Problem 1: Your first MR Quiz

Answer true or false (except for f) with one or two sentences of explanation:

a) Recovery of magnetization along the z axis after a 90^0 pulse does not necessary result in loss of magnetization from the xy plane.
b) A static magnetic field B_0 that is homogeneous results in a free induction decay that persists for a long time.
c) When the magnetization relaxes from the xy plane back to the z axis, it absorbs energy from the lattice.
d) A short tissue T_1 indicates a slow spin/lattice relaxation process.
e) T_2 is in some cases longer than T_1.
f) A sample you examine has a long T_1 and a very short T_2. What kind of sample is that presumably?

Problem 2: Precession

Suppose we are studying ^{1}H nuclei at field strength of 5.87 T. Assume that the oscillating field B_1 is only 10^{-5} as strong as the B_0-field.

a) How fast will M precess around B_1?
b) How much time is required for M to precess one full revolution around B_1?
c) Calculate the flip angle α at the following times after irradiation with B_1 begins: 0, 0.10, and 0.20ms
d) Draw a rotating-frame diagram that shows M at each of the above times.
e) Suppose B_1 is turned off 0.20ms after it was turned on. Describe what happens to **M** in terms of T_1 and T_2 using a diagram in the rotating-frame.

Problem 3: Longitudinal Relaxation

In order to understand MR imaging and spectroscopy methods, it is essential to know the two principles of relaxation with their corresponding time constants. Here, we are going to investigate the spin-lattice (i.e. longitudinal) relaxation (time constant T_1).

a) Write an expression for the longitudinal magnetization as a function of time after a 180^0 pulse. After what time is the M_z component zero?
b) Design an experiment to measure T_1 of a tissue or compound.
c) Suppose you were to conduct an imaging experiment searching for Multiple Sclerosis lesions in the brain (you do not need to know how MR imaging works yet). Looking at the images, you find that the cerebral spinal fluid (CSF, $T_{1,CSF}$=2800ms) is very bright. They outshine adjacent areas of white matter (WM, $T_{1,WM}$=800ms) where lesion growing usually starts, making it hard to spot the lesions.
How could you attenuate the signal from the CSF? (Hint: Note the different T_1 times!) Give also the timing of your experiment.

Problem 4: Liver Tissue Experiment

Liver tissue has a longitudinal relaxation time constant T_1 of 500ms and a transverse relaxation time constant T_2 of 40ms.

What will the MR signal be 40ms after an RF pulse? And 500 ms after?

Problem 5: Excitation Pulses

Hard pulses are RF excitation pulses which are used in various MR experiments.

The time course of a hard pulse is given by $B_1(t) = \begin{cases} 0, t < 0 \\ A,\ \ t \leq 2\tau \\ 0,\ \ t > 2\tau \end{cases}$. Calculate the excitation profile and bandwidth of this pulse.