BME 427: ADVANCED MRI

2026 Spring Quarter

- **Time:** Mondays and Wednesdays, 5:00pm - 6:20pm
- **Location:** Conference Room, 737 N. Michigan Avenue Suite 1600, Chicago 60611 (downtown NU Campus, entrance the the building is on Chicago Avenue)
  In person presence for all course dates is required
- **First class: Tuesday, March 31, 2026**

Instructor

Michael Markl, PhD
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Who takes it: Doctoral and Master Degree students. Advanced Undergraduate students may register with permission of the instructor.

Prerequisite

- General Physics
- BME 305 (Biomedical Signals Analysis)
- BME 327 (Magnetic Resonance Imaging)

or permission of instructor

<u>Physics & mathematics background:</u> vectors, rotation matrices, 1st order differential equations, complex numbers, exponential functions, Fourier Transform, magnetic moment and magnetic field, electromagnetic fields and waves, induction

<u>MRI background:</u> A solid understanding of fundamental physics and engineering concepts of MRI is required (as covered in BME 327): MRI fundamental concepts and image formation; pulse sequence design; k-space, finite sampling and image reconstruction; relaxation and contrast; image quality (SNR, CNR).

<u>Course project work & MATLAB:</u> Course project work will require MATLAB for coding and developing scrips for of MRI image reconstruction, analysis, and display. ***Familiarity with Matlab is an important prerequisite for this course***.

Required Materials / References

The following review articles are good references for preparing for the course.

- Donald B. Plewes, Walter Kucharczyk. Physics of MRI: A Primer. JOURNAL OF MAGNETIC RESONANCE IMAGING 35:1038–1054 (2012)
- Thomas A. Gallagher, Alexander J. Nemeth, Lotfi Hacein-Bey. An Introduction to the Fourier Transform: Relationship to MRI. AJR 190:1396–1405 (2008)

Additional Reading materials will be provided during class

Grading System

Item	% of final grade	Comments
Attendance / Participation	30%	
Project	40%	Project – presentations (midterm, final)
Project	30%	Project – written report

Grading scale:

>=93	A
90-93	A-
87-90	B+
83-87	B
80-83	B-
77-80	C+
73-77	C
70-73	C-

Course Attendance: The design of this course is built around student participation in a small group (see also grading system above). Class attendance is thus mandatory.

Course Description: This is a project-based course in the use of MRI for imaging living tissue. The flexibility of MRI to determine image contrast through altering pulse sequences results in MR being used in a broad range of clinical applications. This course will develop an understanding of the use and design of MR techniques and pulse sequences, image reconstruction, and advanced MRI data analysis concepts. This will include an emphasis on understanding of the more widely used MR acquisition strategies, of image contrast mechanisms, and of data acquisition strategies (k-space sampling, reconstruction, fast imaging, and parallel acquisition concepts).

The course will be split into three sections: The first section will revisit fundamentals and basic concepts of MRI and their applications to disease diagnosis (MRI fundamental concepts and image formation; pulse sequence design; k-space, finite sampling and image reconstruction; relaxation and contrast; image artifacts, fast imaging methods; SNR, CNR, and image artifacts). The second section will cover the more widely used advanced MRI image acquisition strategies and applications areas. Finally, each student will select a project (development of Matlab based MRI data acquisition or analysis/manipulation/reconstruction). The course will culminate with a series of student presentations that will consist of 15-minute project presentations (+ group discussion) which will count as the final project.

Hands-On MRI Lab: The course will include hands-on lab work at MR systems at the Center of Translational Imaging (CTI) at the downtown Chicago campus. Sessions will include hands-on experience with MR imaging and data acquisition using CTI's state-of-the art human MRI systems. MRI data collected during the lab session will be provided to students to conduct further image processing, analysis, and interpretation.