BioE 1330 - Exam 3 3/27/2012
Answer Sheet - Correct answer is A for all questions

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

I. Nuclear reactions tend to move towards it.
II. Positron emitters are on one side of it, while beta emitters are on the other.
III. At higher atomic number, it shows that the number of neutrons tends to be larger than the number of protons.

A. I, II, and III.

B. I and II.

C. I and III.

D. II and III.

E. Only I.

Explanation: All are true.
[*imaging0353.mcq*]

2. Metastable technetium, or Tc-99m, has some desirable properties for a radiotracer, including which of the following?

I. It can be produced cheaply on the hospital site for immediate use.
II. Its decay yields high-energy electrons, known as "beta" particles.
III. Its half life is long enough to last through a study but short enough so that the patient can be discharged in a reasonable time

A. I and III

B. I and II

C. I, II, and III

D. II and III

E. II only

Explanation: Statement II is false. This is an example of metastable isomeric transition, not beta-decay.
[*imaging0414.mcq*]

3. Which of the following statements about combined PET/CT scanners is *false* (or all are true)?

A. The primarily physiological, higher-resolution information from the CT scanner is combined with the primarily anatomical, lower-resolution information from the PET scanner.

B. Registration of the two imaging modalities is greatly facilitated since the patient only needs to be slid a short distance between the actual scanners.

C. The CT scanner is used to determine the attenuation along each Line of Response in the PET scanner.

D. Virtually every PET scanner sold today also contains a CT scanner.

E. All are true.

Explanation: The primarily *anatomical* higher-resolution information from the CT scanner is combined with the primarily *physiological* lower-resolution information from the PET scanner.
[*imaging0415.mcq*]

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

A. Lead septa are not required to generate a projection image.

B. Individual gamma photons are counted and located.

C. Each gamma particle produces a scintillation consisting of many light photons.

D. The contribution from Compton scattering to the image is reduced by analyzing the pulse height of the combined responses of the photomultiplier tubes to each detected gamma particle.

E. Multiple photomultiplier tubes are arranged in a grid behind a large crystal that act in concert to determine the location of the incoming photons with a spatial resolution greater than that of the tubes.

Explanation: Lead septa are indeed required to generate a projection image.
[*imaging0416.mcq*]

5. Which of the following is (are) *true* about SPECT and PET?

I. Each has a corresponding projection modality.
II. Each is a tomographic imaging modality based on the emission of gamma particles from within the patient.
III. Each requires the use of collimators.

A. only II.

B. I and II.

C. I and III.

D. II and III.

E. I, II, and III.

Explanation: PET is not based on a projection modality, though SPECT is. PET does not require the use of collimators, though SPECT does.
[*imaging0267.mcq*]

6. The spatial resolution of a gamma camera can be improved by many factors, including:

A. Decreasing the thickness of the scintillation crystal

B. Increasing the distance between the patient and the camera

C. Decreasing the length of the lead septa in the collimator

D. Increasing the distance between the lead septa in the collimator

E. None of the other choices

Explanation: Decreasing the thickness of the crystal improves resolution, though it also decreases the efficiency of detection. The other options would actually decrease the spatial resolution of the camera.
[*imaging0265.mcq*]

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

A. None of the others is false.

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 of response the radioactivity occurs.

C. In PET imaging the attenuation factor for the pair of photons generated on a given line of response is independent of the location of the activity along that line of response.

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. Random occurrences in which two different decays each contribute a photon that is detected within the same time window constitute a source of noise in PET imaging.

Explanation: They're all true.
[*imaging0263.mcq*]

8. The following are true about positron emitters, *except*, or all are true

A. All are true.

B. They include atoms with low atomic number typically found in normal organic molecules, such as carbon and oxygen.

C. Their decay leads to the generation of antimatter and subsequently to the creation of two 511 keV gamma photons moving in directions approximately 180 degrees apart.

D. They are used in devices that nowadays typically also contain a CT scanner.

E. They are unstable because they have too few neutrons.

Explanation: All are true.
[*imaging0417.mcq*]

9. Which one of the following statements is TRUE (or are they all TRUE)?

A. All of them are TRUE.

B. Nuclear medicine produces images that depict the distribution of a radiotracers; this distribution is generally governed by body function, and not simply structure.

C. Radiotracers make use of radionuclides that emit radiation of appropriate type and energy, have half-lives that are appropriate, and are chemically inert.

D. Planar scintigraphy is the nuclear medicine analog of projection radiography.

E. Event positioning is based on a center-of-mass calculation; unlike radiographic image formation, this takes place on a photon-by-photon basis.

