BioE 1330 - Review Chapters 12 and 13 (MRI) 9/27/2018

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

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your signature

1. A sample is in equilibrium, and a $\pi/2$ pulse is applied. What is the longitudinal magnetization of the sample, as developed in the text?

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

B. $M_z(t) = 0$

C. $M_z(t) = M_0(1 - e^{-t/T_2})$

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

E. $M_z(t) = M_0$

2. An RF excitation of 2×10^{-6} Tesla = 0.2 gauss is applied to a sample of protons (γ =42.58 MHz/Tesla) over 3 ms, what is the angle in radians that M is tipped?

A. $\alpha = \pi/2$

B. $\alpha = (42.58 \times 10^6)(2 \times 10^{-6})(3 \times 10^{-3})$

C. $\alpha = (42.58 \times 10^6)(0.2)(3 \times 10^{-3})$

D. Cannot be determined.

E. $\alpha = 2\pi(42.58 \times 10^6)(2 \times 10^{-6})(3 \times 10^{-3})$

3. What is the bandwidth (kHz) of the RF waveform needed to select a slice that is 2 mm thick, given $G_z = 1$ guass/mm and $\gamma = 4.258$ kHz/guass.

A. 4.258 kHz

B. Not enough information given

C. 85.16 kHz

D. 42.58 kHz

E. 8.516 kHz

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

A. T_E should be extremely long.

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

C. Spin echoes should not be used.

D. T_E should be as short as possible.

E. Any T_E duration can be used provided T_R is short.

5. BOLD fMRI utilizes the following principle:

A. None of the choices.

B. $T2^*$ is decreased by the presence of oxygenated hemoglobin.

C. All of the choices.

D. Water diffuses more quickly along axons.

E. Neuronal activity results in increased blood flow.

6. A large magnetic field $\mathbf{B}_0$ in the z direction is applied to a sample in a clinical MRI scanner. Which of the following is *false* when the x-gradient field is applied?

A. At points with different x-coordinates, the total magnetic field has different magnitudes.

B. The gradient field rotates the orientation of the magnetic field towards the x direction.

C. The gradient field is much smaller in magnitude than $\mathbf{B}_0$.

D. All of the other statements are true

E. $\mathbf{B}_0$ is made extremely uniform so that as much of any non-uniformity as possible is due to the gradient field and not to inhomogeneity in $\mathbf{B}_0$.

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

A. 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).

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

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

D. 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*.

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

8. How does slice selection in MRI take place?

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

B. via manipulation of the magnetic attenuation factor of the tissues

C. via application of a linear magnetic gradient, which limits interaction of the RF to hydrogen with appropriate Larmor frequencies.

D. via external placement of ferromagnetic guides, usually along the z-direction, to direct the detection circuitry

E. via phase encoding to shift the phase such that only hydrogen within the slice is energized

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

A. 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.

B. In T_2-weighted images, fluid appears very bright, because transverse magnetization de-phases relatively slowly in free water.

C. T_E and T_R are among the parameters that are set in order to obtain T_1- and T_2-weighted images.

D. 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.

E. All are true.

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

A. 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'.

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

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

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

E. Transverse relaxation is modeled as an exponential decay.

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

A. It causes $\mathbf{B}_0$ to spin in the transverse plane generating an RF signal.

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

C. It occurs in the transverse plane.

D. All are true.

E. It turns the path along which the RF field generates a tip angle α from a spiral into a simple rotation.

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

I - Water diffuses more quickly along white matter tracts, and DTI measures this diffusion, as well as its direction.
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 - Neuronal activity causes greater diffusion of the water within the axons and can thus be detected.

A. I and III

B. II and III

C. only I.

D. I, II, and III

E. I and II

13. 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. only I.

B. I and II

C. II and III

D. I, II, and III

E. I and III

14. 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 - Saturating the magnetization in a slice, so that only fresh blood entering from outside the slice gives off signal; this requires no contrast agent.
III - Detecting the Doppler shift in the RF signal given off by blood that is moving; this requires no contrast agent.

A. II and III

B. I and III

C. only I.

D. I and II

E. I, II, and III

15. 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. All are true.

C. 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).

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

E. 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.

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

A. 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.

B. All are true.

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

D. They cause those magnetization vectors that have precessed faster and gotten ahead to move to the "back of the pack" where they will eventually catch up with the others to form an echo.

E. They do not cancel all differences between protons, and some dephasing still occurs due to tissue-dependent spin-spin relaxation.

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

A. It decreases with increasing magnetic field.

B. It is dependent on magnetic field but independent of the particular substance (for example, ^{1}H vs. ^{13}C)

C. It is the frequency of precession of the magnetization vector, which is related to the local magnetic field by the gyromagnetic ratio.

D. It is the so-called "frequency of love" of popular lore.

E. None is true.

18. 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 - Tipping the longitudinal magnetization into the transverse plane.
II - Longitudinal relaxation.
III - Transverse relaxation.

A. only I.

B. II and III

C. I and II

D. I and III

E. I, II, and III

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

I - A long T_R is used to allow tissues to be at equilibrium (largest possible longitudinal magnetization vector available to flip).
II - A long T_E is used to avoid signal loss due to dephasing.
III - Proton Density weighted images offer the highest signal-to-noise.

A. I, II, and III

B. I and II

C. II and III

D. I and III

E. only I.

20. Which of the following statements about MR and CT is false?

A. MRI is more expensive than CT.

B. MRI is better for imaging bones, while CT is better for imaging soft tissues.

C. MRI does not expose the patient to ionizing radiation, while CT does.

D. MR images can be acquired in any plane, while CT images are typically acquired only in the axial plane.

E. MRI can be used to determine function as well as anatomy, while CT is generally limited to anatomy only.

21. How does slice selection in MRI take place?

A. via phase encoding

B. via external placement of ferromagnetic guides to direct the detection circuitry

C. via elimination of the magnetic field everywhere except the slice of interest

D. via measurement of the magnetic attenuation factor of the tissues

E. via application of a linear magnetic gradient, generally along the z-direction

22. Which of the following statements about MRI contrast mechanisms is *false*?

A. 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.

B. In proton density-weighted images, the image intensity is roughly proportional to the number of hydrogen nuclei in the sample.

C. In proton density-weighted images, images must be acquired quickly before the signal has a chance to decay from T_2 effects.

D. In T_2-weighted images, fluid appears very bright, and intermediate echo times (T_E) are utilized to maximally differentiate between the T_2 of different tissues.

E. T_1 and T_2 are parameters that are set in the computer in order to obtain T_1- and T_2-weighted images.

23. 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 applied?

I - The magnetic field is still oriented in z direction.
II - The strength of the field is not uniform.
III - At points with different x-coordinates, the magnetic field has different strengths.

A. I and III

B. I and II

C. None.

D. I, II, and III

E. II and III

24. Which one of the following statements is TRUE?

A. All of them

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

C. MR data are scans of Fourier space; MR image reconstruction is based on the inverse 2D Fourier transform and represents the distribution of effective spin density.

D. 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).

E. Manipulation of the gradient coils produces frequency or phase encoding of location.

25. Which of the following is *false* about the Larmor frequency (or all are true)?

A. All are true.

B. It permits the differentiation of received RF signals by the application of a gradient in the magnetic field during data acquisition.

C. It is the frequency of precession of the magnetization vector, which is related to the local magnetic field by the gyromagnetic ratio.

D. It is dependent on the particular element involved (for example, ^{1}H vs. ^{13}C)

E. It permits the selection of a particular slice by the application of a gradient in the magnetic field during the RF pulse.

26. 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 - Tipping the longitudinal magnetization into the transverse plane by means of an RF pulse.
II - Longitudinal and Transverse relaxation with corresponding relaxation times of T_1 and T_2.
III - Precession of the magnetization in the transverse plane due to B_0.

A. II and III

B. I and III

C. I, II, and III

D. I and II

E. only I.

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

A. 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.

B. The resulting tip angle is proportional to the RF field strength and the duration 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. An $\pi/2$ RF pulse transfers the longitudinal magnetization into the transverse plane, where it precesses, producing a detectable signal at the Larmor frequency.

