BioE 1330 - Review Chapters 4, 5, and 6 (X-ray and CT) 1/17/2011

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.

_____

your signature

1. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation?

A. Bremsstrahlung and Characteristic Radiation are both due to the photoelectric effect.

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

C. X-rays from Bremsstrahlung are polyenergetic while those from Characteristic Radiation are monoenergetic.

D. Bremsstrahlung is evident in the spectrum produced by a typical x-ray machine, while Characteristic Radiation is not.

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

2. To minimize blur in planar radiography it is best to

A. minimize the source spot size, minimize the distance from the source to the patient, and minimize the distance from the patient to the film.

B. minimize the source spot size, maximize the distance from the source to the patient, and maximize the distance from the patient to the film.

C. maximize the source spot size, maximize the distance from the source to the patient, and minimize the distance from the patient to the film.

D. maximize the source spot size, minimize the distance from the source to the patient, and minimize the distance from the patient to the film.

E. minimize the source spot size, maximize the distance from the source to the patient, and minimize the distance from the patient to the film.

3. Which of the following statements is false?

A. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the result is excitation.

B. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the result is ionization.

C. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the electron may be raised to a higher energy state (a more outer orbit), but is not ejected.

D. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the electron is ejected from the atom.

E. After both ionization and excitation, a "hole" is formed in the electron shell, which is filled via a process that does not involve characteristic radiation.

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

A. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

B. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

C. In an x-ray tube, magnetic fields are used to accelerate electrons from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

D. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

E. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

5. Which of the following statements is true about filtered backprojection and convolution backprojection?

A. Hounsfield units do not correct for the inherent loss of high frequency in the image.

B. Line integrals along the paths of the x-rays spread out as they reach the detector elements, and this loss or resolution needs to be compensated for.

C. None of the other answers are correct.

D. The Radon transform does not work at low frequencies as well as at high frequencies.

E. The filtering is needed to fill out high frequency portions of the Fourier transform of the image, because the transforms of the individual projections are only lines through the origin and are further apart as one moves further from the origin.

6. The following are true about Helical (Spiral) CT scanners, *except*

A. Although they are more expensive than conventional CT scanners, they pay for themselves by permitting faster patient throughput.

B. Because they require slip-ring electrical connectors, which produce electrical noise and Bremsstrahlung, they are not suitable for clinical use.

C. Filtered backprojection is still possible, by interpolating several spiral "cuts" into a flat slice.

D. They can produce scans of the entire torso in under 30 seconds, reducing motion artifact due to breathing by allowing the patient to hold his breath.

E. They are inherently smoother than older scanners in that the patient moves continuously through the scanner without stopping and starting.

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

A. 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.

B. They allow filtered backprojection to compensate for motion artifact due to the patient breathing.

C. They allow individual scanners to be calibrated, given that the effective energy of a given x-ray tube can vary.

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

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

8. The following are true about the sinogram, *except* (or all are true)

A. It is a pictorial representation of the Radon transform.

B. It exhibits sinusoidal 'traces' each representing the apparent motion of a point within the patient as the angle of projection rotates around the patient.

C. It consists of the individual 1D projections through the patient stacked into a 2D image.

D. All are true.

E. It contains all the information gathered during an individual CT scan of a slice.

9. Bremsstrahlung describes a process in which

A. high energy photons are used to create photoelectrons.

B. high energy photons interact with outer shell electrons.

C. electrons created in the x-ray tube interact directly with atoms in the patient.

D. an electron beam is used to create high energy photons.

E. energy is released through nuclear decay.

10. The following are true of Filtered Back Projection *except*

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

B. It constitutes a process for creating a tomographic image from a series of projections.

C. It is used to maximize resolution in Planar Radiography.

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

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

11. The following are true about x-rays *except*

A. They penetrate the body better than visible light because they have a *longer* wavelength than visible light.

B. They can be thought of as particles or waves.

C. The cause damage to the body because they can produce ions.

D. They may reflect off the tiles on the walls of the room in which the scan is taking place.

E. They are produced in an x-ray tube by Bremsstrahlung over a continuous band of frequencies and by Characteristic Radiation at specific frequencies.

12. The following are true about the dual-energy x-ray scan *except*

A. It is an adaptation to the classical planar radiograph that has recently been introduced into clinical practice.

B. It produces tomographic images to separate the lungs from the ribs.

C. It depends on the patient not moving between the two different scans.

D. It can be used to "subtract"" the bones away from a chest x-ray to better see the underlying lungs.

E. It uses two different scans of the same patient at two different x-ray energies, which produce different relative sensitivities to bone and soft tissues.

13. The healthy kidney is visible on the x-ray radiograph because

A. the kidney filters radioactive tracers.

B. x-rays bend around the surface of the kidney.

C. the healthy kidney is surrounded by fat, which exhibits less attenuation to x-rays than the kidney itself.

D. x-rays reflect off the shiny surface of the kidney.

E. the kidney is completely opaque to x-rays.

14. Given that one chest radiography was taken using 25 mA and 75 kVp at 1.0 m distance between the film and the x-ray source, suppose that a second chest radiograph was taken at 100 mA and 75 kVp that yielded the same exposure. What distance would you expect between the film and the x-ray source?