Explanation: All of them are TRUE.
[*imaging0208.mcq*]

10. SPECT imaging relies on sequential conversions of energy from one form to another. Select the choice that lists the correct sequence of energy forms in a SPECT scan.

A. Radiotracer - γ-ray - light photon - electron stream - voltage in a computer

B. Radiotracer - α-particle - light photon - electron stream - voltage in a computer

C. Radiotracer - γ-ray - electron stream - light photon - voltage in a computer

D. Radiotracer - α-particle - electron stream - light photon - voltage in a computer

E. None of the other choices

Explanation: Radioactive elements decay producing γ-rays, which are converted into light photons by the scintillation crystal of the camera. This light signal is converted into an electron beam by the photomultiplier tubes, which is then decoded by the logic network, analyzed for pulse height (to reduce the effect of scatter), before being stored in the a computer. Radioactive decay producing α-particles is not used in imaging because they are too destructive.
[*imaging0178.mcq*]

11. *Unlike* CT, in nuclear medicine

A. reducing the distance between the desired organ and the surface of the patient reduces total attenuation along the path of the photon.

B. signal can be increased by increasing the radiation dose.

C. crystals are used to convert high energy photons into light photons.

D. electromagnetic radiation, not particulate radiation, is used to image.

E. tomographic slices may be reconstructed by combining radiation detected along multiple linear paths.

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 surface of the body. In CT, the path is all the way through the body, so total attenuation is the same no matter where the target organ is along a given path.
[*imaging0133.mcq*]

12. The following are true about nuclear binding energy, *except*

A. Radioactive decay leads to atoms with lower average binding energy per nucleon.

B. It is equivalent to electron binding energy, but for the particles within the nucleus.

C. For a given nuclide it is dictated by the difference between the sum of the masses of protons, neutrons, and electrons and an atom's actual mass (the mass defect).

D. For protons, it accounts for the fact that they can overcome the electrostatic repulsion within the nucleus.

E. The average binding energy per nucleon varies with the particular nuclide, and accounts for the relative stability of atoms.

Explanation: Radioactive decay leads to atoms with *greater* binding energy.
[*imaging0127.mcq*]

13. Which of the following statements is *false* about radioactive decay (or all are true)?

A. Half-life is fifty percent of the time it takes for all of the sample to decay.

B. Its statistics is governed by the Poisson distribution.

C. All are true.

D. The radioactivity (how many radioactive atoms are undergoing decay every second) decreases with time as an inverse exponential.

E. The number of radioactive atoms remaining in a sample decreases with time as an inverse exponential.

Explanation: Half-life is the time it takes for fifty percent of the sample to decay. Both D and E are true, since they are related by a λ, the decay constant.
[*imaging0418.mcq*]

14. Which of the following statements is *false* about photomultiplier tubes (or all are true)?

A. All are true.

B. Used in an Anger camera to produce an electrical signal whose pulse height is related to the number of light photons generated by a gamma event.

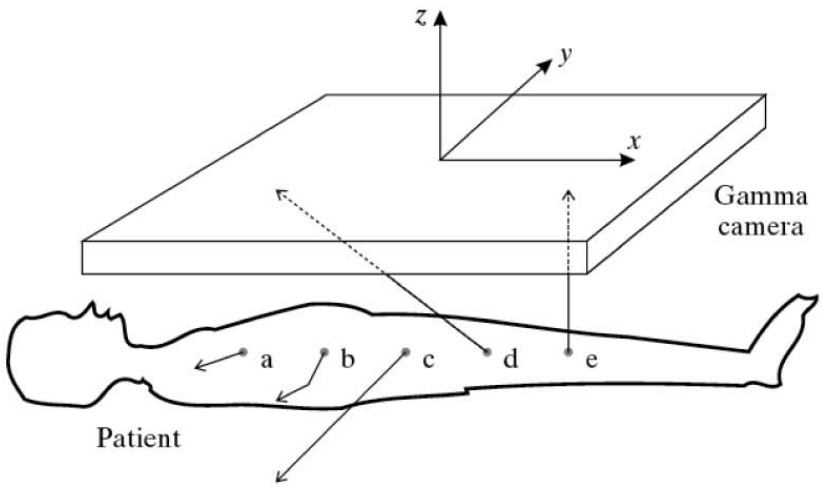
C. Is designed to be extremely sensitive to light photons.

D. Uses a series of dynodes at successively more positive voltage within the tube to create increasing numbers of cascading electrons from an initial few electrons.

E. Uses a photocathode to generate electrons from incoming photons.

Explanation: That's how it works.
[*imaging0419.mcq*]

15. In the following diagram on an Anger camera in action, which of the gamma photons will *increase* the signal to noise ratio?