E. All are true.

28. Which of the following statements about MRI contrast mechanisms is *false*, or all are true?

A. All are true.

B. In proton density-weighted images, the image intensity is roughly proportional to the number of protons in any chemical element within the sample.

C. In proton density-weighted images, images are acquired with a long T_R and a short T_E.

D. 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.

E. In T_2-weighted images, fluid appears very bright, and an intermediate T_E is utilized to maximally differentiate between the T_2 of different tissues.

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

I - The magnetic field is tipped slightly from the z direction to the x direction.
II - The strength of the field is no longer uniform.
III - At points with different x-coordinates, the Larmor frequency is different because of the x-gradient.

A. II and III

B. I and III

C. I, II, and III

D. I and II

E. II

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

A. 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.

B. 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 .

C. All are true.

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

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

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

I - It displays the 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 - Its resolution is much lower (worse) than regular anatomical MRI.

A. only I.

B. I and II

C. I and III

D. II and III

E. I, II, and III

32. 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 - Saturating the magnetization in a slice, so that only fresh blood entering from outside the slice gives off signal; this requires no contrast agent.
III - Detecting the diffusion of blood with Diffusion Tensor Imaging.

A. I and III

B. only I.

C. II and III

D. I and II

E. I, II, and III

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

I - Water diffuses more quickly along white matter tracts, and DTI can measure the amount of this diffusion but not its direction.
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 - It is used to establish neuroanatomy but not neuronal activity.

A. I, II, and III

B. only II.

C. II and III

D. I and II

E. I and III

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

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

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. All are true.

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. Both are based on the interaction between Gadolinium and the tissue to nullify certain tissue types..

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

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

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

D. $M_z(t) = 0$

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

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

A. It occurs in the transverse plane.

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

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

D. All are true.

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

37. 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. I and II

B. I and III

C. II and III

D. only III.

E. I, II, and III

38. 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. 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.

C. 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.

D. All are true.

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.

39. How does slice selection in MRI take place?

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

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

C. via application of a 180° RF pulse

D. via application of a magnetic gradient orthogonal to the slice of interest

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

40. Which one of the following statements is *false* about MRI (or all are true)?

A. All are true.

B. The protons in hydrogen accounts for almost all clinical MRI imaging.

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 Larmor frequency of hydrogen varies slightly for different chemical environments such as fat and water, accounting for the *chemcial shift artifact*.

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

A. 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.

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

D. All are true.

E. Phase encoding capitalizes on the different magnetic resonance properties in solid vs. liquid phases of small domains of hydrogen atoms in tissue.

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

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

B. None is true.

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

D. It decreases with increasing magnetic field.

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

43. 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 and II

B. I, II, and III

C. only I.

D. II and III

E. I and III

44. 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. I, II, and III

B. only I.

C. I and III

D. I and II

E. II and III

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

A. MR is more expensive than CT.

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

C. All are true

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

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

46. 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 III

B. I, II, and III

C. I and II

D. None.

E. II and III

47. 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 measures the tiny magnetic fields produced by currents across the neuron's cell membrane.

A. only I.

B. I, II, and III

C. I and II

D. II and III

E. I and III

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

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

B. All are true.

C. 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.

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

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

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

A. 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.

B. All are true.

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

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

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

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

C. It permits localization by using the Fourier Transform.

D. All are true.

E. It is immune to spatial error from chemical shift artifact.

51. Which one of the following statements is true? The two medical imaging techniques, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging), are complimentary because

A. CT images bone differently from soft tissue whereas MRI does not.

B. MRI is a tomographic modality whereas CT is not.

C. None of the other statements is true.

D. MRI uses ionizing radiation whereas CT does not.

E. CT is a tomographic modality whereas MRI is not.

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

A. It cannot be justified because of its expense.

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

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

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

E. It is never used at all on pregnant patients

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

A. All are true.

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

C. It permits localization by using the Fourier Transform.

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

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

54. 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. only I.

B. I and III

C. I and II

D. I, II, and III

E. II and III

55. How does slice selection in MRI take place?

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

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

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

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

56. 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 II

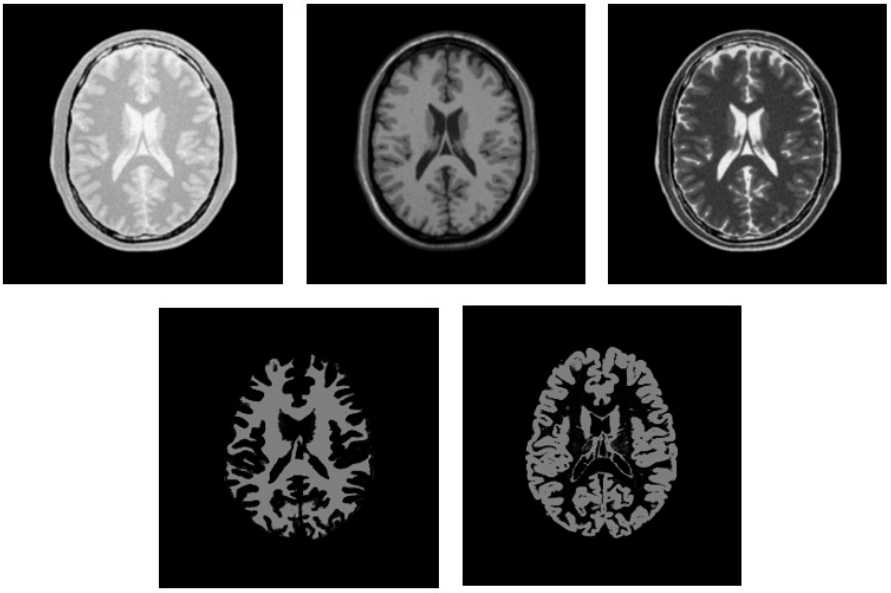
B. only I.

C. I and III

D. II and III

E. I, II, and III

57. The figure below shows five MRI images of human brain, Which of the following statement is *true* in the order of top left, top middle, top right, bottom left and bottom right?



A. Proton Density, T2, T1, Grey Matter, White Matter.

B. Proton Density, T2, T1, White Matter, Grey Matter.

C. T2, T1, Proton Density, White Matter, Grey Matter.

D. Proton Density, T1, T2, White Matter, Grey Matter.

E. Proton Density, T1, T2, Grey Matter, White Matter.

58. Which of the following is *false* about the physics of Magnetic Resonance?

A. Starting at equilibrium in a static magnetic field $\boldsymbol{B}_0$ along the z-axis, a 180° pulse rotates vector M to the negative z-axis.

B. If at $t = 0$ the magnetization vector $\boldsymbol{M}(t)$ is oriented at an angle $\alpha \neq 0°$ and $\alpha \neq 180°$ relative to the z-axis, a static magnetic field $\boldsymbol{B}_0$ along the z-axis will cause a precession of vector $\boldsymbol{M}(t)$ around $\boldsymbol{B}_0$.

C. Nuclei with odd atomic number or odd mass number are capable of having a non-zero angular momentum.

D. Starting at equilibrium in a static magnetic field $\boldsymbol{B}_0$ along the z-axis, a 45° pulse will tip the magnetization vector M into such a state that there is no longitudinal magnetization immediately after the pulse.

E. The Bloch equation puts together both the *forced* and *relaxation* behavior of a magnetic spin system into a single differential equation.

59. Which of the following is *false* about relaxation, (or all are true)?

A. Both longitudinal and transverse relaxation follow exponential functions in time.

B. After a *single* 90° pulse, transverse relaxation leads to a *decrease* of NMR signal while longitudinal relaxation leads to an *increase* of NMR signal.

C. T_2^* relaxation refers to the decay of transverse magnetization caused by a combination of spin-spin relaxation and magnetic field inhomogeneity and therefore T_2^* is shorter than T_2.

D. The reason why MRI can generate contrast in images is that T_1 and T_2 are generally different for various types of tissue.

