BioE 1330 - Exam 4 4/5/2012
Answer Sheet - Correct answer is A for all questions

1. A uniform magnetic field $\mathbf{B}_0$ in the z direction is applied to a sample. Which of the following is TRUE when a x-gradient is then added?

I - The Larmor frequency becomes a function of location.
II - The strength of the magnetic field is no longer uniform.
III - At points with different x-coordinates, the magnetic field has different directions.

A. I and II

B. I, II, and III

C. I and III

D. II and III

E. None.

Explanation: The variation is in the scalar strength, not the direction of the magnetic field.
[*imaging0366.mcq*]

2. Which of the following is *false* about k-space (or all are true)?

A. All are true.

B. The term arises from the convention in physics where wave number k represents a spatial frequency.

C. If we can cover all of k-space, we can recover the image of the corresponding slice.

D. It can be covered rectilinearly using phase encoding, in which case an inverse Fourier transform can recover the image.

E. It can be covered in a polar fashion by using a series of read gradients with different x and y components, in which case filtered back projection is required to "fill in" the high frequencies.

Explanation: All are true.
[*imaging0369.mcq*]

3. Which disease is Pittsburgh compound B (PiB) used for to specifically diagnose using imaging?

A. Alzheimer's disease.

B. Parkinson's disease.

C. Late life depression.

D. Stroke.

E. Multiple sclerosis.

Explanation:
[*imaging0430.mcq*]

4. Which of the following statements about Short Tau Inversion Recovery (STIR) and Fluid Attenuation Inversion Recovery (FLAIR) is *false*, or all are true?

A. All are true.

B. FLAIR is used to suppress watery fluids such as cerebral spinal fluid (CSF), for example, to visualize high-intensity objects in the ventricles.

C. STIR is used to suppress fat, for example, to see tumors in the breast.

D. Both use π RF pulses and then wait for an appropriate amount of time before applying a $\pi/2$ RF pulse, when a particular tissue type has recovered just enough of its longitudinal magnetization to have reached a "null" point.

E. They each suppress a particular tissue type with a specific T_1.

Explanation: T_1, which determines how quickly the longitudinal vector reforms, also determines when the null point is reached after an inversion (π) RF pulse is applied.
[*imaging0368.mcq*]

5. Which of the following is *true* about MRI and pregnancy?

A. It has become commonplace in recent years, and generally considered safe.

B. It is never used at all on pregnant patients

C. Its associated risks to the fetus are considered significant, but occasionally worth it in extreme cases.

D. It cannot be justified because of its expense.

E. It is dangerous because of occasional high iron content of the placenta, but may be used if this condition can be excluded.

Explanation: E is utter nonsense. MRI is generally safe, especially compared to CT, and used increasingly during pregnancy.
[*imaging0431.mcq*]

6. Which of the following statements about MR and CT is *false* (or all are true)?

A. CT can make use of contrast agents whereas MR cannot.

B. All are true

C. MR is more expensive than CT.

D. MR does not expose the patient to ionizing radiation, while CT does.

E. MR is better for imaging soft tissues, while CT is better for imaging bone.

Explanation: Gadolinium is a commonly used MR contrast agent.
[*imaging0365.mcq*]

7. Which of the following is *false* about readout gradient (or all are true)?

A. It is applied during the 90° RF pulse.

B. It is applied during the acquisition of the RF signal.

C. It causes the Larmor frequency to vary across the slice, producing a spectrum of frequencies.

D. It permits localization by using the Fourier Transform.

E. All are true.

Explanation: The "write" gradient, not the readout gradient, is applied during the 90 ° RF pulse.
[*imaging0432.mcq*]

8. The following are (is) true about Proton Density weighted images:

I - A short T_R is used to allow the largest possible longitudinal magnetization vectors to tip over.
II - A short T_E is used to avoid signal loss due to dephasing.
III - Proton Density weighted images offer the highest signal-to-noise, especially when the tip angle is $\pi/2$.

