BioE 1330 - Exam 5 4/23/2012
Answer Sheet - Correct answer is A for all questions

1. The following are true about complex exponentials of the form $re^{j\theta}$ *except*

A. They can represent any complex number except 0, because $re^{j0} = 1$

B. They can operate on the 2D domain (x, y) by, for example, having $\theta = ux + vy$.

C. θ may represent temporal or spatial phase.

D. When multiplied together, they scale each other's magnitudes and rotate each other's phase.

E. They can be used to represent real sinusoids in a format that is amenable to algebraic manipulation, by using complex conjugates to eliminate the imaginary component.

Explanation: Answer A is not true, since if $r = 0$, $re^{j\theta} = 0$
[*imaging0322.mcq*]

2. Which of the following imaging modalities is not inherently tomographic?

A. Fluoroscopy

B. CT

C. Ultrasound

D. PET

E. MRI

Explanation: Fluoroscopy produces a projection rather than a tomographic image.
[*imaging0319.mcq*]

3. Which of the following statements about random variables $N_1, N_2, N_3, \ldots, N_m$, whose probability density functions (pdf's) are $p_1(\eta), p_2(\eta), p_3(\eta), \ldots, p_m(\eta)$, is *false* about their sum, N_S, or all are true?

A. The probability density function of N_S will be the product of the individual pdf's, $p_S(\eta) = p_1(\eta) \times p_2(\eta) \times p_3(\eta) \times \ldots \times p_m(\eta)$.

B. N_S will have a mean of $\mu_S = \mu_1 + \mu_2 + \mu_3 + \ldots + \mu_m$.

C. N_S will have a variance of $\sigma_S^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \ldots + \sigma_m^2$.

D. N_S will have a pdf whose area equals 1.

E. All are true.

Explanation: The probability density function of their sum will be the *convolution* of the individual pdf's, so that $p_S(\eta) = p_1(\eta) * p_2(\eta) * p_3(\eta) * \ldots * p_m(\eta)$. The area of any pdf equals 1, by definition.
[*imaging0318.mcq*]

4. Which of the following statements about resolution is *false*?

A. The Full Width Half Maximum (FWHM) fully defines the resolution, without requiring any further knowledge about the Point Spread Function (PSF).

B. 'Spectral resolution' refers to the ability to distinguish one frequency from another, and is necessarily limited in the Fourier transform of a sampled image.

C. Spatial resolution is limited by the number of pixels or voxels per cm, but may also be further limited by the image acquisition or subsequent filtering.

D. Temporal resolution is limited by the number of images acquired per unit time.

E. Spatial resolution may be defined in terms of the Modulation Transfer Function (MTF), which, in practice, may be said to have a cut-off frequency, whose inverse is the resolution.

Explanation: The Full Width Half Maximum (FWHM) is an incomplete description of the resolution, since it depends on the particular shape of the Point Spread Function (PSF).
[*imaging0316.mcq*]

5. The following is *false* about the Fourier transform $F(u, v)$ of image $f(x, y)$, (or all are true).

A. All are true.

B. The Fourier transform of the projection of an image onto its x axis is a 1D function, equal to the value of the Fourier transform of the original image along its u axis.

C. Rotating an image results in rotating its Fourier Transform.

D. Blurring an image results in reducing the amplitude of the higher spatial frequencies in the image's Fourier transform, found further from the center of the transform than the lower spatial frequencies.

E. The average, or 'DC', value of the image $f(x, y)$ is a real number located at $F(0, 0)$

Explanation: All are true.
[*imaging0315.mcq*]

6. Given the signal $f(x, y) = x + y$: evaluate $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y)\delta(x + 1, y - 2)dxdy$

A. 1

B. $3\delta(x + 1, y - 2)$

C. $f(x + 1, y - 2)$

D. $f(x, y)$

E. 3

Explanation: The double integral performs "sifting" on $f(x, y)$ at location $(-1, 2)$.
[*imaging0313.mcq*]

7. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Sensitivity.