E. All are true

60. Which of the following is *true* about the instrumentation of MRI?

I - Gradient coils and Radio-Frequency coils are both directly related to slice selection.
II - The gradient coils will change both the magnitude and direction of the magnetic field.
III - There are two basic types of RF coils: volume coils and surface coils. Volume coils are preferable to surface coils in most instances because their sensitivity patterns are more uniform within the body.

A. I and III

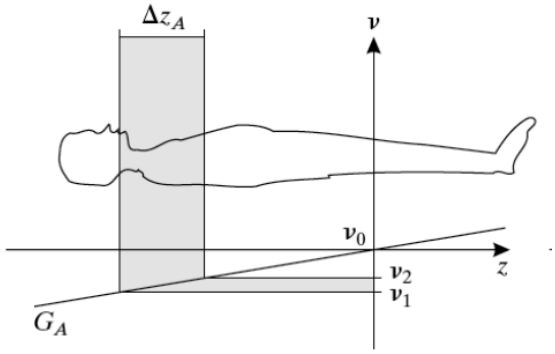
B. I and II

C. only III.

D. II and III

E. I, II, and III

61. Given the graph of slice selection based on z-gradient G_A and an RF sinc pulse containing a band of frequencies ν_1 to ν_2, if we want to narrow the slice within the grey region of the patient, which of the following methods are *correct*?



I - Use a larger z-gradient G_A.
II - Use a smaller z-gradient G_A.
III - Use a wider sinc pulse.
IV - Use a narrower sinc pulse.

A. I and IV

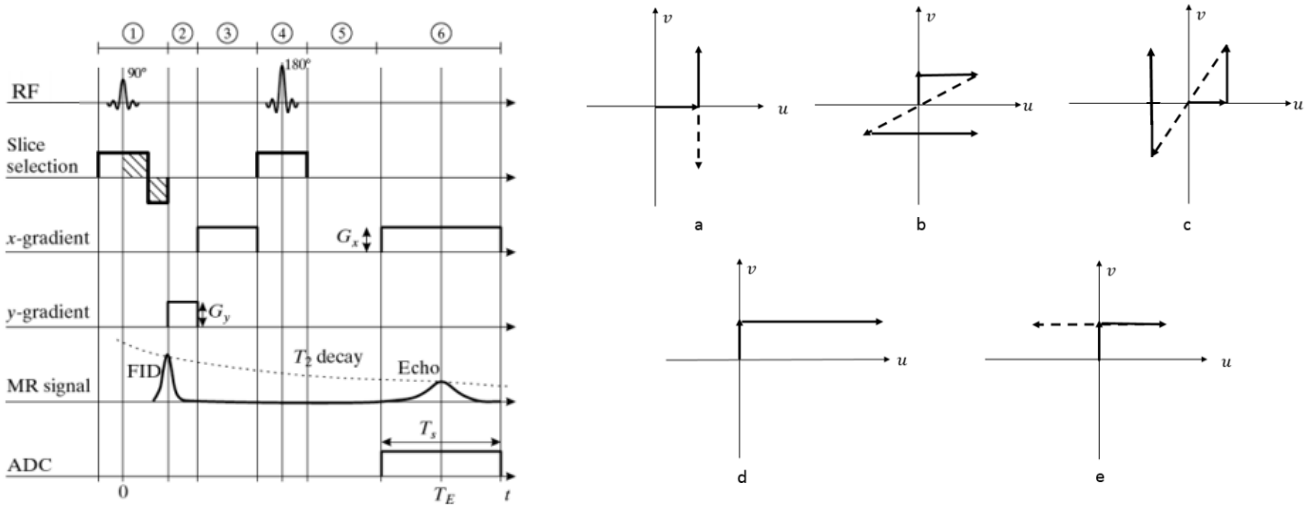
B. I and III

C. None of the others answers is correct.

D. II and III

E. II and IV

62. A pulse sequence diagram is shown in the image below. Which is the corresponding traversal of k-space (Fourier space)?



A. c.

B. b.

C. e.

D. d.

E. a.

63. Which of the following is *true* about the *k-space*?

I - Values in *k-space* are complex numbers.
II - An image can be reconstructed using only one half of the *k-space* because the values in *k-space* are conjugate symmetric.
III - Filling in *k-space* can be accomplished by a wide variety of pulse sequences, which manipulate the gradients, RF pulses, and acquisition times.

A. I, II, and III

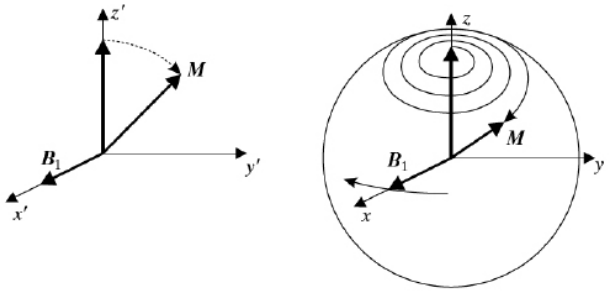
B. II and III

C. I and II

D. only III

E. I and III

64. The figure below shows a fundamental concept in MR imaging. Regarding this concept, the following statements are true *except* (or all are true)



A. B_1 is the magnetic field created by the RF coils to tip the longitudinal magnetization into the transverse plane.

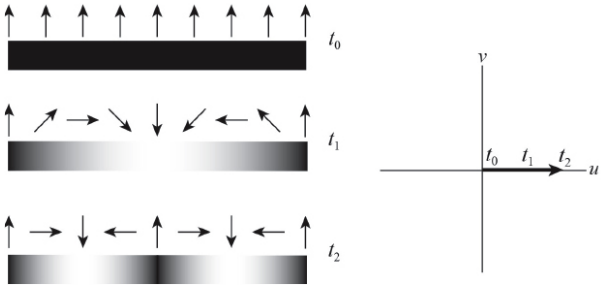
B. B_1 rotates around the z axis at the Larmor frequency corresponding to B_0, so that it is always orthogonal to the (y', z') plane.

C. All are true.

D. The figure on the right is in the stationary coordinate system (x, y, z), whereas the figure on the left is in the rotating frame of reference (x', y', z').

E. After the application of B_1, the angle between the z' axis and the vector $\mathbf{M}$ is known as the "tip angle".

65. The figures below shows a fundamental concept in MR imaging. The figure on the left shows the magnetization in the transverse plane, $\mathbf{M}_{x',y'}$, as a function of location along the x-axis, at 3 successive points in time during the application of a gradient G_x. The following statements are true *except*



A. If all of k space can be traversed, then the MR image can be reconstructed by taking an inverse 2D Fourier transform (some additional filtering may be required depending on how k space is traversed).

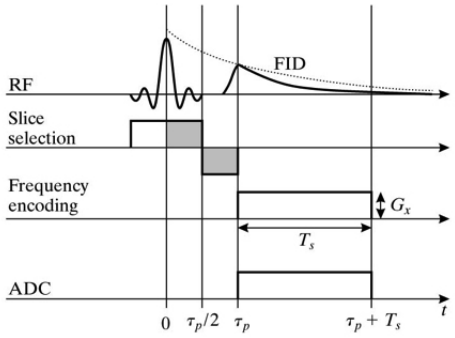
B. The v axis of k space represents spatial frequency in an imaginary dimension, not corresponding to a real dimension in space.

C. The figure on the left shows the spatial frequency of the relative phases of $\mathbf{M}_{x',y'}$ increasing in time.

D. The u axis of k space represents spatial frequency along a real dimension in space, namely x.

E. The figure on the right shows the location in k space indicating higher spatial frequency at successive times.

66. The pulse sequence shown in the figure below includes all of the following *except*



A. A short $\mathbf{B}_1$ field containing a band of frequencies used to tip the longitudinal magnetization into the transverse plane.

