EE101 Homework 4

Please submit it via Blackboard **Due：December 8th 23：59**

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Your name: ___________________ Student ID: __________________

Problem 1: (9 pts)

(1) At room temperature of $293\ K$, if $5\ ml$ water is placed in a magnetic field with strength of $5\ Tesla$, then what is the magnetization, M_0, of the protons within this volume of water? (5 pts)

(2) If we want to improve the image SNR of an MRI scan, which two parameters could be changed? Please explain. (4 pts)

Problem 2: (10 pts)

There is an MRI scanner whose magnetic field has a strength of $9.4\,T$. Provided that the gyromagnetic ratio is $\frac{\gamma}{2\pi} = 67.28\,MHz/T$.

(1) Assume the gradient along z direction is $2\,Gauss/cm$. In order to get an image slice of $3\,mm$ thickness, what should the bandwidth, measured in kHz, of the RF pulse be? ($1\,T = 10^4\,Gauss$)

(2) If the gradient becomes $1\,Gauss/cm$, and the bandwidth of the RF pulse remains unchanged, then what will the slice thickness become?

Problem 3: (10 pts)

Choose the correct option from (a) - (e) and **explain** why these options are correct or wrong. Water in tendons is bound very strongly and cannot diffuse freely. It produces very low MR signal intensity because:

(a) T1 is too short.

(b) T2 is too short.

(c) T2* is very long.

(d) T2 is longer than T1.

(e) T2* is longer than T2.

Problem 4: (18 pts)

Calculate the effects of the following pulse sequences on thermal equilibrium magnetization. The final answer should include x-, y-, and z-components of magnetization.

a) 90°x (a pulse with tip angle 90°, applied about the x-axis).

b) 30°y

c) 90°x 90°y (the second 90° pulse is applied immediately after the first).

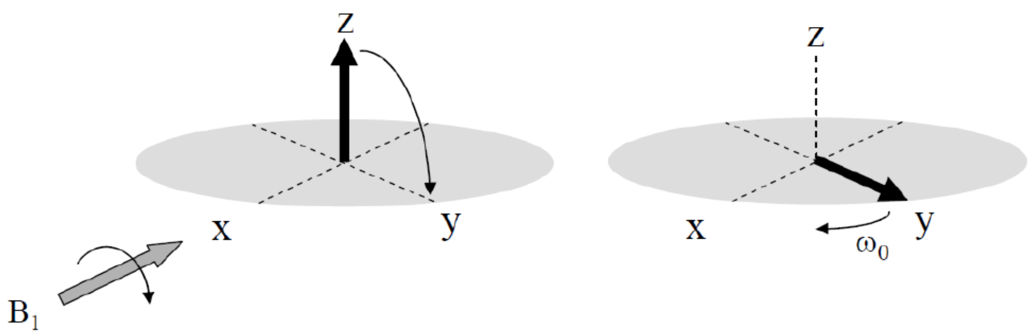

Fig1: Example of the magnetization after a 90°x pulse sequence

Problem 5: (10 pts)

A region of the brain to be imaged contains areas corresponding to tumor, normal brain and lipid. The relevant MRI parameters are:

$$\rho(\text{tumor}) = \rho(\text{lipid}) > \rho(\text{brain})$$

$$T_1(\text{brain}) > T_1(\text{tumor}) > T_1(\text{lipid})$$

$$T_2(\text{lipid}) > T_2(\text{tumor}) > T_2(\text{brain})$$

Which type of weighted spin-echo sequence should be run in order to get contrast between the three different tissues? Explain your reasoning, including why the other two types of weighting would not work.

Problem 6: (12 pts)

Three MR images of the brain are acquired using identical parameters except for the TR and TE times. Three tumors (upper, middle and lower) are seen in one of the images but not in the other two, shown in Fig 2. If the T_1 values for all the tissues (tumors and brain) are less than $2\ s$, and the T_2 values are all greater than $80\ ms$, please describe the *relative* values of proton density, T_1 and T_2 of brain tissue and the three tumors.

