MR Imaging and Reconstruction K. Nayak
EE 591 Fall 2005

MIDTERM EXAM

Monday, October 17, 2004, 10:00 – 11:30am

- This is an **90 minute, open book, open notes** exam. You may use only the Nishimura textbook, class notes, your notes, handouts, and homeworks. No other written material is allowed. **No calculators**.
- This exam contains **FOUR problems**.
- Unless specified, you can assume that all RF excitations are applied at the Larmor frequency $\omega = \omega_o$ and that signal demodulation is also based on ω_o, the field strength is 3 Tesla, and that we are imaging ^1H.
- **Efficient answers that show insight will be rewarded**.
- **Read each problem carefully.**

I will abide by the USC honor code.

Name ______________________________

Signature ______________________________ Date: __________

#1 (30)	
#2 (25)	
#3 (20)	
#4 (25)	
TOTAL	

1. (30 points) **TRUE or FALSE**

For each of the following statements, identify whether it is TRUE or FALSE and provide a brief explanation of why or why not.

(a) The amplitude of the physical signal in MRI is proportional to B_o^2.

(b) T2* is a a tissue property (just like proton density, T1, and T2).

(c) In slice selective excitation, if the gradient amplitude is doubled, the slice thickness is doubled.

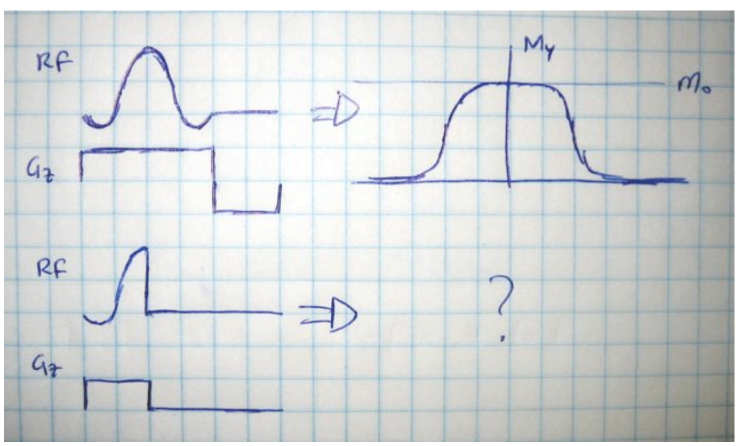
(d) Signal loss due to T2 relaxation during readouts can be modeled as a magnitude weighting in k-space.

(e) Inversion recovery (IR) produces strong image contrast based on T1 relaxation time.

2. (25 points) **Half-Pulse Excitation**

A conventional sinc excitation, and its associated My slice profile is shown below.

Below it, we show a "half-pulse" which is simply the first half of the excitation pulse (RF and gradient). Note that it does not require refocusing since it ends at the excitation k-space origin.

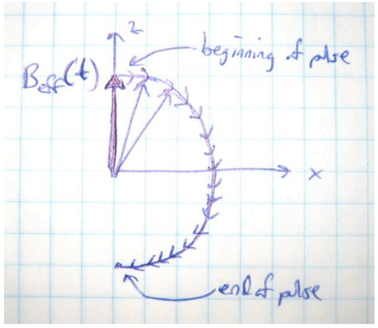


(a) Find the tip angle of this "half-pulse" and sketch it's My slice profile.

(b) This pulse is often used when imaging tissue with extremely short T2. What readout scheme would you use to minimize TE, and conceivably, how short could TE get?

3. (20 points) **Adiabatic Excitaiton**

Adiabatic excitation is often used to invert magnetization from pointing along +k to pointing along –k. In this excitation, Beff begins pointed along +k, and slowly rotates to –k as shown below. M always rotates around Beff according to the Bloch equation, but if Beff moves slowly enough, M stayes effectively "locked" (always pointed in the same direction) with Beff.



(a) The RF pulse produced has a time-varying amplitude and frequency. Find $\Delta w(t)$ and $B1(t)$ to produce the desired Beff trajectory.

(b) If the amplitude $B1(t)$ were doubled, what would the Beff trajectory look like, and would inversion still be achieved?

4. (25 points) **Spin Echo Sequence**

A typical 2DFT spin-echo sequence acquires one k_y line per excitation. A 256x256 acquisition will require 256 repetitions.

In order to reduce scantime by a factor of two, design a double-spin-echo sequence that uses two 180 degree pulses to align off-resonance spins at two points in time. Two different k_y lines should be acquired during each TR.

a) Provide a pulse sequence diagram for your sequence including waveforms for the RF, G_z, G_x, G_y, and DAQ (data acquisition).

b) Sketch the k-space path achieved by one acquisition, and describe how you would vary gradient amplitudes to acquire all data.

c) (extra credit) If there is T_2 decay between the first and second echoes, how will it impact the reconstructed image?