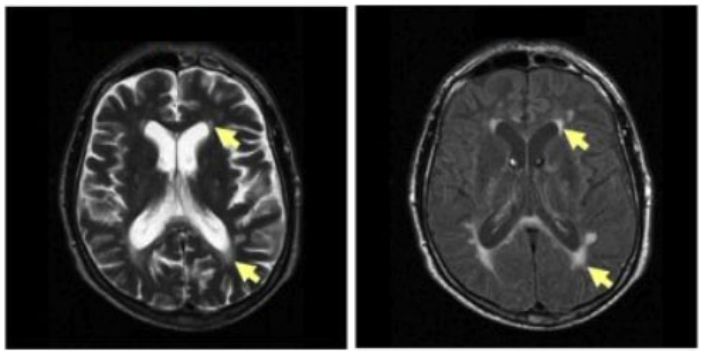
B. A gradient applied during the application of the $\mathbf{B}_1$ field to produce a slice within which the Larmor frequencies match those in $\mathbf{B}_1$.

C. A gradient applied in the transverse plane during signal acquisition to create different Larmor frequencies depending on location.

D. A "refocussing" gradient to realign spins within the transverse plane.

E. A 180° pulse to flip the transverse magnetization, allowing differences between Larmor frequencies due to $\mathbf{B}_0$ field inhomogeneity to be cancelled.

67. The following are true about the images below *except*



A. The image on the right was produced by including a 180° RF pulse at the beginning of the pulse sequence, which reverses the longitudinal magnetization, after which an appropriate "inversion time" was allowed to elapse before applying the usual 90° RF pulse, such that water has no longitudinal magnetization.

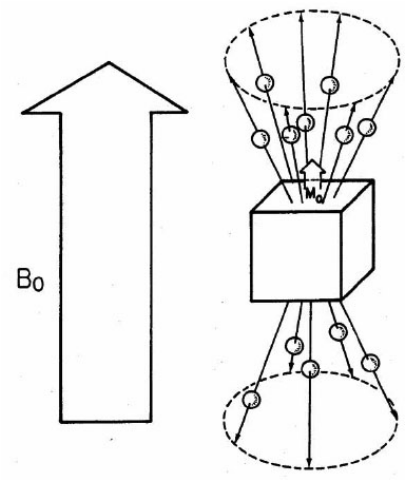
B. Water is suppressed in the image to the right because a band of frequencies is chosen for $\mathbf{B}_1$ that does not include the Larmor frequency of the hydrogen protons in water.

C. The image on the right is a Fluid Attenuation Inversion Recovery (FLAIR) image.

D. The image on the left is a T2-weighted image, as evidenced by the bright cerebrospinal (CSF) fluid, water having a long T2.

E. Periventricular white matter hyperintensities are made more discernable in the image to the right (arrows).

68. The figure below shows a fundamental concept in MR imaging. The following statements are true *except* (or all are true).



A. The net magnetization at rest $\mathbf{M}_0$ within a voxel is aligned with the magnetic field $\mathbf{B}_0$ produced by the superconducting magnet.

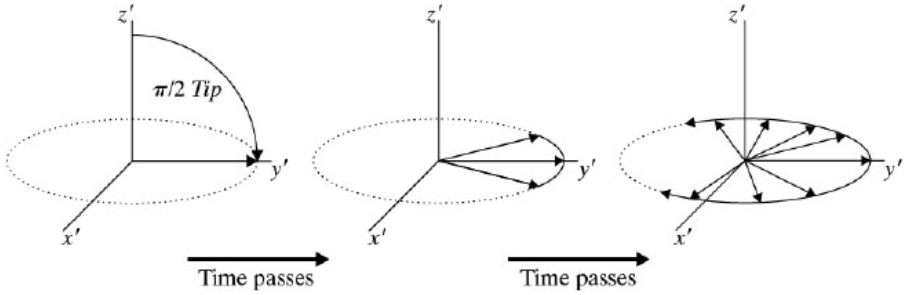
B. $\mathbf{M}_0$ is also called "longitudinal magnetization", and the time it takes to form is called "T1".

C. Quantum mechanics restricts individual protons to one of two states, precessing at a certain angle either with or against $\mathbf{B}_0$.

D. All are true.

E. A larger voxel will yield a larger value for $\mathbf{M}_0$.

69. The figure below shows a fundamental concept in MR imaging. The following statements are true *except* (or all are true).



A. T2-weighted images are primarily dependent upon this mechanism to generate contrast between tissues.

B. $\pi/2$ is the tip angle that yields the greatest signal from the transverse magnetization.

C. All are true.

D. The figures are shown in the reference frame (x', y', z'), known as the "rotating frame of reference", such that faster or slower precessing components are seen to move correspondingly forward or backwards relative to a stationary component.

E. The rate at which the components de-phase is a function solely of the local chemical environment, and is not effected by $\mathbf{B}_0$ field inhomogeneity.

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

I - It displays a measure of neuronal activity by using differences in the susceptibility of oxygenated and deoxygenated hemoglobin.
II - It measures neuronal activity by the uptake of a glucose containing a positron-emitting isotope of fluorine.
III - It determines the direction of axonal structures by measuring diffusion.

A. only I

B. I and II

C. I and III.

D. I, II, and III

E. II and III

71. The equation

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

predicts which of the following phenomena?

A. None of the others is correct.

B. Precession.

C. Temperature dependance of MR signal strength.

D. Relaxation according to T1.

E. Formation of longitudinal magnetization.

72. Which one of the following statements is true? The two medical imaging techniques, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging), are complimentary because

A. CT differentiates soft tissue whereas MRI does not.

B. CT differentiates tissue by attenuation of photons whereas MRI differentiates tissue by the amounts of transverse magnetization.

C. None of the other statements is true.

D. CT involves risk from ionizing radiation, whereas MRI is completely safe for all patients.

E. MRI is a tomographic modality whereas CT is not.

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BioE 1330 - Review Chapters 12 and 13 (MRI) 9/27/2018
Answer Sheet - Correct answer is A for all questions

1. A sample is in equilibrium, and a $\pi/2$ pulse is applied. What is the longitudinal magnetization of the sample, as developed in the text?

A. $M_z(t) = M_0(1 - e^{-t/T_1})$
B. $M_z(t) = M_0(1 - e^{-t/T_2})$
C. $M_z(t) = M_0(e^{-t/T_1})$
D. $M_z(t) = 0$
E. $M_z(t) = M_0$

Explanation: The longitudinal magnetization rebuilds from 0 approaching M_0 as a first order exponential with time constant T_1. Since it is a $\pi/2$ pulse, there is initially no longitudinal magnetization (it has all be tipped into the transverse plane).
[*imaging0136.mcq*]

2. An RF excitation of 2×10^{-6} Tesla = 0.2 gauss is applied to a sample of protons ($\bar{\gamma}$ =42.58 MHz/Tesla) over 3 ms, what is the angle in radians that M is tipped?

A. $\alpha = 2\pi(42.58 \times 10^6)(2 \times 10^{-6})(3 \times 10^{-3})$
B. $\alpha = (42.58 \times 10^6)(0.2)(3 \times 10^{-3})$
C. $\alpha = (42.58 \times 10^6)(2 \times 10^{-6})(3 \times 10^{-3})$
D. $\alpha = \pi/2$
E. Cannot be determined.

Explanation:
The gyromagnetic ratio $\bar{\gamma}$ is in units of MHz/Tesla, and determines the Larmor frequency given the strength of the magnetic field, in this case, provided by the RF excitation in the rotating frame of reference.
[*imaging0137.mcq*]

3. What is the bandwidth (kHz) of the RF waveform needed to select a slice that is 2 mm thick, given $G_z = 1$ guass/mm and $\bar{\gamma} = 4.258$ kHz/guass.

A. 8.516 kHz
B. 4.258 kHz
C. 42.58 kHz
D. 85.16 kHz
E. Not enough information given

Explanation: The gyromagnetic ratio $\bar{\gamma}$ is in units of kHz/Tesla, and determines the Larmor frequency given the strength of the magnetic field, in this case, provided by the RF excitation in the rotating frame of reference. The bandwidth is proportional to the change in magnetic field, which is proportional to the gradient. $2mm \times 1guass/mm \times 4.258kHz/guass = 8.516kHz$.
[*imaging0138.mcq*]

4. 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 provided T_R is short.