A. 0.67

B. 0.95

C. 1.0

D. .10

E. .12

Explanation: Given

		disease	
		+	-
test	+	a	b
	-	c	d

Sensitivity is $\frac{a}{a+c}$.
[*imaging0308.mcq*]

8. Which of the following terms include the phenomena in planar X-ray detectors by which each X-ray photon creates a useful shower of visible light photons?

I - Luminescence
II - Fluorescence
III - Phosphorescence

A. I, II

B. I and III

C. II and III

D. II

E. I

Explanation: Fluorescence, which is a form of luminescence, provides the useful light photons. Phosphorescence is too slow to do so.
[*imaging0337.mcq*]

9. The following are true of Filtered Back Projection *except* (or all are true)

A. All are true

B. The Back Projection part is simply the concept that each projection predicts the presence of contributions somewhere along each line of projection, and that these will tend to add up over different projections where the actual contributions are.

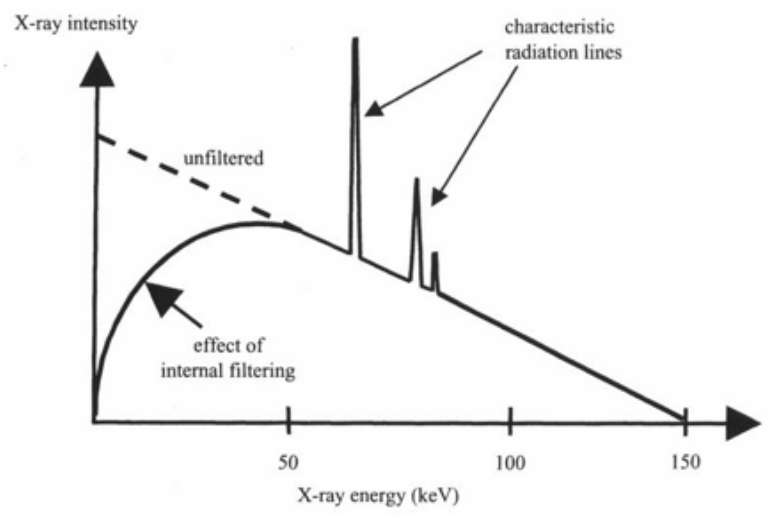
C. Its application is based on the inverse Radon transform and the fact that the 1D Fourier transform of a projection through a 2D image is a line through the origin of the 2D Fourier transform of that image.

D. Filtering is used to boost high frequencies, in effect, to fill in under-sampled areas in the Fourier transform of the tomographic image.

E. It can be accomplished either by multiplication in the frequency domain or convolution in the spatial domain.

Explanation: All are true
[*imaging0336.mcq*]

10. In the graph below, decreasing the tube current (Amperes) would cause which of the following (or none is true)?



A. Scaling the height of the graph lower evenly across energy.

B. Absence of characteristic radiation lines as the current crossed below the corresponding energy levels.

C. No change in the graph.

D. None of the other choices

E. Reduction in the maximum energy of photons due to Bremsstrahlung.

Explanation: Decreasing the tube current of the X-ray machine would simply mean that more photons are coming per second, with exactly the same energy distribution.
[*imaging0335.mcq*]

11. How can one reduce magnification effects of a projection radiography system?

A. Move the X-ray source further from the detector, with the object remaining the same distance from the detector.

B. Move the object closer to the X-ray source.

C. Move the object further from the detector.

D. Decrease the tube current of the X-ray source.

E. None of the other answers is correct.

Explanation: Moving the object closer to the X-ray source makes it's projection larger on the detector. Likewise, moving the object further from the detector brings the object closer to the X-ray source. Both *increase* magnification. The tube current of the X-ray source has no effect on magnification.
[*imaging0328.mcq*]

12. The following are true about CT numbers (Hounsfield units) *except*

A. They permit interpretation of tissue attenuation at a single location in the patient from a single planar X-ray scan (projection radiograph).