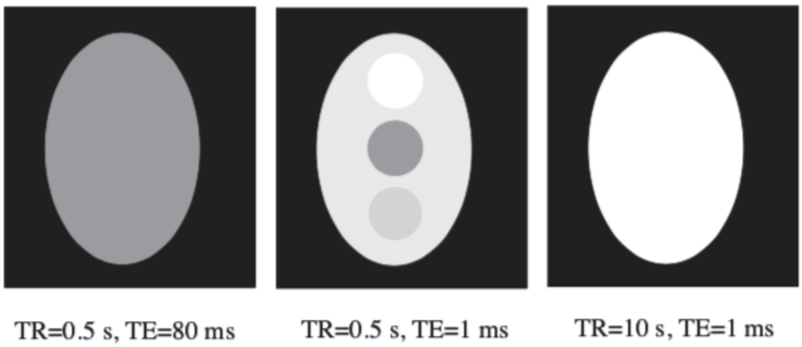

Fig 2. Three phantom MR images

Problem 7: (15 pts)

Consider the pulse sequence in Fig 3 (surface 2 equals two times surface 1). Draw the trajectory of k in the k-space.

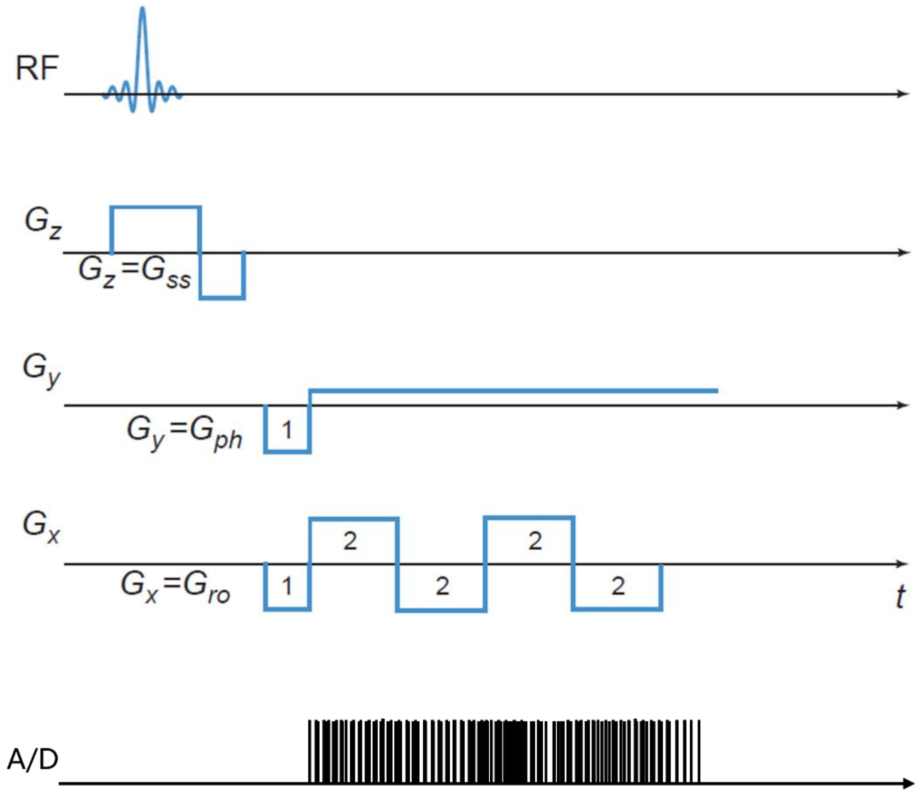

Fig 3

Problem 8: (16 pts)

Determine whether each of the following statements is true or false, with one or two sentences of ***explanation***.

(a) A higher strength of the RF field from the RF coil means that the duration of the $90°$ pulse decreases.

(b) A longer T_1 relaxation time means that the voltage induced in the RF coil lasts longer and so a larger MRI signal is achieved.

(c) One line of k-space data acquired for each value of the phase encoding gradient corresponds to one line of the image.

(d) A short tissue T_1 indicates a slow spin-lattice relaxation process.