D. T_E should be extremely long.

E. Spin 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*]

5. BOLD fMRI utilizes the following principle:

A. Neuronal activity results in increased blood flow.

B. $T2^*$ is decreased by the presence of oxygenated hemoglobin.

C. Water diffuses more quickly along axons.

D. All of the choices.

E. None of the choices.

Explanation: Blood Oxygen Level Dependent (BOLD) Functional MRI (fMRI) shows neuronal activity by its increase in blood flow, which results in increased oxygenated hemoglobin because of increased blood flow. Oxygenated hemoglobin has a *longer* $T2^*$ and thus a stronger signal. The fact that water diffuses more quickly along axons is used in Diffusion Tensor Imaging (DTI).
[*imaging0140.mcq*]

6. A large magnetic field $\mathbf{B}_0$ in the z direction is applied to a sample in a clinical MRI scanner. Which of the following is *false* when the x-gradient field is applied?

A. The gradient field rotates the orientation of the magnetic field towards the x direction.

B. The gradient field is much smaller in magnitude than $\mathbf{B}_0$.

C. $\mathbf{B}_0$ is made extremely uniform so that as much of any non-uniformity as possible is due to the gradient field and not to inhomogeneity in $\mathbf{B}_0$.

D. At points with different x-coordinates, the total magnetic field has different magnitudes.

E. All of the other statements are true

Explanation: The gradient field produces a variation is in the scalar strength, not the direction, of the overall magnetic field.
[*imaging0141.mcq*]

7. 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*]

8. How does slice selection in MRI take place?

A. via application of a linear magnetic gradient, which limits interaction of the RF to hydrogen with appropriate Larmor frequencies.

B. via manipulation of the magnetic attenuation factor of the tissues

C. via external placement of ferromagnetic guides, usually along the z-direction, to direct the detection circuitry

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

E. via phase encoding to shift the phase such that only hydrogen within the slice is energized

Explanation: Slice selection occurs by controlling the strength generally of the z-gradient of the magnetic field and by controlling the frequency of the RF pulses. The other choices do not make any sense or are incorrect.
[*imaging0143.mcq*]

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

A. All are true.

B. T_E and T_R are among the parameters that are set in order to obtain T_1- and T_2-weighted images.

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. In T_2-weighted images, fluid appears very bright, because transverse magnetization de-phases relatively slowly in free water.

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 T_1 and T_2. The parameters that are set for each image include T_R, T_E, and the tip angle α.
[*imaging0144.mcq*]

10. 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*]

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

A. It causes $\mathbf{B}_0$ to spin in the transverse plane generating an RF signal.

B. All are true.

C. It occurs in the transverse plane.

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

E. It turns the path along which the RF field generates a tip angle α from a spiral into a simple rotation.

Explanation: $\mathbf{B}_0$ is the axis of the rotating frame of reference and does not spin.
[*imaging0146.mcq*]

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

I - Water diffuses more quickly along white matter tracts, and DTI measures this diffusion, as well as its direction.
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 - Neuronal activity causes greater diffusion of the water within the axons and can thus be detected.

A. I and II

B. II and III

C. I and III

D. I, II, and III

E. only I.

Explanation: Neuronal activity is detected by BOLD, not DTI, and does not cause greater diffusion of water in the axons.
[*imaging0147.mcq*]

13. 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*]

14. 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 - Saturating the magnetization in a slice, so that only fresh blood entering from outside the slice gives off signal; this requires no contrast agent.
III - Detecting the Doppler shift in the RF signal given off by blood that is moving; this requires no contrast agent.

A. I and II

B. I, II, and III

C. I and III

D. II and III

E. only I.

Explanation: III is not true. Doppler is used in ultrasound, not in MRI. Electromagnetic induction propagates at the speed of light, not the speed of sound, so any Doppler shift would be negligible.
[*imaging0149.mcq*]

15. 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*]

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

A. All are true.

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 eventually catch up with the others to form an echo.

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. They do not cancel all differences between protons, and some dephasing still occurs due to tissue-dependent spin-spin relaxation.

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, leaving the desired tissue-dependent spin-spin relaxation.
[*imaging0151.mcq*]

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

A. It is the frequency of precession of the magnetization vector, which is related to the local magnetic field by the gyromagnetic ratio.

B. It is the so-called "frequency of love" of popular lore.

C. It decreases with increasing magnetic field.

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

E. None is true.

Explanation: The Larmor frequency depends both on the local magnetic field (to which it is proportional) and the substance (which determines the proportionality, the gyromagnetic ratio).
[*imaging0152.mcq*]

18. 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 - Tipping the longitudinal magnetization into the transverse plane.
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.
[*imaging0153.mcq*]

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

I - A long T_R is used to allow tissues to be at equilibrium (largest possible longitudinal magnetization vector available to flip).
II - A long T_E is used to avoid signal loss due to dephasing.
III - Proton Density weighted images offer the highest signal-to-noise.

A. I and III

B. I and II

C. I, II, and III

D. II and III

E. only I.

Explanation: II is false, a *short* T_E is used to avoid signal loss due to dephasing.
[*imaging0154.mcq*]

20. Which of the following statements about MR and CT is false?

A. MRI is better for imaging bones, while CT is better for imaging soft tissues.

B. MR images can be acquired in any plane, while CT images are typically acquired only in the axial plane.

C. MRI is more expensive than CT.

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

E. MRI can be used to determine function as well as anatomy, while CT is generally limited to anatomy only.

Explanation: As Dr. Branstetter mentioned, MRI is ideal for imaging soft tissues, while CT is optimal for tissues with high attenuation coefficients, like bone. The other statements are all true.
[*imaging0184.mcq*]

21. How does slice selection in MRI take place?

A. via application of a linear magnetic gradient, generally along the z-direction

B. via measurement of the magnetic attenuation factor of the tissues

C. via external placement of ferromagnetic guides to direct the detection circuitry

D. via elimination of the magnetic field everywhere except the slice of interest

E. via phase encoding

Explanation: Slice selection occurs by controlling the strength generally of the z-gradient of the magnetic field and by controlling the frequency of the RF pulses. The other choices do not make any sense or are incorrect.
[*imaging0185.mcq*]

22. Which of the following statements about MRI contrast mechanisms is *false*?

A. T_1 and T_2 are parameters that are set in the computer in order to obtain T_1- and T_2-weighted images.

B. In proton density-weighted images, images must be acquired quickly before the signal has a chance to decay from T_2 effects.

C. In proton density-weighted images, the image intensity is roughly proportional to the number of hydrogen nuclei in the sample.

D. In T_2-weighted images, fluid appears very bright, and intermediate echo times (T_E) are utilized to maximally differentiate between the T_2 of different tissues.

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: T_1 and T_2 are not parameters to be set during image acquisition. Rather, they are characteristics of tissues being imaged. MRI involves the measurement of T_1 and T_2. The parameters that are set for each image include T_R, T_E, and the tip angle α.
[*imaging0192.mcq*]

23. 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 applied?

I - The magnetic field is still oriented in z direction.
II - The strength of the field is not uniform.
III - At points with different x-coordinates, the magnetic field has different strengths.

A. I, II, and III

B. I and II

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.
[*imaging0216.mcq*]

24. Which one of the following statements is TRUE?

A. All of them

B. MR data are scans of Fourier space; MR image reconstruction is based on the inverse 2D Fourier transform and represents the distribution of effective spin density.

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

D. Manipulation of the gradient coils produces 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: See the text book for explanation.
[*imaging0218.mcq*]

25. Which of the following is *false* about the Larmor frequency (or all are true)?

A. All are true.

B. It permits the selection of a particular slice by the application of a gradient in the magnetic field during the RF pulse.

C. It permits the differentiation of received RF signals by the application of a gradient in the magnetic field during data acquisition.

D. It is dependent on the particular element involved (for example, ^{1}H vs. ^{13}C)

E. It is the frequency of precession of the magnetization vector, which is related to the local magnetic field by the gyromagnetic ratio.