A. e

B. a

C. b

D. c

E. d

Explanation: Gamma photons a, b, and c do not reach the detector, so do not increase the signal. Photon d does reach the detector, but at the wrong location (assuming it makes it through the collimator), and so it constitutes noise, not signal.
[*imaging0420.mcq*]

16. Which of the following statements is *false* about phased arrays in ultrasound (or all are true)?

A. They are not capable of being used for Doppler imaging.

B. Dynamic focusing of the array is possible during the reception of the echo from a single transmitted pulse, but is not possible for the transmitted pulse itself.

C. Timing between the elements can be used to steer a beam both for transmitting and receiving.

D. All are true.

E. Given a two-dimensional array of transducer elements, 3D ultrasound images may be acquired by steering the beam in both azimuth and elevation.

Explanation: Doppler can be used with pulsed ultrasound to find the flow towards or away from a phased array at particular location in the image.
[*imaging0421.mcq*]

17. 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*]

18. Which of the following statements is *false* about the use of the complex exponential in modeling ultrasound, (or all are true)?

A. All are true.

B. They permit mathematically tenable integration of many sources of ultrasound waves converging on a single point to determine the extent of constructive or destructive interference.

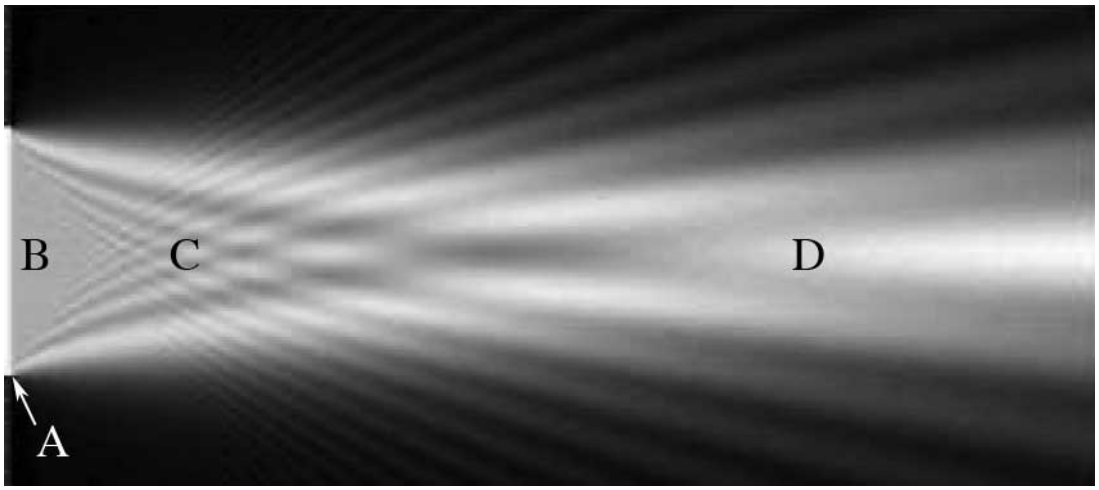
C. They allow for the imaginary component of a physical quantity, but generally require that the imaginary component will be canceled by a complex conjugate.

D. They are also the foundation of much of modern optics, which has many similarities to ultrasound.

E. They generally are used to translate differences in path-length into differences in phase, given a certain frequency.

Explanation: The use of complex exponentials instead of real sinusoids encapsulates phase in such a way that algebra and calculus are straightforward, and is the heart of not only ultrasound design, but of modern optics.
[*imaging0422.mcq*]

19. 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*]

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

A. All are true.

B. The resolution cell expands laterally (orthogonal to the range direction) with distance from the transducer, but remains constant in the range direction.

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, while range resolution stays the same.
[*imaging0423.mcq*]

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

A. They travel with so little attenuation through bone and air that no echoes are generated in these tissues.

B. Echoes are generated primarily because of changes in the acoustic impedance of the tissue

C. Scattering of the waves from targets smaller than the acoustic wavelength is the primary source of useful information in the image.

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

E. They are primarily compression rather than shear waves.

Explanation: Attenuation in bone and air is very high at the frequencies of ultrasound used in medicine. This accounts for the lack of ability to image these tissues.
[*imaging0424.mcq*]

22. The following are true about theoretical plane waves in ultrasound, *except*

A. Spatial variation occurs only along directions perpendicular to the direction of propagation.

B. Their general solution includes the superposition of a forward-traveling wave and a backward-traveling wave.

C. They can be viewed equally well as functions of time or of distance.

D. Their pressure in not attenuated as the distance traveled increases.

E. They are approximated within the Very Near Field of the ultrasound transducer, where the transducer face appears infinitely large.

