

## SDSU Foundations of Neuroimaging 569/769

### Professor:

Marty Sereno -- email: [msereno@sdsu.edu](mailto:msereno@sdsu.edu)  
recording time (2020): MWF 9:00-9:50 AM (grad: F 8:00-8:50)  
recording location: [SSW 2667](#) (Zoom question-session TBA)  
*take hand-written notes for better memory consolidation!*  
*take-home exams, final/paper based on lecture content*

### Readings:

Huettel, S., A.W. Song, and G. McCarthy (2014) *Functional Magnetic Resonance Imaging*, 3rd ed.  
*Sereno Lecture Notes PDF* (single-page links on homepage)  
<http://www.cogsci.ucsd.edu/~sereno/569/notes.pdf>  
Additional background readings, references:  
<http://www.cogsci.ucsd.edu/~sereno/569/readings.html>

### Exams:

[Homework #1](#) (due 10/12/2020, code/graphs printout)  
[Homework #2](#) (due 11/23/2020, code/graphs printout (img [here](#))  
Final Paper: 5(ugrad)/10(grad)-page literature review on narrow methodological topic (start search in *Magnetic Resonance in Medicine, Neuroimage, Human Brain Mapping*)

### Learning Objectives:

Students will be able to do the following:

- (1) explain precession/excitation/recording/contrast of magnetic resonance signals and echoes using the Bloch equation
  - (2) compute Fourier transform, use it to explain how RF simulation, gradients, and RF coil signals generate k-space data and how brain images are reconstructed from that data
  - (3) diagram main classes anatomical/functional pulse sequences
  - (4) describe diffusion, perfusion, and spectroscopic imaging
  - (5) describe origin/localization of EEG/MEG signals, cortical surface-based methods, and how to combine them w/fMRI
- N.B.: consult with me if a disability hinders your performance so we can use University resources to maximize learning

### Lecture Topics: (Fall 2020)

#### Week of Aug 24 (MWF) -- Introduction

Introduction to Neuroimaging -- MRI, fMRI, EEG, MEG  
MRI hardware  
Spin and Precession

#### Week of Aug 31 (MWF) -- Bloch Equation

Bloch Equation  
Dot/Cross/Complex Products  
Precession solution  
Initial-Value Solutions to Differential Equation  
T1, T2 solutions  
Bloch Equation/Solution -- matrix version

#### Week of Sep 07 (WF) -- Signal Equation

*[no class: Mon, Sep 07]*  
RF Excitation  
Signal Equation  
Phase-Sensitive Detection

#### Week of Sep 14 (MWF) -- Echoes

Free Induction Decay  
Spin Echo  
Spin Echo Equations  
Simulated Echo, Spin Echo Trains  
Gradient Echo, Gradient Echo Trains

#### Week of Sep 21 (MWF) -- Using the Bloch Equation

Saturation-Recovery Signal  
Inversion-Recovery Signal  
Spin Echo Signal  
Gradient Echo Signal  
Gray-White Contrast  
Signal-to-Noise

#### Week of Sep 28 (MWF) -- Fourier Transform

Complex Algebra

Fourier Transform  
Negative Exponents, Orthogonality  
Spatial Frequency Space (k-Space)  
One k-Space Point -- 3 representations

#### Week of Oct 05 (MWF) -- Gradients, Slice Selection

Gradient Fields  
Gradient Combination  
Slice Selection  
RF Pulse Details

#### Week of Oct 12 (MWF) -- MRI Image Formation

*1st Take-Home Exam Due*  
Frequency-Encoding -- A Misnomer  
Frequency-Encoding -- Incorrect and Correct Intuition  
Imaging Equation (ID)  
Phase Encoding  
3D Imaging  
Spin Phase in Image Space  
Gradients Move Signal in k-Space

#### Week of Oct 19 (MWF) -- Image Reconstruction

Image Reconstruction  
Aliasing and FOV  
Under/Over Sample  
Replicas, FTs  
General Linear Inverse for MRI Reconstruction

#### Week of Oct 26 (MWF) -- Practical Pulse Sequences

Fast Spin Echo  
Fast Gradient Echo  
Quantitative T1/PD/T2\* Methods  
Gradient Echo EPI, Spin Echo EPI, Single-Shot Spiral  
SENSE, GRAPPA, Simultaneous Multi-Slice, 3D EVI

#### Week of Nov 02 (MWF) -- Image Artifacts

Fourier Shift Artifacts  
EPI vs. Spiral Artifacts  
Image-Space View Localized B0 Defect  
Effect Local B0 Defect on Reconstruction  
Shimming, B0-Mapping, Navigators  
Gradient Non-linearities  
RF Field Inhomogeneities

#### Week of Nov 09 (MF) -- Diffusion and Perfusion Imaging

Diffusion-Weighted Imaging and Tract Tracing  
*[no class: Wed, Nov 11]*  
Perfusion Imaging (Arterial Spin Labeling)

#### Week of Nov 16 (MWF) -- Phase-Encoded, Block Design

Phase-Encoded Stimulus for Mapping  
Convolution  
General Linear Model and Solution, Geometric Picture  
Cluster Correction -- 3D and Surface-Based  
Normalize, Strip Skull, Non-Isotropic Filtering  
Region-Growing, Tessellation: 3D -> 2D  
Cortical Unfolding and Flattening  
Sulcus-Based Alignment

#### Week of Nov 23 (Mon-only) -- Cortical Surface Methods

*2nd Take-Home Exam Due*  
Cortical Thickness Measurement  
Mapping Cortical Visual Areas  
*[no class Wed/Fri, Nov 25/27]*

#### Week of Nov 30 (MWF)-- Source of EEG/MEG

Intracortical Source of EEG/MEG  
Grad, Div, Curl  
1D/2D/3D Current Source Density  
Why We Can Ignore Magnetic Induction

#### Week of Dec 07 (MW) -- Neuroimaging EEG/MEG

Forward Solution  
Minimum Norm Linear Inverse  
Noise-Sensitivity Normalization  
*[no class: Fri, Dec 11]*

#### Week of Dec 14 -- Final Paper/Exam: Due Dec 17