Explanation: The Larmor frequency depends both on the local magnetic field (to which it is proportional) and the substance (which determines the proportionality, the gyromagnetic ratio).
[*imaging0296.mcq*]

26. 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 - Tipping the longitudinal magnetization into the transverse plane by means of an RF pulse.
II - Longitudinal and Transverse relaxation with corresponding relaxation times of T_1 and T_2.
III - Precession of the magnetization in the transverse plane due to B_0.

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. You can tell precession in B_0 (as well as tipping with the RF pulse, which is precession in B_1) is covered by the inclusion of the cross product.
[*imaging0297.mcq*]

27. 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*]

28. Which of the following statements about MRI contrast mechanisms is *false*, or all are true?

A. In proton density-weighted images, the image intensity is roughly proportional to the number of protons in any chemical element within the sample.

B. In proton density-weighted images, images are acquired with a long T_R and a short T_E.

C. All are true.

D. In T_2-weighted images, fluid appears very bright, and an intermediate T_E is utilized to maximally differentiate between the T_2 of different tissues.

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: Only protons in hydrogen are imaged, mainly those within fat and water.
[*imaging0300.mcq*]

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

I - The magnetic field is tipped slightly from the z direction to the x direction.
II - The strength of the field is no longer uniform.
III - At points with different x-coordinates, the Larmor frequency is different because of the x-gradient.

A. II and III

B. I and II

C. I and III

D. I, II, and III

E. II

Explanation: The gradient is in the scalar strength, not the direction of the magnetic field.
[*imaging0301.mcq*]

30. 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*]

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

I - It displays the 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 - 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: Neuronal activity leads to a local increase in blood flow and therefore increased oxygenated hemoglobin.
[*imaging0303.mcq*]

32. 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 - Saturating the magnetization in a slice, so that only fresh blood entering from outside the slice gives off signal; this requires no contrast agent.
III - Detecting the diffusion of blood with Diffusion Tensor Imaging.

A. I and II

B. I, II, and III

C. I and III

D. II and III

E. only I.

Explanation: III is not true. Diffusion is much slower than blood flow.
[*imaging0304.mcq*]

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

I - Water diffuses more quickly along white matter tracts, and DTI can measure the amount of this diffusion but not its direction.
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 - It is used to establish neuroanatomy but not neuronal activity.

A. II and III

B. I and II

C. I and III

D. I, II, and III

E. only II.

Explanation: DTI can measure the amount as well as the direction of the diffusion. It does not measure neuronal activity, which is primarily done with fMRI.
[*imaging0299.mcq*]

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

A. Both are based on the interaction between Gadolinium and the tissue to nullify certain tissue types..

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. All are true.

Explanation: Gadolinium is not required.
[*imaging0295.mcq*]

35. 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*]

36. 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*]

37. 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*]

38. 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*]

39. How does slice selection in MRI take place?

A. via application of a magnetic gradient orthogonal to the slice of interest

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.
[*imaging0359.mcq*]

40. Which one of the following statements is *false* about MRI (or all are true)?

A. All are true.

B. The Larmor frequency of hydrogen 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 protons in hydrogen accounts for almost all clinical MRI imaging.

Explanation: All are true.
[*imaging0360.mcq*]

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

A. Phase encoding capitalizes on the different magnetic resonance properties in solid vs. liquid phases of small domains of hydrogen atoms in tissue.

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 is baloney. Wrong kind of "phase".
[*imaging0361.mcq*]

42. 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) as well as the particular atomic number, atomic mass, and chemical environment of the atom (which determine 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*]

43. 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*]

44. 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*]

45. 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*]

46. 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*]

47. 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 measures the tiny magnetic fields produced by currents across the neuron's cell membrane.

A. I and II

B. I, II, and III

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. The electrical behavior of the neuron is not measured directly, so III is wrong.
[*imaging0367.mcq*]

48. 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*]

49. 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*]

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

A. It is immune to spatial error from chemical shift artifact.

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: It is not immune to chemical shift artifact. Chemical shift changes the Larmor frequency and thus the apparent location as encoded by frequency.
[*imaging0370.mcq*]

51. Which one of the following statements is true? The two medical imaging techniques, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging), are complimentary because

A. None of the other statements is true.

B. CT images bone differently from soft tissue whereas MRI does not.

C. MRI uses ionizing radiation whereas CT does not.

D. MRI is a tomographic modality whereas CT is not.

E. CT is a tomographic modality whereas MRI is not.

Explanation:
[*imaging0406.mcq*]

52. 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*]

53. 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*]

54. 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*]

55. 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*]

56. 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

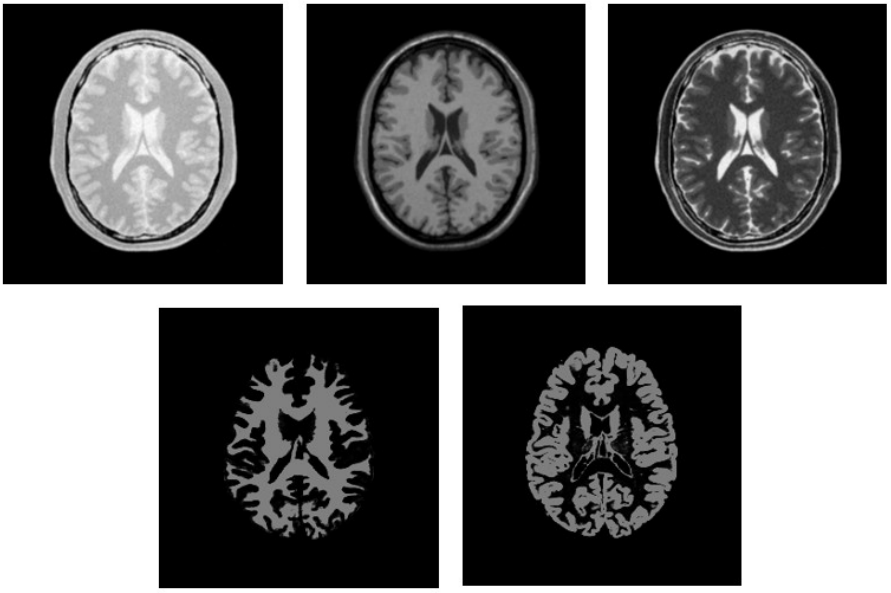
C. I and II

D. II and III

E. only I.

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

57. The figure below shows five MRI images of human brain, Which of the following statement is *true* in the order of top left, top middle, top right, bottom left and bottom right?



A. Proton Density, T1, T2, White Matter, Grey Matter.

B. Proton Density, T2, T1, White Matter, Grey Matter.

C. Proton Density, T1, T2, Grey Matter, White Matter.

D. Proton Density, T2, T1, Grey Matter, White Matter.

E. T2, T1, Proton Density, White Matter, Grey Matter.

Explanation: Water (CSF, eyeballs) is brighter than anything else in T2, white matter is shorter than grey matter in T1, everything is bright on proton density including water.
[*imaging0447.mcq*]

58. Which of the following is *false* about the physics of Magnetic Resonance?

A. Starting at equilibrium in a static magnetic field $\boldsymbol{B}_0$ along the z-axis, a 45° pulse will tip the magnetization vector M into such a state that there is no longitudinal magnetization immediately after the pulse.

B. Starting at equilibrium in a static magnetic field $\boldsymbol{B}_0$ along the z-axis, a 180° pulse rotates vector M to the negative z-axis.

C. If at $t = 0$ the magnetization vector $\boldsymbol{M}(t)$ is oriented at an angle $\alpha \neq 0°$ and $\alpha \neq 180°$ relative to the z-axis, a static magnetic field $\boldsymbol{B}_0$ along the z-axis will cause a precession of vector $\boldsymbol{M}(t)$ around $\boldsymbol{B}_0$.

D. Nuclei with odd atomic number or odd mass number are capable of having a non-zero angular momentum.

E. The Bloch equation puts together both the *forced* and *relaxation* behavior of a magnetic spin system into a single differential equation.

Explanation: Only a 90° pulse will accomplish this.
[*imaging0448.mcq*]

59. Which of the following is *false* about relaxation, (or all are true)?

A. After a *single* 90° pulse, transverse relaxation leads to a *decrease* of NMR signal while longitudinal relaxation leads to an *increase* of NMR signal.

