EE225E/BIOE265 Spring 2014 Miki Lustig
Principles of MRI

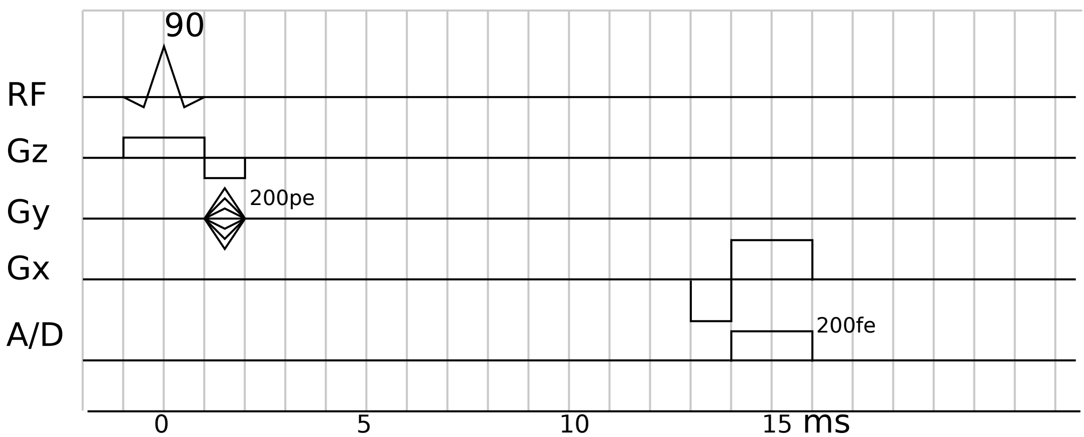
Assignment 10

Due April 18th, 2014, Self Grading Due April 21st, 2014

1) Finish reading the Nishimura book.

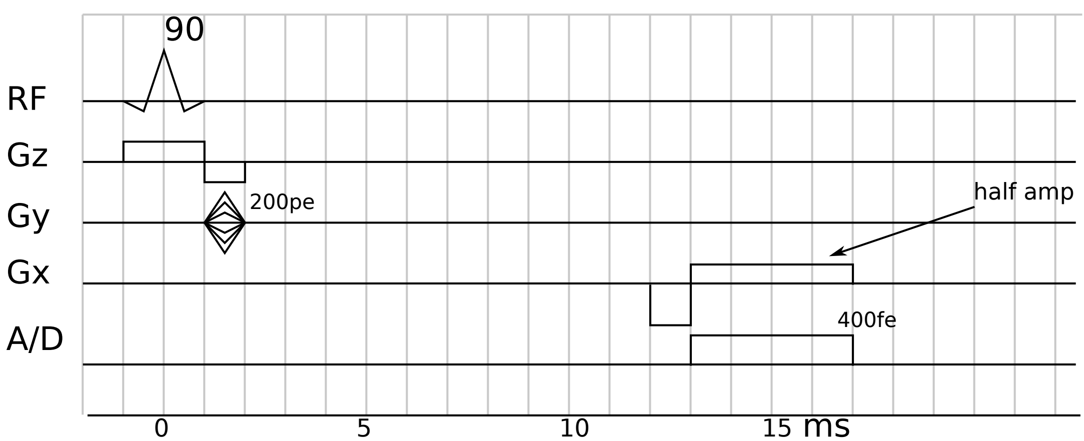
2) *From Midterm 2013: SNR*

Consider an object with $T_2 = 90$ms and $T_2^* = 30$ms. The following sequence provides an SNR of 100, and will be used as reference.



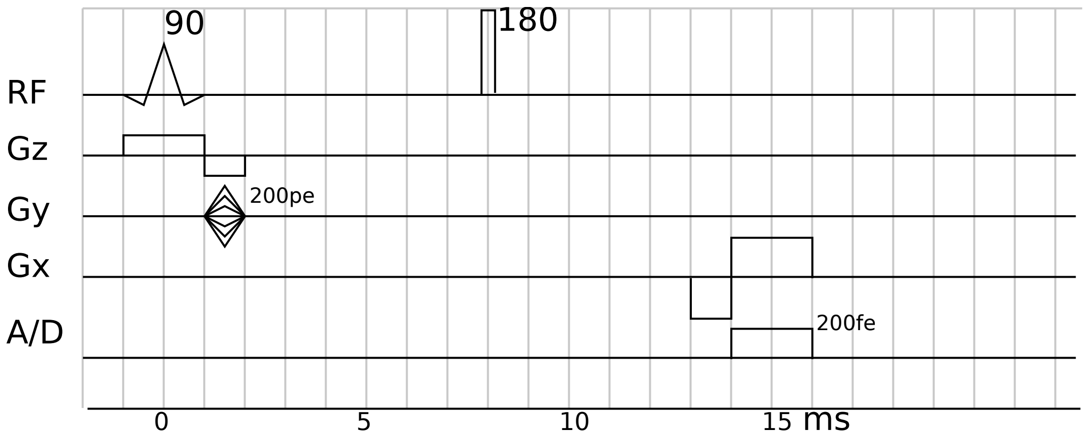
Find the SNR for each of the following modified sequences. Explain in detail what parameters have changed and how they affect the resulting SNR

