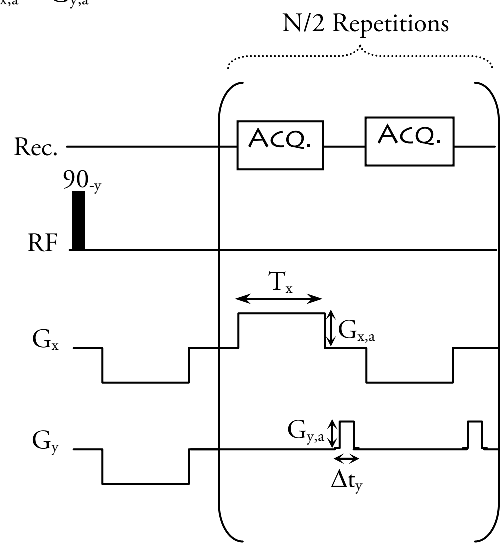
MRI Primer, Exercise #5
Due 5/Jan/2010

1. **Resolution**. Consider a 2D EPI experiment designed to sample a rectangular 2D object – say, the brain on the left, below, having a field of view (FOV) L along both axes (x & y) – at the same resolution (= number of points), N, along both axes (assume it is an even number). Prove– given the pulse sequence on the right, and that $T_x=N\Delta t_y$ – that

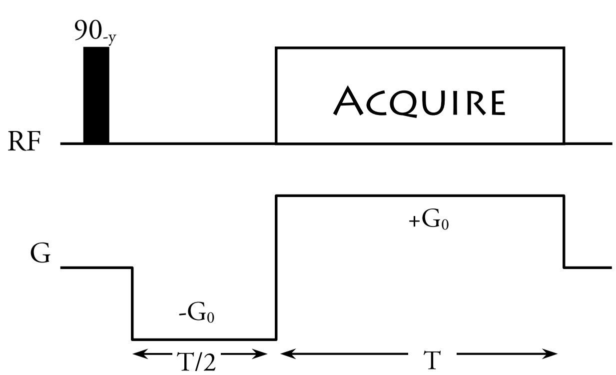
$$G_{x,a} = G_{y,a}$$

Object imaged:
1. Size L × L
2. N voxels along each axis

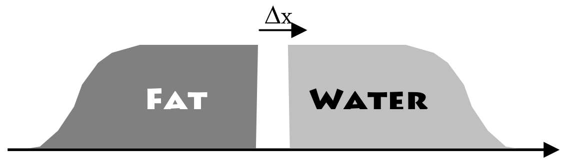


2. **Chemical Shift Artifact**. Suppose you're imaging a 1D object that has both water (which is chosen to be on-resonance, meaning it has no offset) and fat (which has an offset of about $\Delta\omega$=450 Hz at 3T):

You use the following sequence:



a. Explain why the fat image will be shifted by an amount Δx relative to its actual position, and determine Δx:



Hint: consider the offset of a spin (at some position x) being imaged, $\omega = \gamma G x + \Delta\omega$. Its signal will be ~ $e^{i\omega t} = e^{ikx + \Delta\omega t}$ as a function of time. Neglecting for the moment questions of resolution and relaxation, its signal will give rise to a peak at some position, $\bar{x}$, when Fourier transformed. When $\Delta\omega = 0$, the points $\bar{x}$ and x will be the same, but not so when $\Delta\omega \neq 0$. What will $\bar{x}$ be in that case? How will $\bar{x}$ depend on x and $\Delta\omega$? Use that insight to deduce Δx.

b. What would your suggestion be for minimizing this artifact – that is, decreasing Δx? Note: This shift can cause serious problems at boundaries between fatty and "regular" tissue; for example, when imaging the spinal cord, which is sheathed in fat.

3. **1D Imaging Parameters**. In a 1D imaging sequence shown in question 2 (forget about artifacts for this question, just focus on the sequence), you – as the MRI machine's operator – can vary one of 4 parameters: N, the number of points; G_0, the strength of the gradient; Δt, the time between successive acquired points (also known as the dwell time); and T, the total acquisition time. Note they are not all independent: for example, $T = N\Delta t$. How would changing each of these parameters, **while keeping the others fixed,** affect the field of view (i.e., size of the imaged object), number of voxels and size of each voxel? Fill in the following table with either (i.) increase, (ii.) decrease or (iii.) no effect, and **justify** each answer concisely (use the numbers/letters to refer to the entries; e.g., when explaining how increasing the gradient affects the field of view, refer to it as case 1A).

Parameter **increased**	A. Field of View	B. Number of voxels	C. Size of each voxel
1. Gradient (G_0)			
2. Total Acquisition time (T), by increasing Δt and keeping N constant.			
3. Number of acquired points (N), by keeping T and decreasing Δt.			
4. Dwell time (Δt), by increasing T and keeping N constant)			