B. They are used to compensate for the fact that the effective energy $\bar{E}$ of the X-ray photons varies from scanner to scanner.

C. They are based on measured values for the linear attenuation coefficient for water.

D. They yield standard values for tissue types such as -1000 HU for air, 0 HU for water, 3000 for bone, etc., that vary by only about $\pm$ 2 HU between scans and across scanners.

E. They account for the fact that CT, compared to most other imaging modalities, is very quantitative in the physical meaning of pixel intensity.

Explanation: Local tissue attenuation cannot be retrieved from a single projection radiograph, since each pixel in the image represent the total attenuation along a projected line through the patient.
[*imaging0327.mcq*]

13. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation (or none is true)?

A. Bremsstrahlung creates polyenergetic x-rays as incoming electrons are slowed at varying rates by atoms in the target, while Characteristic Radiation creates monoenergetic x-rays due to quantum effects.

B. Bremsstrahlung is due to Compton Scattering but Characteristic Radiation is not.

C. Bremsstrahlung is due to the photoelectric effect, while Characteristic Radiation is not.

D. Bremsstrahlung and Characteristic Radiation are both generated by incoming x-rays.

E. None is true.

Explanation: Bremsstrahlung is the "breaking radiation" produced in an x-ray tube by a stream of electrons hitting a metal target, and is polyenergetic. Characteristic Radiation is also produced there, and is monoenergetic, resulting from displaced electrons being replaced from higher shells.
[*imaging0288.mcq*]

14. All of the following statements about Compton scattering of X-rays are true, *except* (or all are true.

A. All are true.

B. Compton scattering is caused by interactions between an X-ray photon and an outer shell electron.

C. Compton scattering is the most common interaction for higher energy X-ray, as compared to the photoelectric effect, which predominates at lower energy X-rays.

D. Compton scattering can be at least partially removed once it occurs.

E. Compton scattering reduces the signal-to-noise of X-ray images.

Explanation: Compton-scattered X-rays are selectively removed by the lead septa in front of the detector, so D is true. So are all the others.
[*imaging0255.mcq*]

15. The following are true about positron emitters, *except*

A. They tend to be isotopes with too many neutrons.

B. They include atoms found in normal organic molecules.

C. Their decay leads to the creation of two 511 keV gamma photons.

D. Their decay leads to the creation of antimatter.

E. They are particularly useful in imaging brain function.

Explanation: They have too few neutrons, and so "want" to turn a proton into a neutron but giving off a positron.
[*imaging0051.mcq*]

16. *Unlike* in x-ray based imaging modalities, in nuclear medicine

A. orienting the patient with the desired organ near the detector reduces total attenuation in the intervening tissue.

B. to get more signal we can increase dose.

C. we can increase detector efficiency by making it thicker, but this reduces resolution.

D. high energy photons are used to image.

E. tomographic slices may be reconstructed.

Explanation: Since the gamma photons in nuclear medicine originate within the body, the amount of attenuation depends on the distance between the organ and the detector.
[*imaging0052.mcq*]

17. Which of the following statements is *false*?

A. In PET imaging the attenuation factor for the pair of photons depends on the location of the activity along the line of response.

B. Coincidence detection in PET is used to determine the direction of travel of the two simultaneously emitted gamma photons, and hence to decide on which line the radioactivity occurs.

C. PET imaging uses isotopes of elements more commonly occurring in biological systems than SPECT.

D. An uncertainty always exists as to the location of the positron decay due to the distance the positron travels before annihilating with an electron.

E. None of them

Explanation: In PET imaging the attenuation factor does not depend on the location of the activity along the line of response, because the total path traveled by both gamma particles remains the same along a given line of response for any starting point.
[*imaging0057.mcq*]

18. Which of the following statements is (are) TRUE about detector crystals in Anger cameras?

I - Thick detectors are less efficient than thin detectors, but they provide greater spatial resolution.
II - Each gamma ray produces a scintillation consisting of many light photons.
III - Multiple small crystals are arranged in a grid to permit determination of the location of the radiation.