a) Sequence:



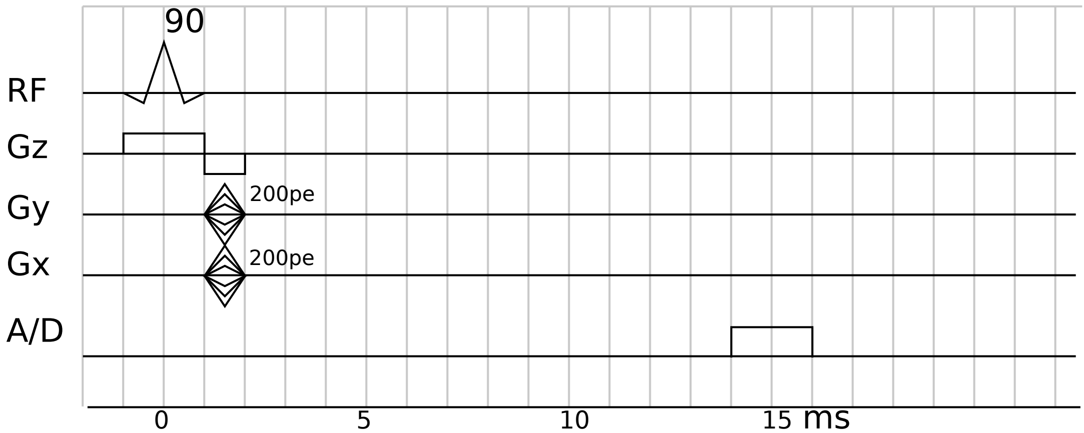
SNR:	Because:

b) Sequence:



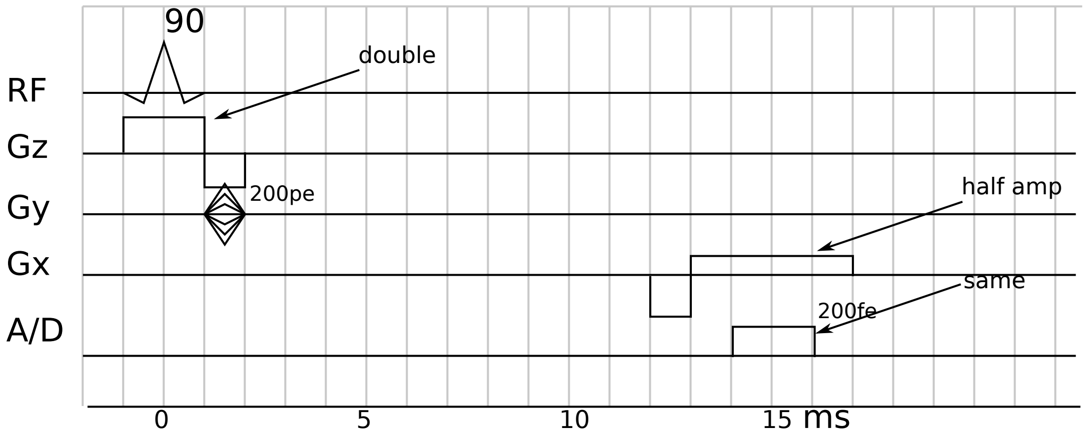
SNR:	Because:

c) Sequence:



SNR:	Because:

d) Sequence:



SNR: Because:

3) You have a working 2DFT gradient-recalled echo pulse sequence that produces an image with an SNR_1 of 100. What is the new SNR_2 after you make *one* of the following changes. Add a brief explanation as well.

a) Double the TBW of the slice selective RF pulse, while the RF pulse duration and the slice select gradient remain the same.

$SNR_2 =$

b) Double the readout gradient strength, while keeping the A/D duration and sampling rate the same.

