

Take-Home Midterm

Due: At the start of class (9:30 AM) on Thursday, November 10, 2005. Please be prompt. The examination score will be reduced by 20% for every 10 minutes that the exam is turned in late. No examinations will be accepted after 9:50 AM.

Guidelines:

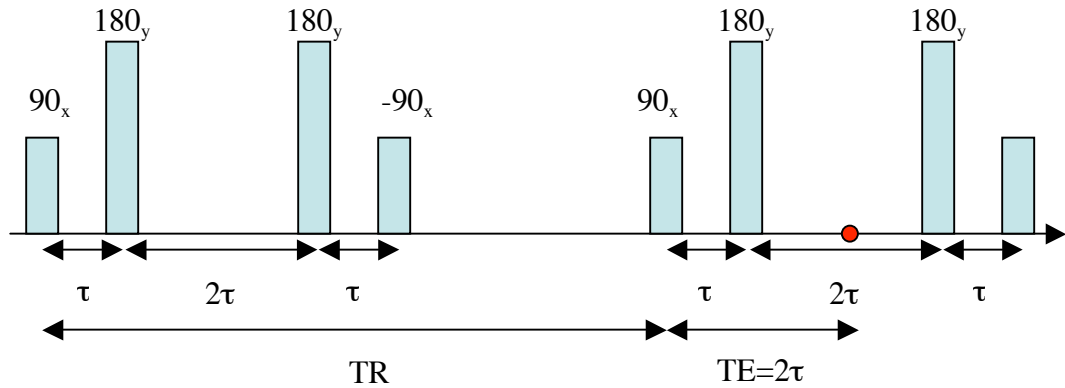
- 1) The work turned in should reflect your own effort and understanding. You may not discuss the problems with anyone aside from the course instructor or TA.
- 2) If you have questions regarding the wording or meaning of a problem, please contact the instructor. E-mails will be sent through Studentlink to clarify wording or correct mistakes, so make sure that you check your e-mail. Clarifications and corrections will also be posted on the website under the announcement link.
- 3) You may cite results from the course textbook, homework solutions, or lecture slides. Use of external sources (e.g. journal papers, web) is **not** recommended, but if you do use an external source, you are required to cite it.
- 4) In order to obtain partial credit, please make sure that you justify each step in your solutions.

I acknowledge and have followed the above guidelines:

Signed _____

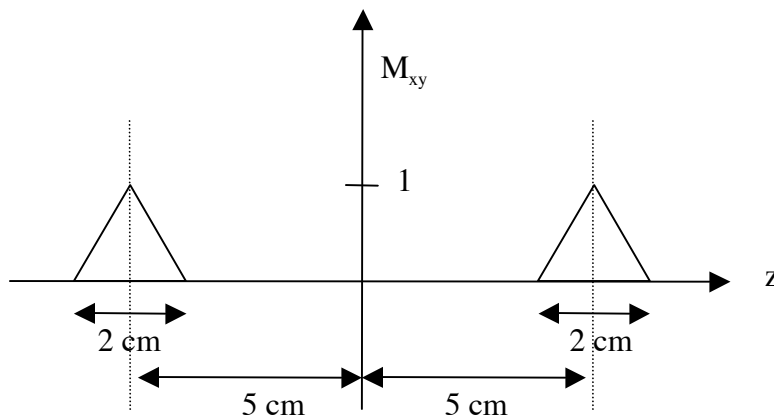
Problem 1. Image Contrast (10 pts)

Consider the imaging sequence shown below. Find an expression for the signal intensity at the red dot. Your expression should be a function of T_1 , T_2 , TR, and TE. You may assume that the -90_x degree pulse flips magnetization that is in the transverse plane back along the longitudinal plane.



Problem 2. Slice Profile (30 pts)

Consider the slice profile shown below. Assume that the largest B1 amplitude available is 0.2 Gauss. Calculate the B1 waveform and gradient strength required to achieve the desired slice profile. You will want to make use of the maximum B1 amplitude so that the pulse is as short as possible. Make a plot of the B1 waveform, indicating amplitudes and important features of the waveform (e.g. timing of the zeros). You may want to use MATLAB to make the plot.



Problem 3

Design of an echoplanar imaging (EPI) pulse sequence (60 pts total)

(a) Design an EPI pulse sequence to meet the following requirements: $FOV_x = 256$, $FOV_y = 192$ mm, matrix size = 64×48 (i.e., resolution in x and y directions = 4 mm); maximum available gradient = 2 G/cm; minimum rise-time from zero gradient to full amplitude = 200 μ sec (i.e. maximum slope or slew-rate = 10 G/cm/msec = 100 mT/m/msec). In other words, the gradient cannot change instantaneously, but takes 200 μ sec to go from 0 G/cm to 2 G/cm. Assume that the ADC is only on during the flat parts of the readout gradient, and that the sample rate of the ADC is 100 KHz (i.e., $\Delta t = 10 \mu$ sec). Your design should use trapezoidal and/or triangular gradients, where the maximum slope of your gradients is limited by the slew-rate specification. Your design should make full use of the gradient strengths and slew rates to cover k-space **in the shortest time possible**. In your design, the 25th k_y line (phase-encode direction) should go through the $k_y = 0$ origin, so that you end up with a slightly asymmetric coverage of k-space, with 24 k_y lines below the origin and 23 k_y lines above the origin. Similarly, the coverage in the readout direction is asymmetric, so that either the 25th or 24th ADC sample of each line (depending on odd or even line) coincides with $k_x = 0$. **Hint:** Your answer should be similar to the figure used for Problem 5 in Homework 4. The main difference is that we assume finite slew-rates here, so instead of having rectangles for the gradient waveforms, you will end up with trapezoids and triangles. For your answer,

- (i) (35 pts) Write a **short** MATLAB program to calculate the pulse sequence parameters. Document the program clearly to explain your logic. Use the following input/output format for your program:

[gxr, gxd, gyp, gyd]= epi(fovx,fovy,dt,maxG,trise,nx,ny)

where gxr, gxd, gyp, and gyd are MATLAB structures that have the following elements (amp, trise, tflat). For example, gxr.amp, gxr.trise, gxr.tflat are the amplitude, risetime, and flat time of the gxr gradient. Note that for triangular gradients, the flat time will be zero. The gradient structures gxr, gxd, gyp, and gyd correspond to the readout gradient, readout dephaser, phase gradient, and phase dephaser, respectively.

Please submit an electronic version of your MATLAB program via e-mail by 9:30 AM on 11/10/05. Name your function epi_{your initials}.m. For example, epi_tl.m. Also, hand in a print-out of your code.

- (ii) (5 pts) Plot out representative sections of the pulse sequence with important parameters clearly labeled.
- (iii) (10 pts) Make a plot of the k-space trajectory. You may want to use MATLAB.
- (b) (10 pts) Give a rigorous explanation for why it is not necessary to collect the 24th k_y line above the origin. A hand-waving explanation was given in class. **HINT:** Your answer should be around 5 lines of algebra and should make use of your knowledge about how FOV and resolution affect sampling in the Fourier domain.