A. II and III

B. I and II

C. I, II, and III

D. I and III

E. only I.

Explanation: I is false, a *long* T_R is used to maximize the population of longitudinal vectors to tip over.
[*imaging0364.mcq*]

9. Which of the following statements about fMRI is (are) *true*?

I - It displays a measure of neuronal activity by using differences in the magnetic susceptibility of oxygenated and deoxygenated hemoglobin.
II - It depends on changes in blood flow in areas of neuronal activity.
III - It has been used to demonstrate particular portions of the cortex involved with activation of particular muscles.

A. I, II, and III

B. I and II

C. I and III

D. II and III

E. only I.

Explanation: Neuronal activity leads to a local increase in blood flow and therefore increased oxygenated hemoglobin.
[*imaging0433.mcq*]

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D. I and III

E. only I.

Explanation: I is false, a *long* T_R is used to maximize the population of longitudinal vectors to tip over.
[*imaging0364.mcq*]

11. Which one of the following statements is *false* about MRI?

A. Although hydrogen accounts for almost all clinical MRI imaging, protons in any atom can be used to image with MRI.

B. The Larmor frequency of hydrogen, which relates the rate of precession of the magnetization vector of a sample to the local magnetic field, varies slightly for different chemical environments such as fat and water, accounting for the *chemcial shift artifact*.

C. The observed signal in MRI is an RF signal produced by the rapidly rotating transverse magnetization.

D. Manipulation of the gradient coils can produce frequency or phase encoding of location.

E. The RF coils or resonators receive the MR signals, and may be large (e.g., a body coil) or small (e.g., a surface coil).

Explanation: Only nuclei with odd atomic number or odd mass number can be used in MRI.
[*imaging0142.mcq*]

12. Which of the following statements about Diffusion Tensor Imaging (DTI) with MRI is (are) *true*?

I - Water diffuses more quickly within the cell bodies of neurons than along the much narrower axons, and DTI measures this diffusion.
II - It uses a pair of strong gradient pulses, the first to de-phase the spins, and the second to re-phase the spins. If no net movement occurs, these cancel. If movement (diffusion) occurs they do not cancel.
III - Tensors permit the analysis of the direction of the diffusion in 3 dimensions, not just its magnitude.

A. II and III

B. I and II

C. I and III

D. I, II, and III

E. only III.

Explanation: Water diffuses more quickly along white matter tracts, and DTI measures this diffusion, as well as its direction.
[*imaging0357.mcq*]

13. How does slice selection in MRI take place?

A. via application of a magnetic gradient such that only the slice of interest has Larmor frequencies within the spectrum of the RF pulse.

B. via tipping of the $\mathbf{B}_0$ magnetic field into the plane of the slice of interest

C. via application of the RF pulse only within the slice of interest.

D. via elimination of the $\mathbf{B}_0$ magnetic field everywhere except within the slice of interest

E. via application of a 180° RF pulse

Explanation: Slice selection occurs by controlling the strength generally of the z-gradient of the magnetic field $\mathbf{B}_0$ (but not changing its direction) and by controlling the frequency of the RF pulses. The other choices do not make any sense or are incorrect.
[*imaging0434.mcq*]

14. The Bloch Equations, which describe the time course of the magnetization vector $\mathbf{M}(t)$,

$$\frac{d\mathbf{M}(t)}{dt} = \gamma\mathbf{M}(t) \times \mathbf{B}(t) - \mathrm{R}\{\mathbf{M}(t) - \mathbf{M}_0\}$$

where $\mathbf{B}(t) = \mathbf{B}_0 + \mathbf{B}_1(t)$ is composed of the static and RF fields, and where the matrix R is

$$\begin{pmatrix} \frac{1}{T_2} & 0 & 0 \\ 0 & \frac{1}{T_2} & 0 \\ 0 & 0 & \frac{1}{T_1} \end{pmatrix}$$

define the behavior of which of the following?

I - Precession of $\mathbf{M}(t)$ around both $\mathbf{B}_0$ and$\mathbf{B}_1(t)$.
II - Longitudinal relaxation.
III - Transverse relaxation.