$SNR_2 =$

c) Double both the readout gradient strength and the sampling rate, while halving the duration of the A/D window. Assume the anti-aliasing filter bandwidth matches the sampling rate.

$SNR_2 =$

d) Double the number of phase encodes, while keeping the maximum phase-encode gradient amplitude the same.

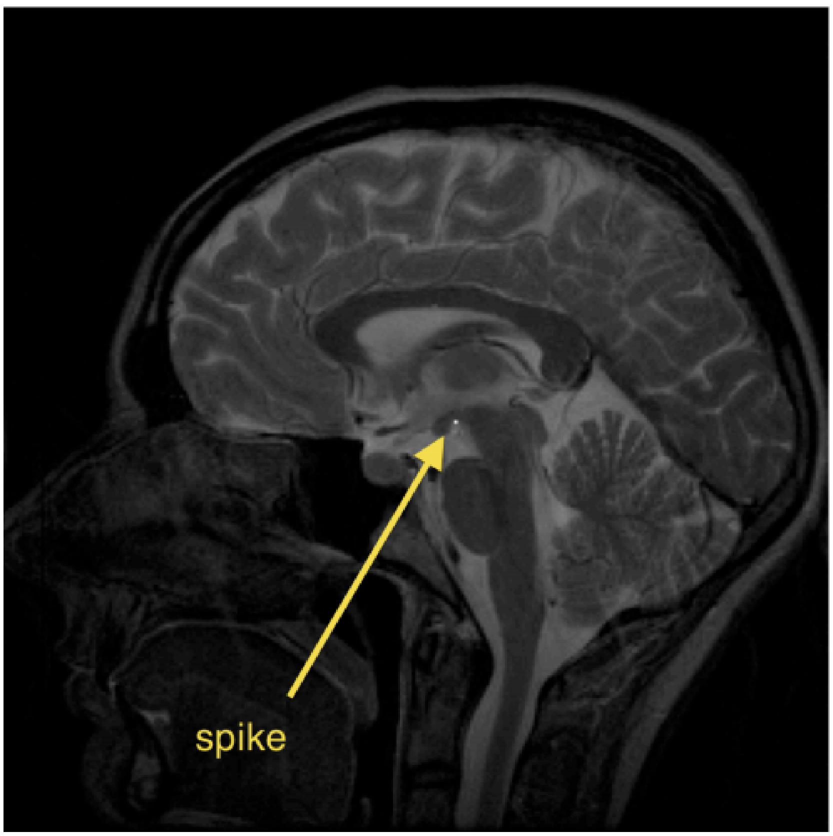
$SNR_2 =$

4) *From Midterm 2 2012: System Imperfections*

There are many sources of systems imperfections in MRI. Some of them we covered in class. Among the most common are:

- System delays between the RF, the Gradients and A/D
- RF Interference
- B_1 Inhomogeneity
- DC offset in the receive preamps
- Spike noise in the data
- Loss, of either quadrature or in-phase receive paths
- Gradient non-linearity

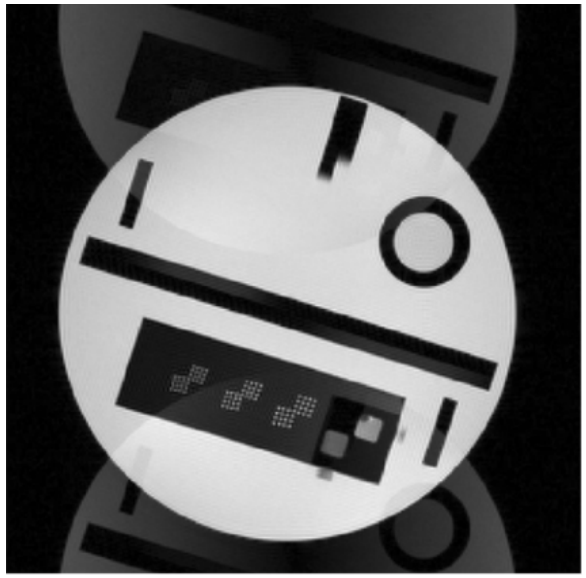
a) The image below was acquired using a regular T2-weighted spin-echo 2DFT sequence. Which of the above could be the cause for the following image artifact? Briefly explain how the imperfection results in the appearance of the artifact.