A. only II

B. I and II

C. II and III

D. I and III

E. only III

Explanation: Thick detectors are *more* efficient than thin detectors, and they provide *less* spatial resolution, so I is false. Anger cameras use one or two large crystal detectors, so III is false.
[*imaging0121.mcq*]

19. Regarding two atoms of the same isotope, the following is (are) true:

I. They have the same number of protons.
II. They have the same number of neutrons.
III. They may have different energy levels, with at least one being considered metastable, and thereby represent different isomers.

A. I, II, and III

B. I and III

C. II and III

D. I and II

E. I

Explanation: The classic example is Technetium-99 and Technetium-99m, which are different isomers of the same isotope.
[*imaging0126.mcq*]

20. Which of the following is (are) *true* about *mass defect*?

I. It is the difference between the sum of the masses of the isolated protons, neutrons, and electrons of an atom and the atoms actual mass.
II. It is translated via $E = mc^2$ into the binding energy holding the atom together, which may also be expressed in MeV.
III. It is expressed in unified atomic mass units (u), where 12 u = the mass of Carbon-12

A. I, II, and III.

B. I and II.

C. I and III.

D. II and III.

E. Only I.

Explanation: All are true.
[*imaging0268.mcq*]

21. Which of the following is (are) *true* about the "line of stability" for nuclides?

I. On coordinates of the number of neutrons vs the number of protons, it plots the most stable isotope of each element.
II. At low atomic numbers it shows that the atomic mass tends to be twice the atomic number.
III. At high atomic numbers, it shows that the number of neutrons tends to be smaller than the number of protons.

A. I and II.

B. I, II, and III.

C. I and III.

D. II and III.

E. Only I.

Explanation: At high atomic numbers the number of neutrons tends to be *larger* than the number of protons.
[*imaging0269.mcq*]

22. Which of the following statements is *false* about the pulse-echo mode of operation (or all are true)

A. Color Doppler is not possible with pulse-echo ultrasound, since the underlying frequency of the ultrasound cannot be accurately determined after just a few cycles.

B. The same transducers usually generate and receive the ultrasound pulses.

C. Short duration collections of cycles are generally used, representing the underlying frequency of the ultrasound multiplied by an envelope.

D. In the frequency domain, the spectrum of the transmitted signal appears as a band of frequencies whose width is inversely related to the duration of the transmitted signal.

E. All are true.

Explanation: Color Doppler is possible with pulse-echo ultrasound, by comparing the phases of received signals compared to expected phases.
[*imaging0348.mcq*]

23. Huygen's principle is best stated as

A. A wavefront may be interpreted as a collection of the centers of spherically propagating waves that interfere with each other.

B. The amplitude of a spherically propagating wave must be equal in all directions.

C. A spherical wave can propagate in an outward or inward direction

D. Interference patterns are best approximated by assuming a constant speed of wave propagation throughout the space.

E. The imaginary component of a complex exponential is not linear.

Explanation: B, D, and E are not true. C is true, but not Huygen's principle, which generally assume outward propagation.
[*imaging0347.mcq*]

