MEDICAL PHYSICS 568: PHYSICS OF MAGNETIC RESONANCE IMAGING

MWF, 8:50AM, RM WIMR 1022 (3 CREDITS)
INSTRUCTOR: M. ELIZABETH MEYERAND, DEPT OF MEDICAL PHYSICS
WIMR 1129 or 2128 ECB (EMAIL:MEMEYERAND@.WISC.EDU)
263-1685 OFFICE HOURS: FLEXIBLE. CALL FOR APPOINTMENT

Textbook: MRI: The Basics by R.H. Hashemi, W.G. Bradley and C.J. Listanti
COURSE OUTLINE: SPRING, 2013

DATE		TOPIC	HOMEWORK
W	22-JAN	INTRODUCTION, CLASS OVERVIEW, MATH REVIEW	**Read Ch. 1, 2 & 9**
F	24-JAN	*Jigsaw activity*: BASIC PRINCIPLES OF MRI	**Q: Ch. 2**
M	27-JAN	"	
W	29-JAN	"	
F	31-JAN	Ans to Chap 2; Begin prob set #1	
M	3-FEB	prob set #1 con't	**Read Ch. 3 & 4**
W	5-FEB	Prob set #1 con't; present prob set #1 to class	
F	7-FEB	RF Pulse & T1, T2 & T2* in class "newspaper exercise"	**Work on exercise**
M	10-FEB	"newspaper exercise" con't	**Work on exercise**
W	12-FEB	Present Newspaper Exercise – "cocktail party"	**Read Ch. 5-8**
F	14-FEB	Fast Fourier in a nutshell	
M	17-FEB	PULSE SEQUENCES - lecture	
W	19-FEB	**EXAM #1**	
F	21-FEB	HARDWARE – begin group work	**Read Ch. 10 & 27: Q: Ch. 27**
M	24-FEB	HARDWARE con't	**Read Ch. 27: Q: Ch. 27**
W	26-FEB	2 groups give Powerpoints	**Read Ch. 11-13**
F	28-FEB	2 groups give Powerpoints	**Read Ch. 11-13**
M	3-MAR	IMAGING I - lecture	**Q: Ch. 11-13:Read Ch. 14-17**
W	5-MAR	Ans to Chap 14-17; prob set #2 in class	
F	7-MAR	IMAGING II – lecture K-SPACE; Prob set #3 in class	**Read Ch. 20-23: Q: Ch. 20-21**
M	10-MAR	Ans to Chap 20-21 – lecture EPI, FSE GRASE	**Read Ch. 19: Q Ch. 19 & 23**
W	12-MAR	**EXAM #2**	
F	14-MAR	ARTERIAL SPIN LABELING (ASL) *jigsaw activity*	**Read Ch. 24-26**

-------- SPRING BREAK --------

M	24-MAR	ASL *jigsaw activity*	
W	26-MAR	ASL *jigsaw activity*	
F	28-MAR	ASL *jigsaw activity*	
M	31-MAR	ASL *jigsaw activity*	
W	2-APR	TOF & FLOW COMP - lecture	
F	4-APR	PHASE CONTRAST - lecture start prob set #4	**Complete prob set #5 post**
M	7-APR	Diffusion MRI Part I - lecture	**Read Ch. 18**
W	9-APR	Diffusion MRI Part II - lecture	
F	11-APR	Diffusion MRI Part III - lecture	
M	14-APR	Diffusion MRI Part IV - lecture	
W	16-ARR	ARTIFACTS - lecture	**Q: Ch. 18**
F	18-APR	ARTIFACTS & MRS - lecture	
M	21-APR	Ans to Chap 18; Prob set #5 in class	
W	23-APR	Imaging Jeopardy activity	
F	25-APR	**EXAM #3**	
M	28-APR	CLINICAL GROUP WORK	**Clinical group work**
W	30-APR	"	**Clinical group work**
F	2-MAY	PRESENTATIONS	
M	5-MAY	PRESENTATIONS	
W	7- MAY	PRESENTATIONS	
F	9- MAY	PRESENTATIONS	

IN CLASS PROBLEM SETS: The course is split into 3 sections of subject matter. At the conclusion of each section there will be an exam. During each section, you will have opportunities to work in groups to solve problem sets during class time. A person from the group will present the answers to each problem to the rest of the class. During the semester you must present the solutions to at least 2 problems. You must decide amongst your group which problems you will present.