A. I, II, and III

B. I and II

C. I and III

D. II and III

E. only I.

Explanation: The Bloch equation encapsulates all three processes into a single differential matrix equation.
[*imaging0363.mcq*]

15. Which of the following statements about transverse relaxation is *false*?

A. Transverse relaxation is due to the transfer of magnetization from the transverse (x-y) plane to the longitudinal (z) direction.

B. The measured relaxation time T_2^* is shorter than the tissue-dependent time constant T_2, because it also contains a term due to field inhomogeneity, ${T_2}'$.

C. The use of a 180° (π) pulse cancels de-phasing due to field inhomogeneity.

D. Transverse relaxation time T_2 tends to be much shorter than longitudinal relaxation time T_1.

E. Transverse relaxation is modeled as an exponential decay.

Explanation: Transverse relaxation is not due to the transfer of magnetization from the transverse (x-y) plane to the longitudinal (z) direction, which is the slower process governed by T_1. Rather, transverse relaxation is due to de-phasing of the magnetization within the transverse plane.
[*imaging0145.mcq*]

16. Which of the following is true about the Larmor frequency (or none is true)?

A. It is dependent both on the local magnetic field (to which it is proportional) and the particular atomic number, atomic mass, and chemical environment of the atom (which determines the proportionality, the gyromagnetic ratio).

B. It is dependent only on the atomic number and mass of the particular element but not on the chemical environment that atom.

C. It decreases with increasing magnetic field.

D. It is dependent on magnetic field but independent of the particular atomic number and atomic mass (for example, ^{1}H vs. ^{13}C)

E. None is true.

Explanation: B is wrong because of chemical shift. The whole use of NMR in chemistry depends upon this variation with chemical environment.
[*imaging0362.mcq*]

17. Which of the following statements about MRI contrast mechanisms is *false* (or all are true)?

A. T_1 and T_2 are among the parameters that are set in order to measure tissue characteristics T_R and T_E.

B. All are true.

C. In proton density-weighted images, signals must be acquired quickly after the RF pulse, before the signal has a chance to decay from T_2 effects, and the image intensity is roughly proportional to the number of hydrogen nuclei in the sample.

D. T_R is the time between RF excitations and T_E is the time between an excitation and the formation of an echo; T_R is generally greater than T_E.

E. In T_1-weighted images, differences in rate of reformation of the longitudinal component of magnetization are emphasized, as compared with T_2-weighted images, in which differences in the de-phasing rates of the transverse magnetization are differentiated.

Explanation: MRI involves the measurement of the inherent tissue characteristics, T_1 and T_2 . The parameters that are set for each image include T_R, T_E and the tip angle α
[*imaging0358.mcq*]

18. Which of the following statements about the rotating frame of reference in MRI is *false* (or all are true)?

A. All are true.

B. $\mathbf{B}_0$ is the axis of the rotating frame of reference and does not spin.

C. It occurs in the transverse plane.

D. It is modeled as a phasor spinning in the complex plane.

E. It permits the precession of the magnetization due to the RF pulse (denoted $\mathbf{B}_1$) to appear as a simple rotation.

Explanation: The precession in E would appear as a spiral in fixed coordinates.
[*imaging0356.mcq*]

19. A sample is in equilibrium, and a $\pi/2$ pulse is applied. What is the transverse magnetization of the sample, as developed in the text (ignoring dephasing due to spin-spin interactions)?

A. $M_{xy}(t) = M_0 e^{-j(2\pi\nu_0 t-\phi)}$

B. $M_z(t) = M_0(1 - e^{-t/T_1})$

C. $M_{xy}(t) = M_0 e^{-t}$

D. $M_z(t) = 0$

E. $M_{xy}(t) = M_0$

Explanation: The transverse magnetization ignoring dephasing is described as a phasor rotating in the xy plane at the Larmor frequency ν_0 with arbitrary initial phase ϕ.
[*imaging0355.mcq*]

20. Which of the following are legitimate methods of accomplishing Magnetic Resonance Angiography (MRA), to image blood flow?

