EE 591, Fall 2004 K. Nayak
MR Imaging and Reconstruction

MIDTERM EXAM

Tuesday, October 19, 2004, 3:30 – 4:50pm

please observe the honor code

- This is an **80 minute, open book, open notes** exam. You may use only the Nishimura textbook, class notes, your notes, handouts, and homework. No other written material is allowed. **No calculators**.
- This exam contains **five problems**.
- Unless specified, assume that all RF excitations are applied at the Larmor frequency $\omega = \omega_o$ and that signal demodulation is based on ω_o, the field strength is 3 Tesla, and we are imaging ^1H (4257 Hz/G).
- **Efficient answers that show insight will be rewarded**.
- **Read each problem carefully.**

1. (20 points) **Short Answer**

   Provide short answers (with explanation) for each of the following questions. When appropriate, please use sketches / diagrams to illustrate your point.

   a. Gibbs ringing is a characteristic of Fourier imaging methods. How can ringing artifact be reduced, and what are the side effects?

   b. What object and sequence parameters influence T_2^*?

   c. Does the excitation k-space approach apply to large tip excitations?

2. (25 points) **Sequence Design**

   A "dual-spin-echo" sequence with a long TR can be used to simultaneously acquire a proton density weighted image (minimum TE) and a T2 weighted image (TE ≈ T2) from a single scan.

   For comparison and interpretation, it is important for off-resonant spins to experience similar artifact in both images. Design an appropriate dual spin echo pulse sequence with TE_1 = 20ms and TE_2 = 100ms.

   - Provide a pulse sequence diagram including RF, Gx, Gy, Gz, and DAQ. Identify all relevant timing parameters.

   - Sketch the k-space path from one TR, and describe what you did to maintain comparable off-resonance artifact.

3. (10 points) **Sampling Model**

   In conventional 2DFT imaging, the acquisitions typically cover a square in k-space with $W = W_{kx} = W_{ky}$. Truncation in k_x and k_y produce blurring along x and y. Evaluate the blurring function along the x axis? and along the x=y line (45º)? Is higher resolution achieved along the x=y line? Explain?

4. (30 points) **Off-Resonance in 2D Imaging**

   We are imaging a 2D slice. Suppose that the off-resonance within the slice is a linear function of position: $\Delta w(x,y) = ax + by$. The acquisition gradients are $G_x(t)$ and $G_y(t)$.

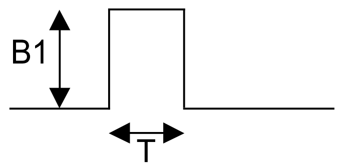
   What is the effective k-space trajectory $k_x(t)$, $k_y(t)$?

   Hint: Start with the signal equation. The solution should be a function of $G_x(t)$, $G_y(t)$, a, b, and t.

   If you know the values of a and b in advance, how would you adjust a 2DFT pulse sequence to make the actual samples fall along a rectangular grid in k-space? Explain in words, or with a sketch.

5. (15 points) **Excitation**

The following RF pulse is called a “hard” pulse:



a. Suppose that peak B1 is limited to 0.16 Gauss. What is the shortest duration, T, which can produce a 90º tip?

b. If this pulse were played by itself (no accompanying gradient), and using the small-tip approximation, find an amplitude and duration that produces a 30º tip for water (w=0) and no tip for lipid (w=-440 Hz).