B. All are true

C. Both longitudinal and transverse relaxation follow exponential functions in time.

D. T_2^* relaxation refers to the decay of transverse magnetization caused by a combination of spin-spin relaxation and magnetic field inhomogeneity and therefore T_2^* is shorter than T_2.

E. The reason why MRI can generate contrast in images is that T_1 and T_2 are generally different for various types of tissue.

Explanation: Longitudinal relaxation also leads to an *decrease* of NMR signal, as the magnetization reforms in the z direction.
[*imaging0449.mcq*]

60. Which of the following is *true* about the instrumentation of MRI?

I - Gradient coils and Radio-Frequency coils are both directly related to slice selection.
II - The gradient coils will change both the magnitude and direction of the magnetic field.
III - There are two basic types of RF coils: volume coils and surface coils. Volume coils are preferable to surface coils in most instances because their sensitivity patterns are more uniform within the body.

A. I and III

B. I and II

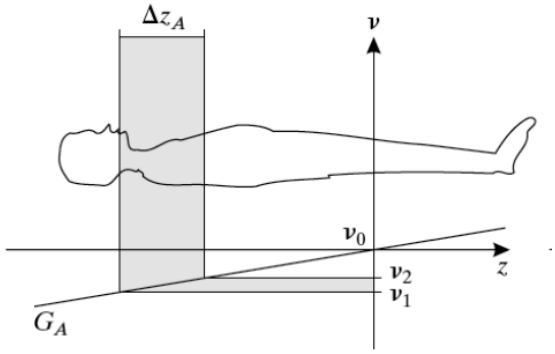
C. I, II, and III

D. II and III

E. only III.

Explanation: RF coils are directly related to slice selection because the frequencies making up the pulse determine the slice selected during the write gradients. The gradient coils do not change the direction of the magnetic field, only the strength.
[*imaging0450.mcq*]

61. Given the graph of slice selection based on z-gradient G_A and an RF sinc pulse containing a band of frequencies ν_1 to ν_2, if we want to narrow the slice within the grey region of the patient, which of the following methods are *correct*?



I - Use a larger z-gradient G_A.
II - Use a smaller z-gradient G_A.
III - Use a wider sinc pulse.
IV - Use a narrower sinc pulse.

A. I and III

B. I and IV

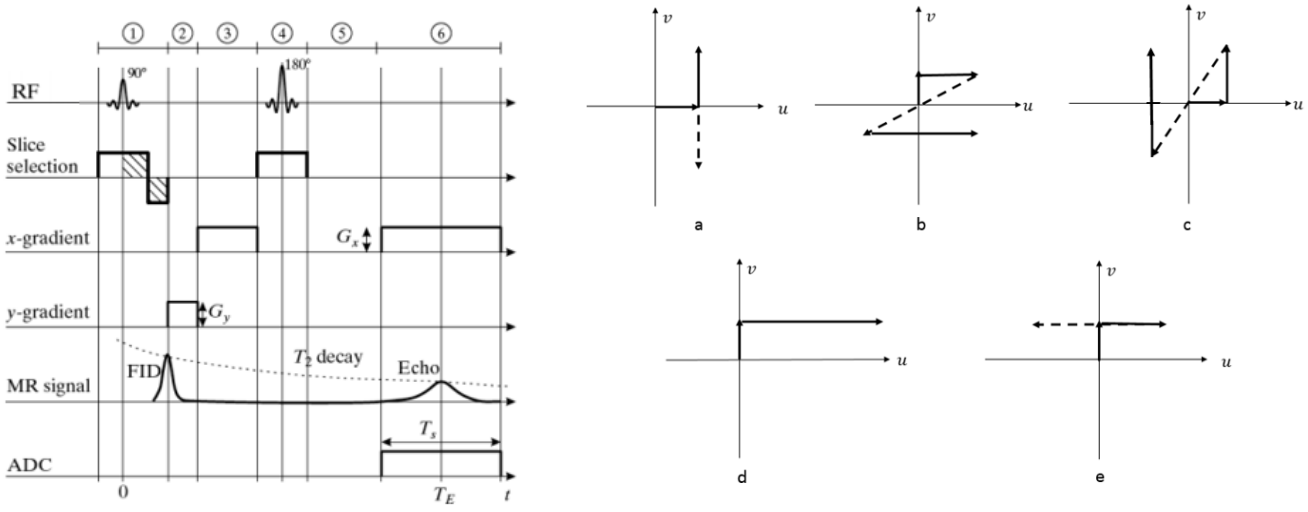
C. II and III

D. II and IV

E. None of the others answers is correct.

Explanation: A larger gradient will make the slice containing Larmor frequencies within the RF band narrower. A wider sinc pulse will have a narrower band of frequencies and hence a narrower slice.
[*imaging0451.mcq*]

62. A pulse sequence diagram is shown in the image below. Which is the corresponding traversal of k-space (Fourier space)?



A. b.

B. a.

C. c.

D. d.

E. e.

Explanation: This is a spin-echo sequence with phase encoding. There is a windup for the read-gradient.
[*imaging0452.mcq*]

63. Which of the following is *true* about the *k-space*?

I - Values in *k-space* are complex numbers.
II - An image can be reconstructed using only one half of the *k-space* because the values in *k-space* are conjugate symmetric.
III - Filling in *k-space* can be accomplished by a wide variety of pulse sequences, which manipulate the gradients, RF pulses, and acquisition times.

A. I, II, and III

B. I and II

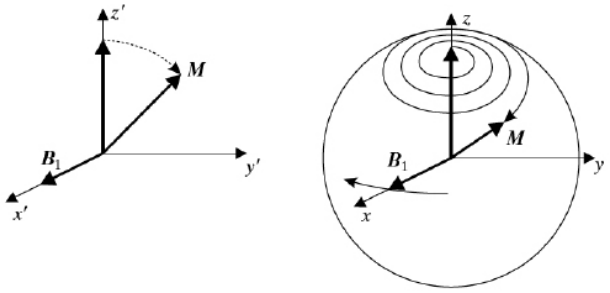
C. I and III

D. II and III

E. only III

Explanation: All are true.
[*imaging0453.mcq*]

64. The figure below shows a fundamental concept in MR imaging. Regarding this concept, the following statements are true *except* (or all are true)



A. All are true.

B. B_1 is the magnetic field created by the RF coils to tip the longitudinal magnetization into the transverse plane.

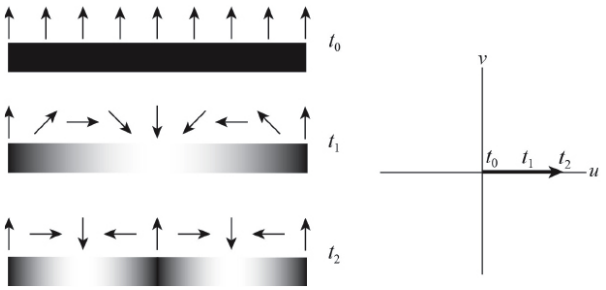
C. The figure on the right is in the stationary coordinate system (x, y, z), whereas the figure on the left is in the rotating frame of reference (x', y', z').

D. After the application of B_1, the angle between the z' axis and the vector $\mathbf{M}$ is known as the "tip angle".

E. B_1 rotates around the z axis at the Larmor frequency corresponding to B_0, so that it is always orthogonal to the (y', z') plane.

Explanation:
[*imaging0485.mcq*]

65. The figures below shows a fundamental concept in MR imaging. The figure on the left shows the magnetization in the transverse plane, $\mathbf{M}_{x',y'}$, as a function of location along the x-axis, at 3 successive points in time during the application of a gradient G_x. The following statements are true *except*



A. The v axis of k space represents spatial frequency in an imaginary dimension, not corresponding to a real dimension in space.

