Spring 2015: MPHY8147 Advanced Physics of MRI

Days and Times: 1 – 2:15 pm, Tuesday and Thursday, Spring Semester 2015

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

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

Text: Principles of Magnetic Resonance Imaging
by Dwight G. Nishimura, printed by www.lulu.com

Recommended References: Principles of Nuclear Magnetic Resonance Microscopy, by Paul T. Callaghan, Oxford University Press

Prerequisites: Undergraduate level calculus and calculus-based physics; familiarity with linear algebra

Evaluation Scheme: graded homework assignments, 1 required classroom presentation, 2 mid-term exams, 1 final exam

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, flow, and quantifying metabolite concentrations. Students will gain laboratory experience in acquiring MR images and spectra using one of the MRI scanners at the CMRR. Near the end, each student will give a 15-minute presentation describing a relevant journal article about theoretical principles or an application of MRI or MRS.

Course Schedule:

Date	Topic	Instructor
T 1/20	Review of the necessary mathematics	Garwood
Th 1/22	Nuclear spin, Boltzman	“
T 1/27	Semi-classical description of NMR – The Bloch equations	“
Th 1/29	Relaxation and Chemical shift	“
T 2/3	Pulse sequence elements a) RF pulses b) Gradient pulses c) Selective excitation	“
Th 2/5	d) Signal acquisition	“
T 2/10	e) Frequency encoding f) Phase encoding	“
Th 2/12	MRI sequences, data acquisition and optimization a) Gradient echo	“

Date	Topic	Instructor
	b) Hahn and Carr-Purcell Spin Echoes c) Stimulated echo	
T 2/17	Ernst equation, Signal-to-noise (SNR), spatial resolution	"
Th 2/19	Lab Session – Image Acquisition	Einstein
T 2/24	1st mid-term exam	
Th 2/26	Digital signal processing and image reconstruction a) Signal equation b) Digital sampling requirements (Nyquist)	"
T 3/3	Scanner hardware and RF coils	Adriany
Th 3/5	c) k-space d) Basic FT reconstruction e) Post-processing and image artifacts	Garwood
T 3/10	B0 and B1 inhomogeneity mapping	Van de Moortele
Th 3/12	Image contrast and relaxation time weighting and mapping a) T1 b) T2 c) T2* d) contrast agents e) diffusion	"
T 3/17 Th 3/19	SPRING BREAK	
T 3/24	Parallel imaging	Moeller
Th 3/26	Lab Session – Producing different contrasts	Einstein
T 3/31	Magnetic Resonance Spectroscopy (MRS) a) shimming b) single voxel MRS	Tkac
Th 4/2	c) CSI	Metzger
T 4/7	d) metabolite quantification	Bolan
Th 4/9	2nd mid-term exam	
T 4/14	Lab Experience –MR spectroscopy	Tkac
Th 4/16	Mapping relaxation times; rotating frame relaxation	Garwood
T 4/21	Specialized sequences and applications a) EPI; fMRI	Ugurbil
Th 4/23	b) Perfusion	Ugurbil
T 4/28	c) Radial MRI	Garwood
Th 4/30	MRI Safety	Shrivastava
T 5/5	Student presentations	
Th 5/7	Review	Garwood
T 5/12	Final Exam	