CLINICAL GROUP WORK:
At the end of the course, your group will be required to give a 20-minute oral presentation based on some patient data that you will be given. Each member of your group will have to comment on a specific aspect of the patient data set. More details on the activity will be given toward the end of the semester. Your grade on the presentation will be based on: 1/3 presentation style (eye-contact with the audience, not simply reading your slides, talking with sufficient but not excessive volume, no distracting mannerisms, 1/3 presentation professionalism (clarity of speech and readability of slides, staying within the time limit), 1/3 technical clarity and accuracy (presenting sufficient background material, explaining your topic clearly and accurately).

GRADING AND SCHEDULE:

Grading: highest/middle/lowest exam scores weighted 25/20/15%, "group" grade for your clinical group work presentation: 25%. The remaining 15% of your grade will result from your presentation of problem set questions. Exams will cover material presented in lectures AND in the problem sets and group activities so make sure you understand your classmate's answers to the problem sets AND the material covered in the group activities.

COURSE CONTENT:

INTRODUCTION: Introduction to magnetic resonance imaging and spectroscopy & review of Fourier transform theory as it applies to MRI.

MR PHYSICS: Introduction to MR physics. The origin of the magnetic moment, definition of units used in MRI and the behavior of the magnetic moment in a magnetic field. This section also includes a discussion of the chemical shift and it's relevance to MR.

CLASSICAL MR: A description of the magnetic resonance phenomenon from the classical physics perspective: Spin precession, excitation and a derivation of the Bloch equations.

SIGNAL DETECTION: Detection of the MR signal: Induction of a MR signal in a RF coil using the principle of reciprocity and also includes sections on signal demodulation, signal to noise ratio and tissue heating by RF energy.

PULSE SEQUENCES: Includes examples of the most basic RF pulse sequence yielding a free induction decay. Other topics include a saturation recovery sequence, steady-state free precession, the Carr-Purcell sequence and multiple spin echo sequences. Application-specific sequences for fat and cerebral spinal fluid nulling are also included.

SELECTIVE EXCITATION: The generation of "hard" and "soft" RF pulses. The generation of binomial, adiabatic and composite RF pulses along with a discussion of their application.

MR HARDWARE: The basic hardware elements of a MRI system. The construction and design of RF and gradient coils.

IMAGING METHODS: The entire process of image generation including slice selection, phase encoding and signal readout. Multi-slice imaging along with 3D volume imaging.

ADVANCED TECHNIQUES: The different methods to decrease imaging time. Fast and single-shot techniques such as EPI and FSE will be contrasted to each other in terms of speed, spatial resolution and the production of artifacts.

ARTERIAL SPIN TAGGING: The different methods of arterial spin tagging (AST) for imaging blood flow and perfusion will be addressed. Limitation and advantages of each method along with their respective applications.

IMAGE QUALITY: The limitation in intrinsic resolution is defined. Alternative k-space sampling schemes are presented. Contrast to noise is defined and assessed for several imaging methods.

ARTIFACTS; The most common types of MR artifacts are displayed and the mechanisms behind them discussed. Artifacts discussed include: susceptibility, chemical-shift, aliasing, truncation and data acquisition.

PHASE GHOSTS: Phase ghosts. The phenomenon of phase ghosting in MR is defined and explained in terms of motion ghosting, quadrature errors and data modulation in k-space.

FLOW AND DIFFUSION: Spin tagging and phase contrast methods are described. "Black" blood and "bright" blood methods are explained. Diffusion imaging is described in one and three dimensions.

PERFUSION: Perfusion imaging with contrast agent injection will be described in detail.

SPECTROSCOPY: In vivo spectroscopy. Different methods of localized spectroscopy are described. A discussion is also included of spectroscopy using nuclei other than protons.