24. The following are true about the transducers used in clinical ultrasound imaging, *except* (or all are true)

A. All are true.

B. The resonance of the transducer is intentionally dampened, primarily from behind (the side away from the patient).

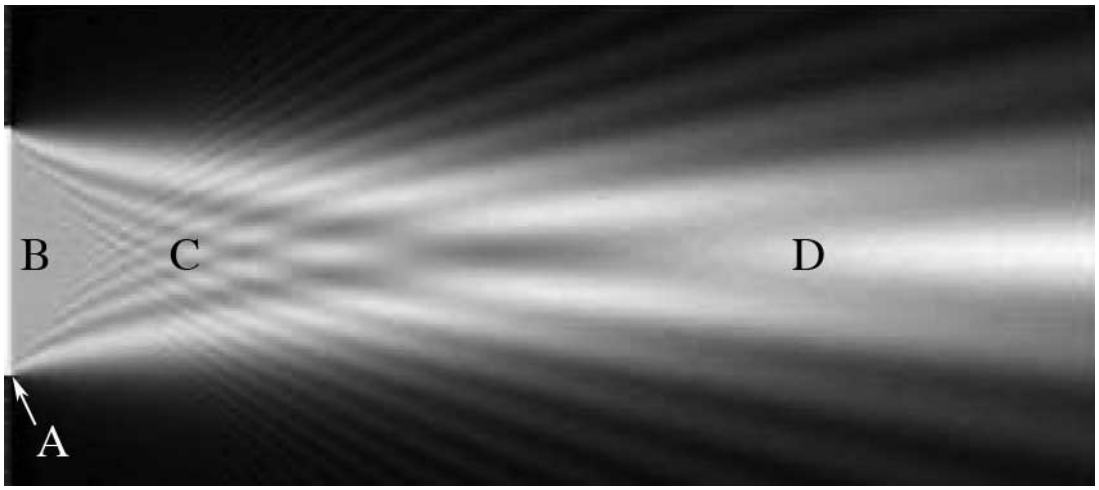
C. Although early transducers were physically moved to create an image, the great majority of modern transducers use an array of transducer elements to *both* steer and focus the ultrasound waves.

D. To increase transmission and reception, a special matching layer is placed between the transducer and the patient of intermediate impedance between that of the transducer elements and the patient.

E. A matching layer 1/4 wavelength thick is used so that reflected waves within the layer are 180° out of phase and cancel.

Explanation: All are true.
[*imaging0345.mcq*]

25. In ultrasound, which of the following is *not* true about the *field pattern*, an example of which is shown below (the figure actually shows a field pattern for light, but is analogous to that found with ultrasound).



A. The field pattern is for the transmission of ultrasound by the transducer, not for the reception of echoes.

B. The field pattern represents a pattern of standing waves of constructive and destructive interference for a given aperture and wavelength, and is independent of the particular target being scanned.

C. The label "C" marks the Fresnel zone.

D. The label "B" marks the Very Near Field, where the transducer appears infinitely large.

E. The label "D" marks the Fraunhofer zone.

Explanation: The field pattern is identical for transmission and reception.
[*imaging0343.mcq*]

26. Which of the following statements is *false* about the Fraunhofer zone? (or all are true)

A. Lateral image resolution within this zone is constant with distance from the transducer.

B. All are true.

C. The field pattern is basically a function of angle off the axis.

D. There are *no* null points due to destructive interference along the axis in this zone.

E. There *are* null points due to destructive interference off the axis in this zone.

Explanation: Lateral image resolution within this zone worsens with distance to the transducer. Range resolution stays the same.
[*imaging0342.mcq*]

27. The following are true about the waves used in clinical ultrasound imaging, *except*

A. Scattering of the waves from targets smaller than the acoustic wavelength is primarily a source of noise in the image.

B. Their absorption coefficient in biological tissue is roughly proportional to frequency.

C. They are generally produced in short bursts.

D. Distance to a target is determined by time of flight.

E. They are primarily compression rather than shear waves.

Explanation: Scattering of the waves from targets smaller than the acoustic wavelength is actually the primary source of useful information in the image.
[*imaging0341.mcq*]

28. Which of the following affects the intensity of a pixel in an ultrasound image ?

I. changes in acoustic impedance of the tissue at the pixel location.
II. the particular configuration of scatterers smaller than the resolution of the ultrasound within the pixel's resolution cell.
III. attenuation, reflection, or scattering between the transducer and the pixel location.

A. I, II, and III.

B. I and II.

C. I and III.

D. II and III.

E. None of the other answers

Explanation: All are true. Answer two describes speckle. Answer III effects the ultrasound energy reaching the location and thus the strength of the echo.
[*imaging0274.mcq*]

29. 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*]

30. 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*]

31. 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*]

32. 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*]

33. 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*]

34. 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*]

35. 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*]