	Relaxation, Excitation, and the Bloch Eqns	Bolan
2	1/26/17	Basic NMR experiments	Bolan
3	1/31/17	MR System Hardware and RF Coils	Adriany
3	2/2/17	**Lab - Intro to the MR System**	
4	2/7/17	Pulse sequence elements	Bolan
4	* 2/9/17	Signal detection and sampling	Bolan
5	2/14/17	Spatial Encoding	Bolan
5	2/16/17	Image Reconstruction	Bolan
6	2/21/17	Basic MRI sequences	Bolan
6	2/23/17	MRI SNR and Spatial resolution	Bolan
7	2/28/17	Image contrast	Bolan
7	3/2/17	Advanced MR Methods	Bolan
8	3/7/17	**Midterm**	
8	* 3/9/17	RF Pulses	Garwood
9	3/14/17	Spring Break - no class	
9	3/16/17	Spring Break - no class	
10	3/21/17	Relaxation mechanisms & relaxometry	Garwood
10	3/23/17	**Lab – Contrasts & system calibration**	
11	3/28/17	Parallel Imaging	Moeller
11	3/30/17	MRS: SVS	Tkac
12	4/4/17	MRS: CSI/MRSI	Metzger
12	4/6/17	MRS: Quantification	Bolan
13	4/11/17	**Lab - MRS**	Tkac
13	4/13/17	EPI/fMRI	Ugurbil
14	4/18/17	MRI in Clinical practice	McKinney
14	4/20/17	MRI Safety	Eryaman
15	4/25/17	Diffusion MRI	Lenglet
15	4/27/17	ISMRM - no class	
16	5/2/17	Student presentations	Bolan
16	5/4/17	Review	Bolan
17		**Final Exam**	

* These two classes may be moved to a different room at the CMRR

Grading

Scale:	A= 90-100%; B=80-89%; C=70-79%; D=60-69%; F= <60%
Assessments:	weekly homework assignments (25%) 1 project with classroom presentation (25%) 1 mid-term exam (25%) 1 final exam (25%)

Late Work: All assignments must be submitted to me by 5 p.m. on the stated date. Late work will be penalized 5% for each day it is late. The weekend counts as one day.

Make Up Work: Accommodation for missed exams or assignments will be made for legitimate, documented excuses.

Expected workload
Students are expected to spend 2 hours in out-of-class work for each in-class hour.

Technology Requirements
Students will need access to ***Matlab*** or some other technical computing environment (e.g., python). If you do not have it available through your own lab you can access it through the CSE Labs: https://wwws.cs.umn.edu/download_software/matlab

Scholastic Conduct
Academic integrity is essential to a positive teaching and learning environment. All students enrolled in University courses are expected to complete coursework responsibilities with fairness and honesty. Failure to do so by seeking unfair advantage over others or misrepresenting someone else's work as your own, can result in disciplinary action.

Communication
This term we will be using Moodle for distributing course materials, submitting homework, and for class discussion. The class URL is pending,

Disabilities
We will make every reasonable effort to accommodate students with disabilities. Please communicate with Prof. Bolan directly via email, phone, or in person to help set this up.

Student Conduct
Instructors are responsible for maintaining order and a positive learning environment in the classroom. Students whose behavior is disruptive either to the instructor or to other students will be asked to leave. Students whose behavior suggests the need for counseling or other assistance may be referred to their college office or University Counseling Services. Students whose behavior may violate the University Student Conduct Code may be referred to the UMC Student Conduct Committee.

Sexual Harassment
Please note that sexual harassment by any member of the University community, student, faculty, staff, administration, is prohibited. To review the complete policy on this issue, view the following webpage
http://www1.umn.edu/regents/policies/humanresources/SexHarassment.pdf.