Cause:

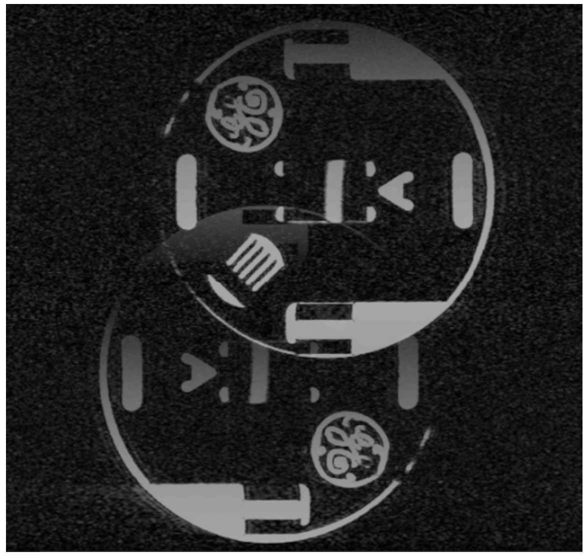
Explain:

b) The image below was obtained using one of the single-shot acquisition sequences. Which of the above could be the cause for the following image artifact? Briefly explain how the imperfection results in the appearance of the artifact.



Cause: Explain:

c) The image below was acquired using a regular T2-weighted spin-echo 2DFT sequence. Which of the above could be the cause for the following image artifact? Briefly explain how the imperfection results in the appearance of the artifact.

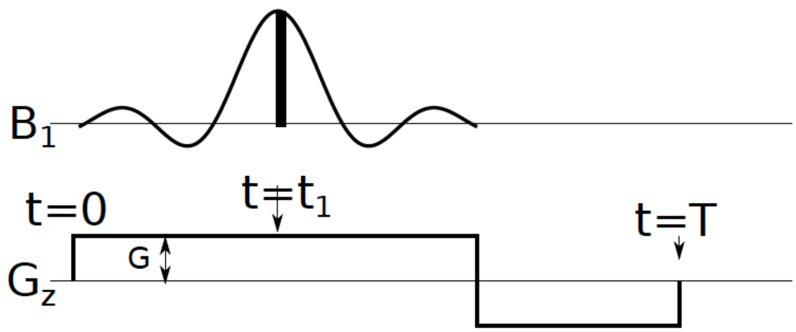


Cause:

Explain:

5) *From Midterm 2 2012: Relaxation During RF Pulses*

When deriving the small-tip-angle approximation for slice selective RF pulses we assumed that the RF pulse duration is much smaller than T2, and so it can be neglected. This is a good approximation in general, but fails when the T2 relaxation is short. In this question we will explore the case when T2 relaxation can not be neglected anymore. We will still assume the small-tip-angle approximation in which $M_z = M_0$ for the entire pulse duration. Under this approximation, at each time point new transverse magnetization is created and evolves independently. For example, consider the following pulse



The B_1 field at time $t = t_1$ will produce new transverse magnetization $\Delta M_{xy}(z, t_1) = iM_0 \sin(\gamma B_1(t_1)\Delta t) \approx iM_0\gamma B_1(t_1)\Delta t$

a) The new x-verse magnetization $\Delta M_{xy}(z, t_1)$ will evolve over time. Find an expression for it at the end of the pulse (at time T). Assume transverse relaxation T_2.

$\Delta M_{xy}(z, t)$ at time T $=$

b) Show that the slice profile $M_{xy}(z,T)$ has the form of

$$M_{xy}(z,T) = i\gamma M_0 \int_0^T \tilde{B}_1(t) e^{-i2\pi k_z(t) z} dt$$

Find the expression for the "effective RF field" $\tilde{B}_1(t)$ as a function of the original $B_1(t)$. What is $k_z(t)$?

$\tilde{B}_1(t) \;=$	$k_z(t) \;=$

c) The slice profile can be expressed as a Fourier transform in excitation k-space

$$M_{xy}(z,T) = i\gamma M_0 \int_{k_z} \tilde{B}_1(k_z) e^{-i2\pi k_z z} dk_z.$$

For the above pulse, find the expression for t as a function of k_z, then find the "effective" RF field in k-space $\tilde{B}_1(k_z)$.
$\tilde{B}_1(k_z)$ has the form: $\tilde{B}_1(k_z) = C \cdot W(k_z) B_1(k_z)$ where C is a constant and $W(k_z)$ is a function of k_z)

$\tilde{B}_1(k_z) \;=$	$t(k_z) \;=$

d) What will be the (two) effects of T_2 relaxation on the actual slice profile? Explain.

Effect I:

Effect II:

e) The T2 of white matter is two orders of magnitude longer than the T2 of myelin. Design (qualitatively) a slice selective RF pulse that will mostly excite myelin.

B_1

G_z