Explanation: Whereas spherical waves spread out attenuating pressure by $1/r$, planar waves do not spread out, and thus maintain their full amplitude. Spatial variation occurs only along the direction of propagation, *not* along directions perpendicular to the direction of propagation.
[*imaging0340.mcq*]

23. In ultrasound, with an incident planar wave that is not perpendicular to a boundary where the acoustic impedance Z changes, the following are true *except* (or all are true).

A. The direction of wave propagation will bend *towards* the perpendicular to the boundary if the speed of sound *increases* across the boundary.

B. Reflection will always occur.

C. Refraction will occur if and only if the wave velocity c changes, as governed by governed by Snell's Law.

D. Particle velocity on both sides of the boundary v is independent of (and generally much slower than) wave velocity c

E. All are true

Explanation: Refraction depends only on c. Reflection depends only on Z and the angle of incidence. Particle velocity v is generally much slower than wave velocity c. Picturing the row of soldiers leaving the cornfield at an angle shows them bending away the perpendicular to the boundary.
[*imaging0425.mcq*]

24. Which of the following statements is (are) *true* about resonance in an ultrasound transducerr?

I. The resonant frequency is largely determined by the thickness of the transducer and the speed of sound within it.
II. The longer the resonance lasts for a given transmit pulse, the better the resolution in the range direction of the resulting image .
III. Resonant energy is primarily and intentionally lost out the back of the transducer.

A. I and III.

B. I and II.

C. II and III.

D. I, II, and III.

E. None of the others is correct.

Explanation: Longer resonance means a longer transmit envelope and poorer resolution in the range direction. Therefore the resonance is intentionally lost, primarily by using damping material behind the transducer.
[*imaging0279.mcq*]

25. Ultrasound is commonly used in adults for non-invasive imaging of all of the following, *except*

A. Lung

B. Breast

C. Fetus

D. Testicle

E. Kidney

Explanation: Ultrasound does not penetrate air and thus is not normally used to image the lung.
[*imaging0426.mcq*]

26. Which of the following statements is *false* about Doppler in ultrasound (or all of the others are true)?

A. Motion orthogonal to the ultrasound beam results in Doppler shift to a lower frequency.

B. In continuous-wave Doppler, discrete pulses of ultrasound are not used, but rather a continuous sinusoid is transmitted, received, and shifted by the transmit frequency down to the audio range, where motion may simply be heard as a "whooshing" sound.

C. All of the others are true

D. In Color Doppler, pulses of ultrasound are analyzed as to their phase shift over the period between pulses, and therefore aliasing can result if enough phase shift occurs.

E. Power Doppler delivers a more sensitive measure of absolute motion but cannot determine the direction of that motion.

Explanation: Motion away from the transducer results in a shift to a lower frequency, but motion orthogonal to the ultrasound beam results in no Doppler shift.
[*imaging0277.mcq*]

27. As the frequency of an ultrasound beam increases:

A. Resolution increases and depth of penetration decreases

B. Resolution decreases and depth of penetration decreases

C. Resolution increases and depth of penetration increases

D. Resolution decreases and depth of penetration increases

E. Resolution increases and depth of penetration remains the same

Explanation: Higher frequency ultrasound yields greater spatial resolution at the cost of poorer depth of penetration.
[*imaging0195.mcq*]

28. Regarding the speed of sound c, impedance Z, compressibility κ, and density ρ, all of the following are true *except*

A. All are true.

B. c is dependent on both κ and ρ.

C. Z is dependent on both κ and ρ.

D. Z increases as ρ increases.

E. c decreases as ρ increases.

Explanation: Higher density makes the tissue stiffer and slower to accelerate.
[*imaging0427.mcq*]

29. Regarding the following equation (where p is pressure and c is the speed of sound), the following are true *except* (or all are true)

$$\nabla^2 p = \frac{1}{c^2}\frac{\partial^2 p}{\partial t^2}$$

A. All are true.

B. The "del" or "nabla" symbol indicates the Laplacian operator, which is the divergence of the gradient.

C. It contains derivatives of pressure in space.

D. It contains derivatives of pressure in time.

E. The equation describes the creation and propagation of pressure waves.

Explanation:
[*imaging0428.mcq*]

30. The following is true about Time-Gain Compensation (TGC), *except* (or all are true)

A. All are true.

B. It is used to compensate for the enormous attenuation of ultrasound to the target and back again.

C. It is often represented by a column of slidable adjustments on the ultrasound scanner that are manually adjusted during operation.

D. It permits the brightness of the image to be adjusted at various depths.

E. It controls the gain of the amplifier as the echoes return from an individual transmit pulse.

Explanation:
[*imaging0429.mcq*]