# BIM 241 – Introduction to Magnetic Resonance Imaging

Fall 2020

**Instructor:** Audrey Fan (apfan@ucdavis.edu)
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Office Hours (virtual): Tuesdays at 10:00am and by appointment
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**TA:** Greg Wheeler (gjwheeler@ucdavis.edu)
Office Hours (virtual): Wednesdays at 11:00am
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**Course Lectures:** **Tuesdays and Thursdays, 8:30 – 9:50am**
https://ucdavis.zoom.us/j/94482937263?pwd=RjN6T0RsSVZxRHVHWU9GOU50OVFwQT09

**Prerequisites:** Background in engineering with basic knowledge of signals and systems, e.g., Fourier transforms and convolution. Familiarity with linear algebra and MATLAB software.

**Learning Goals:** By the end of the course, students will be able to

1. Describe the basic hardware, acquisition, and reconstruction concepts of magnetic resonance imaging (MRI).
2. Employ fundamental concepts of MRI physics to characterize and make predictions about image properties.
3. Implement an advanced MRI acquisition or reconstruction approach in MATLAB to demonstrate the effect of optimizing design parameters.

**Text**: "*Principles of Magnetic Resonance Imaging*" by Dwight G. Nishimura

**Optional Sources:** "*Handbook of MRI Pulse Sequences*." M.A. Bernstein, K.F. King, X.J. Zhou. Elsevier Academic Press, Burlington, MA, 2004

"*Principles of Magnetic Resonance Imaging: A Signal Processing Approach*." Z-P. Liang, P.C. Lauterbur. Series in Biomedical Engineering. IEEE Press, New York, 2000

**Grading:** The final grade reflects our beset assessment of your understanding of the material and will be weighted as:

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|---|---|
| **Problem Sets** | **40%** |
| **Midterm (in-class)** | **20%** |
| **Final Project** | **40%** |

**Problem Sets:** Problem sets are due at the beginning of lecture on the due date. Collaboration with one classmate is permitted, provided the write-up is your own and you provide the name of your partner on your solutions.

The problem sets and the final project of the course will rely heavily on MATLAB. All figures should have labeled axes and colorbar scales where appropriate.

**Tentative schedule:**

| Date | | Topic | Notes | Problem Sets |
|---|---|---|---|---|
| Oct 1 | Thu | 1. Course overview and MRI introduction | **Nishimura Ch. 3.1** | |
| Oct 6 | Tue | 2. Physics of MRI: Bloch equation | **Nishimura Ch. 4.4 – 4.5** | |
| Oct 8 | Thu | 3. Signal equation and Fourier interpretation (k-space) | **Nishimura Ch. 5.1-5.3** | **Pset 1 due** |
| Oct 13 | Tue | 4. Signal equation continued | **Nishimura Ch. 5.4 – 5.6** | |
| Oct 15 | Thu | 5. Sampling, field of view, and spatial resolution | **Nishimura Ch. 5.7** | **Pset 2 due** |
| Oct 20 | Tue | 6. Spin echoes, inversion recovery, and image contrast | **Nishimura Ch. 7.1 – 7.2, 7.4** | |
| Oct 22 | Thu | 7. Signal-to-noise ratio in MRI | **Nishimura Ch. 7.5** | **Pset 3 due** |
| Oct 27 | Tue | 8. Radiofrequency (RF) excitation and rotating frame | **Nishimura Ch. 6** | |
| Oct 29 | Thu | 9. Small-tip approximation to RF pulses, ***Class project overview*** | | **Pset 4 due** |
| Nov 3 | Tue | 10. Fourier design of RF pulses and review | **Class notes** | |
| Nov 5 | Thu | **MIDTERM (self-paced)** | | |
| Nov 10 | Tue | 11. Partial k-space, conjugate synthesis, field mapping | **Bernstein Ch. 13.4 – 13.5** | |
| Nov 12 | Thu | 12. Reconstruction of non-Cartesian data | **Bernstein Ch. 13.2** | **Project proposal due** |
| Nov 17 | Tue | 13. Gridding, apodization and sampling density | **Bernstein Ch. 13.2** | |
| Nov 19 | Thu | 14. Parallel imaging: Image space methods | **Deshmane A et al., *JMRI* 2012** | **Pset 5 due** |
| Nov 24 | Tue | 15. Parallel imaging: k-space methods | **Deshmane A et al., *JMRI* 2012** | **Project update due** |
| Nov 26 | Thu | **THANKSGIVING DAY** | | |
| Dec 1 | Tue | 16. Echo planar imaging and functional MRI | **Bernstein Ch. 16.1** | |
| Dec 3 | Thu | 17. Diffusion and perfusion imaging | **Berstein Ch. 17.1 – 17.2** | |
| Dec 8 | Tue | **FINAL PROJECT PRESENTATIONS** | | |
| Dec 10 | Thu | **FINAL PROJECT PRESENTATIONS** | | |