B. The figure on the left shows the spatial frequency of the relative phases of $\mathbf{M}_{x',y'}$ increasing in time.

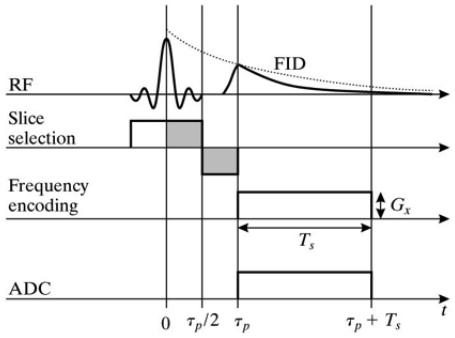
C. The figure on the right shows the location in k space indicating higher spatial frequency at successive times.

D. If all of k space can be traversed, then the MR image can be reconstructed by taking an inverse 2D Fourier transform (some additional filtering may be required depending on how k space is traversed).

E. The u axis of k space represents spatial frequency along a real dimension in space, namely x.

Explanation: the v axis represents spatial frequency in a real dimension in space, namely, in the y direction. The use of a phasor to represent $\mathbf{M}_{x',y'}$ is an unusual case for Fourier, in which an imaginary number is used to represent a real parameter.
[*imaging0486.mcq*]

66. The pulse sequence shown in the figure below includes all of the following *except*



A. A 180° pulse to flip the transverse magnetization, allowing differences between Larmor frequencies due to $\mathbf{B}_0$ field inhomogeneity to be cancelled.

B. A short $\mathbf{B}_1$ field containing a band of frequencies used to tip the longitudinal magnetization into the transverse plane.

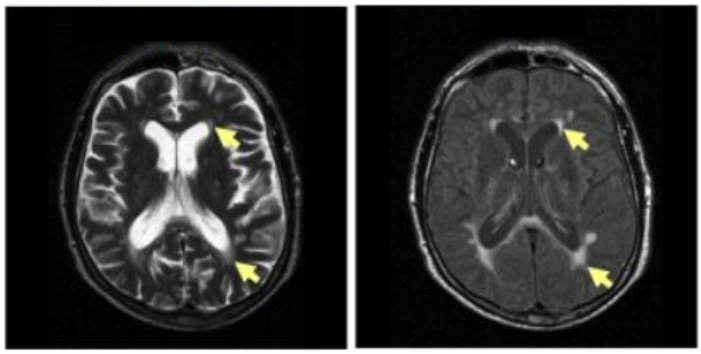
C. A gradient applied in the transverse plane during signal acquisition to create different Larmor frequencies depending on location.

D. A gradient applied during the application of the $\mathbf{B}_1$ field to produce a slice within which the Larmor frequencies match those in $\mathbf{B}_1$.

E. A "refocussing" gradient to realign spins within the transverse plane.

Explanation: There is no 180° pulse in this pulse sequence.
[*imaging0487.mcq*]

67. The following are true about the images below *except*



A. Water is suppressed in the image to the right because a band of frequencies is chosen for $\mathbf{B}_1$ that does not include the Larmor frequency of the hydrogen protons in water.

B. The image on the left is a T2-weighted image, as evidenced by the bright cerebrospinal (CSF) fluid, water having a long T2.

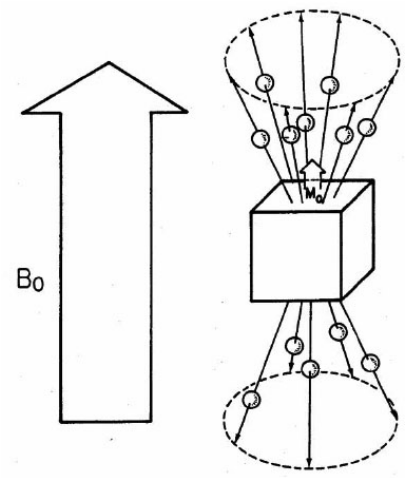
C. The image on the right is a Fluid Attenuation Inversion Recovery (FLAIR) image.

D. The image on the right was produced by including a 180° RF pulse at the beginning of the pulse sequence, which reverses the longitudinal magnetization, after which an appropriate "inversion time" was allowed to elapse before applying the usual 90° RF pulse, such that water has no longitudinal magnetization.

E. Periventricular white matter hyperintensities are made more discernable in the image to the right (arrows).

Explanation: Water is energized by $\mathbf{B}_1$ along with other tissues, but suppressed by the mechanism described in Answer D.
[*imaging0488.mcq*]

68. The figure below shows a fundamental concept in MR imaging. The following statements are true *except* (or all are true).



A. All are true.

B. The net magnetization at rest $\mathbf{M}_0$ within a voxel is aligned with the magnetic field $\mathbf{B}_0$ produced by the superconducting magnet.

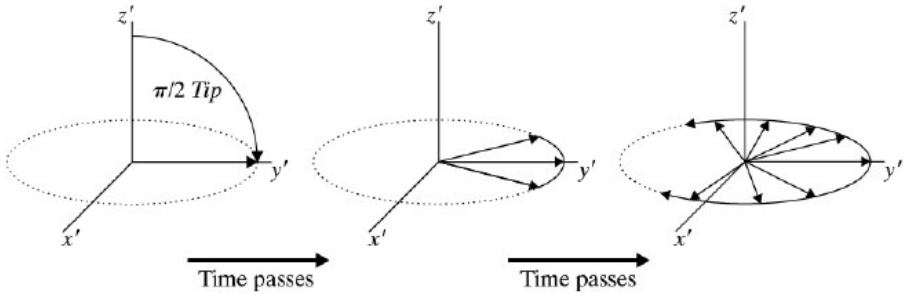
C. Quantum mechanics restricts individual protons to one of two states, precessing at a certain angle either with or against $\mathbf{B}_0$.

D. A larger voxel will yield a larger value for $\mathbf{M}_0$.

E. $\mathbf{M}_0$ is also called "longitudinal magnetization", and the time it takes to form is called "T1".

Explanation:
[*imaging0489.mcq*]

69. The figure below shows a fundamental concept in MR imaging. The following statements are true *except* (or all are true).



A. The rate at which the components de-phase is a function solely of the local chemical environment, and is not effected by $\mathbf{B}_0$ field inhomogeneity.

B. $\pi/2$ is the tip angle that yields the greatest signal from the transverse magnetization.

C. The figures are shown in the reference frame (x', y', z'), known as the "rotating frame of reference", such that faster or slower precessing components are seen to move correspondingly forward or backwards relative to a stationary component.

D. T2-weighted images are primarily dependent upon this mechanism to generate contrast between tissues.

E. All are true.

Explanation: The rate at which the components de-phase is a function of the local chemical environment, but is also affected by $\mathbf{B}_0$ field inhomogeneity, which changes the Larmor frequency depending on location.
[*imaging0490.mcq*]

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

I - It displays a measure of neuronal activity by using differences in the susceptibility of oxygenated and deoxygenated hemoglobin.
II - It measures neuronal activity by the uptake of a glucose containing a positron-emitting isotope of fluorine.
III - It determines the direction of axonal structures by measuring diffusion.

A. only I

B. I and II

C. I, II, and III

D. II and III

E. I and III.

Explanation: Answer II is the mechanism by which PET, not fMRI, detects neuronal activity. Answer III describes Diffusion Tensor Imaging (DTI), not fMRI.
[*imaging0491.mcq*]

71. The equation

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

predicts which of the following phenomena?

A. Precession.

B. Relaxation according to T1.

C. Formation of longitudinal magnetization.

D. Temperature dependance of MR signal strength.

E. None of the others is correct.

Explanation: Precession results from a force orthogonal to both **M** and **B**, provided the angle between them is not zero.
[*imaging0492.mcq*]

72. Which one of the following statements is true? The two medical imaging techniques, CT (Computed Tomography) and MRI (Magnetic Resonance Imaging), are complimentary because

A. CT differentiates tissue by attenuation of photons whereas MRI differentiates tissue by the amounts of transverse magnetization.

B. CT differentiates soft tissue whereas MRI does not.

C. None of the other statements is true.

D. MRI is a tomographic modality whereas CT is not.

E. CT involves risk from ionizing radiation, whereas MRI is completely safe for all patients.

Explanation: MRI is not completely safe for patients with pacemakers, embedded metal, etc.
[*imaging0493.mcq*]