BPhy 8147 – Advanced Physics of MRI
Fall Semester, 2005

Instructors

Cheryl Olman*	6-7601	cheryl@cmrr.umn.edu	243 Elliott
Pat Bolan	6-2001	bolan@cmrr.umn.edu	108.1 CMRR
Malgorzata (Gosia) Marjanska	4-4580	gosia@cmrr.umn.edu	105 CMRR
Kamil Ugurbil	6-9592	kamil@cmrr.umn.edu	102C CMRR
Pierre-Francois Van de Moortele	5-8397	pfvdm@cmrr.umn.edu	102K CMRR

*instructor of record

The class will meet Tuesday/Thursday 10:10 – 11:30 at the CMRR (Room 107, Seminar Room). There will be six laboratory sessions which may be scheduled for a different time slot – this will be discussed on the first day of class. Updated schedules, assignments and answer keys, and supplemental readings will be posted on the course website: http://www.cmrr.umn.edu/class/Bphy8147

Course Description

NMR (nuclear magnetic resonance) and MRI physics, spatial selection and encoding, imaging hardware and system engineering. Imaging sequences, associated contrast/resolution. NMR spectroscopy with an emphasis on *in vivo*. Recent developments in MRI.

Homework assignments will be provided weekly, and there will be a final exam. Lab assignments will be integrated with the lectures and crucial for course completion; CMRR site-specific safety training will be required for lab participation.

Grading and Attendance Policy

The course is offered for three credits, graded on an A-F basis (93 – 100 A, 90 – 92 A-, 88 - 89 B+ … <60 F).

- Homework will comprise 50% of the course grade.
- Lab participation and attendance will comprise 30% of the course grade.
- The final exam will contribute 20% of the course grade.

Textbooks and Other Readings

No required textbook. Copies of relevant materials will be provided. Suggested texts:

- *Magnetic Resonance Imaging – Physical Principles and Sequence Design* by EM Haacke, RW Brown, MR Thompson, R Venkatesan
- *Magnetic Resonance Imaging* by M. T. Vlaardingerbroek and J. A. den Boer
- *Handbook of MRI Pulse Sequences* by M. A. Bernstein, K. F. King, and X. J. Zhou
- *Spin Dynamics* by M. Levitt
- *In Vivo Spectroscopy* by R. de Graaf

Date	Topic	Description	Lecturer
9/6	*Introduction*	Math and (classical) physics reminders	Olman
9/8	*Quantum mechanics*	Spin-1/2 nuclei: frequency, precession, population distribution, bulk magnetization, chemical shift	Olman
9/13	*FID*	Relationship between frequency and temporal domains, noise, simple spectra	Olman
9/15	*RF pulses, Part I*	Excitation, frequency (bandwidth), phase	Olman
9/20	*LAB 1 (9.4T)*	Hardware, introduction to FID, bandwidth (no imaging gradients)	Olman
9/22	*Bloch equations*	Derivation; addition of relaxation; steady state solution with multiple pulses	Olman
9/27	*RF pulses, Part II*	90, 180, temporal envelope and frequency selectivity, pulse sequence diagrams	Bolan
9/29	*Imaging introduction*	Gradients, slice selection, readout encoding	Bolan
10/4	*Imaging introduction*	Phase encoding, 2D FT, k-space	Bolan
10/6	*Imaging basics*	Gradient echo, spin echo, pulse sequence diagrams, 3D imaging	Bolan
10/11	*LAB 2 (9.4T) See note below**	Measure T_1 and T_2 in high resolution samples, no localization	Marjanska, Olman
10/13	*No class*	Minnesota workshop	
10/18	*Imaging basics*	Interactive rehearsal for imaging laboratory	Bolan
10/20	*Fast Imaging*	Concepts of k-space coverage, FLASH, EPI, SPIRAL, fast SE	Van de Moortele
10/25	*LAB 3 (3T) See note below***	Imaging introduction: flip angle, FOV, phase encoding, resolution, etc.	Bolan
10/27	*Imaging/contrast Lyons Research Bldg*	Bloch revisited: gray/white/CSF intensity	Ugurbil
11/1	*Lab 3 (3T) makeup Only for Tues group*	Imaging introduction: flip angle, FOV, phase encoding, resolution, etc.	Bolan
11/3	*LAB 4 (4 or 9.4T)*	2D imaging – slow and fast	Van de Moortele
11/8	*Fast Imaging*	Details of EPI and SPIRAL, imperfections and resulting artifacts	Van de Moortele
11/10	*Imaging/contrast*	Magnetization prepared fast imaging. Partial voluming, imaging sequences advantages and disadvantages. Other parts of the body; clinical topics	Ugurbil
11/15	*Coils and RF pulses*	Tuned circuit, volume and surface coil, advanced RF pulses (adiabatic)	Ugurbil
11/17	*LAB 5 (3T)*	Contrast in the brain (Siemens)	Olman
11/22	*Parallel imaging*	Hardware and image reconstruction	Van de Moortele
11/24	*No class*	Thanksgiving	
11/29	*Spectroscopy*	Chemical shift, J-coupling (^{1}H)	Marjanska
12/1	*Spectroscopy*	Different nuclei, including spin > 1/2	Marjanska
12/6	*Lab 6 (4 or 9.4T)*	Spectroscopy	Marjanska
12/8	*Spectroscopy*	Localization (CSI, ISIS, PRESS, STEAM, LASER)	Marjanska
12/13	*Shimming*	Concepts, B_0 field mapping, FASTMAP	Van de Moortele
TBD	*Final exam*		

* For Lab 2, those groups that normally meet on Tuesdays will meet on Tues 10/11. Those in the Wednesday lab sections will meet on Wednesday 10/12. ** For Lab 3, those groups that normally meet on Tuesdays will meet on Tues 10/25. Those in the Wednesday lab sections will meet on Wednesday 10/126.