I - Introduction of a contrast agent (gadolinium) into the vasculature to reduce the T1 or T2 relaxation time of protons located nearby.
II - Detecting of blood flow using Doppler shift in the Larmor frequency.
III - Saturating the magnetization in a slice, so that only fresh blood entering from outside the slice gives off signal; this requires no contrast agent.

A. I and III

B. I, II, and III

C. I and II

D. II and III

E. only I.

Explanation: III is not true. Doppler shift is used in ultrasound, but not in MRI.
[*imaging0435.mcq*]

21. For T_2 -weighted contrast images (maximizing differences in transverse relaxation times) the following is true:

A. T_E should be in the middle of the range for T_2 values.

B. T_E should be as short as possible.

C. Any T_E duration can be used so long as T_R is short.

D. T_E should be extremely long.

E. Echoes should not be used.

Explanation: To differentiate tissues by their transverse relaxation time T_2, an echo time T_E is chosen in the middle of the range of the T_E values for the various tissues, so that the echo strength will depend maximally upon T_E.
[*imaging0139.mcq*]

22. The following are true about Spin Echoes *except* (or all are true).

A. They reverse the dephasing so that T_2 has no effect on the intensity of the recovered echo.

B. They are accomplished using a 180° (π) RF pulse, which flips each magnetization vector to the other side of the transverse plane.

C. They cause those magnetization vectors that have precessed faster and gotten ahead to move to the "back of the pack" where they will still be precessing faster .

D. They are used to cancel the effect of field inhomogeneity, which causes some protons to have different Larmor frequencies than others due to their location in the magnet.

E. All are true.

Explanation: Spin echoes flip the magnetization vectors over so that the leading ones are now behind and will catch up. They cancel the effects of field inhomogeneity, which accounts for ${T_2}^*$, leaving the desired tissue-dependent T_2 due to spin-spin relaxation.
[*imaging0302.mcq*]

23. Which of the following is *false* about tipping the magnetization vector with an RF field (or all are true)?

A. All are true.

B. It only occurs to the extent that the Larmor frequency corresponding to the local magnetic field is contained within the spectrum of the RF pulse.

C. It amounts to precession around the RF magnetic field, which can be viewed as tipping within a rotating frame of reference.

D. The resulting tip angle is proportional to the RF field strength and the duration of the RF pulse.

E. An $\pi/2$ RF pulse transfers the longitudinal magnetization into the transverse plane, where it precesses, producing a detectable signal at the Larmor frequency.

Explanation: All are true.
[*imaging0298.mcq*]

24. The following are true about Phase Encoding *except* (or all are true).

A. Phase encoding permits selective activation of a particular slice in the patient by restricting interaction between the RF field and the Larmor frequency of particular protons.

B. It is generally used to establish coordinates in the third dimension (y), after slice selection and frequency encoding have established coordinates in the other two dimensions (z and x, respectively).

C. It is accomplished by activating a phase-encode gradient for a certain amount of time to add a "twist" proportional to distance along the phase-encode dimension. A series of these are collected each with a different amount of phase-encode gradient.

D. It typically results in a rectilinear traversal of k-space, permitting direct application of the inverse Fourier transform.

E. All are true.

Explanation: Answer A refers to the slice selection gradient, not the phase encoding gradient.
[*imaging0150.mcq*]

25. Which of the following statements about Magnetic Resonance Spectroscopy (MRS) with MRI is (are) *true*?

I - It displays the proton spectrum for a region of the MRI scan, allowing differentiation of hydrogen atoms by their local biochemical environment.
II - It essentially makes use of the Chemical Shift Artifact, which normally is considered a problem in MRI.
III - Its resolution is much lower (worse) than regular anatomical MRI.

A. I, II, and III

B. I and II

C. I and III

D. II and III

E. only I.

Explanation: All are true. Slight differences in the Larmor frequency for hydrogen atoms due to their biochemical environment cause the Chemical Shift Artifact, but may be used to produce useful spectra of regions in the MRI image.
[*imaging0148.mcq*]