A. 0.25 m

B. 0.5 m

C. 4.0 m

D. 1.0 m

E. 2.0 m

15. Which one of the following statements is *false*?

A. Compton scattering, which changes the path of photons in the body rendering them useless in image formation, is particularly a problem at low x-ray energies.

B. The electron beam in an x-ray tube transfers energy to the target via collisional transfer (generating heat) and radiative transfer (generating characteristic radiation and bremsstrahlung radiation).

C. Ionization is the ejection of an orbiting electron from an atom; ionizing radiation has sufficient energy to produce ionization.

D. A "K-edge" occurs in the energy spectrum of photons at the binding energies of inner shell electrons, because above these energies many electrons become available and the probability of the photoelectric effect rises sharply.

E. The probability of the photoelectric effect increases non-linearly with increasing effective atomic number of the material through which the radiation passes.

16. Which of the following actions increase the SNR in a planar radiograph?

I - Increasing the scatter fraction.
II - Decreasing the scatter fraction.
III - Increasing the absorption of the tissue.
IV - Decreasing the absorption of the tissue.

A. I and IV

B. II and IV

C. None has any effect on SNR.

D. II and III

E. I and III

17. Characteristic radiation peaks

A. result from electrons moving from one orbit to another of greater binding energy.

B. have too much energy to be useful for imaging.

C. are filtered out before reaching the patient.

D. are different from Bremsstrahlung radiation in that they are not harmful to the patient.

E. don't have enough energy to be useful for imaging.

18. All of the following statements describe imaging using X-rays, *except*

A. The risk of cancer increases with each scan.

B. Radiation sources remain active within the patient after the scan.

C. Only tissues with different attenuation coefficients can be distinguished.

D. Iodine and barium are commonly used as contrast agents because of their high atomic number.

E. Projection and tomographic images are both obtainable.

19. Which of the following statements about the Projection Slice Theorem is *false*?

A. The Projection Slice Theorem requires the projection to be along one of the cardinal axes, i.e., the x-axis or the y-axis.

B. The Projection Slice Theorem depends on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

C. The Projection Slice Theorem allows us to perform image reconstruction using filtered backprojection in the frequency domain.

D. A set of lines is produced using the Projection Slice Theorem that must be filtered to "fill in" the high frequency regions between those lines.

E. It states that the 1-D Fourier transform of the projection through a 2-D image is a line through the origin of the 2-D Fourier transform of that image.

20. All of the following statements are true about the sinogram, *except*:

A. One axis of the sinogram represents the angle of projection.

B. It represents a collection of 1-D projections through a 2-D image.

C. The sinogram results from applying the Radon transform to a 2-D image, and as such has an inverse transform to recreate the original image.

D. Only angles between 0 and π need to be represented, since projection in one direction is the same as in the opposite direction.

E. The sinogram of a uniformly gray 2-D image does not exist.

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

A. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

B. X-rays and gamma rays represent distinct and non-overlapping regions of the electromagnetic spectrum.

C. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

D. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

E. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

22. Why do barium and iodine (contrast agents) appear white on x-ray?

A. They equally reflect all wavelengths of visible light.

B. They have a high atomic number and have K edges in the diagnostic x-ray range.

C. They form ions in the normal environment of the body.

D. They allow more x-rays to pass.

E. They produce less Compton interaction at higher energies.

23. Ultraviolet light has a wavelength in the range of 4-400 nanometers, what is the frequency range? (speed of light $= 3 \times 10^8$ m/s)

A. 1.2 GHz to 120 GHz

B. 7.5×10^{14} Hz to 7.5×10^{16} Hz.

C. 1.2 Hz to 120 Hz

D. 1.33×10^{-15} Hz to 1.33×10^{-17} Hz

E. 7.5 Hz to 7.5 MHz

24. The following is *not true* about Characteristic Radiation

A. It is a form of radiative transfer.

B. It is caused by the interaction of an electron with a nucleus of an atom.

C. A K-shell hole is created prior to the emission of the characteristic x-ray.

D. The intensity spectrum exhibits discrete narrow bands.

E. The incoming electron collides with a K-shell electron.

25. Which of the following photons constitutes ionizing radiation?

A. X-ray with energy of 45 KeV.

B. Ultraviolet light with energy of 4.1 eV

C. All of the above.

D. Infrared radiation with energy of 1.24 eV.

E. Radio Waves with energy of 120×10^{-6} eV.

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

A. Use a higher radiation dose.

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

C. Move the object away from the detector.

D. Move the object closer to the detector.

E. Use a smaller object.

27. Which of the following is *false* about the 2D Radon Transform (or all are true)?

A. It is the basis for filtered back projection.

B. It has an inverse transform.

C. It is a linear operator.

D. All are true.

E. It relates multiple 1D projections to a 2D tomographic slice.

28. Hounsfield units are defined relative to the CT absorption coefficient of

A. Barium.

B. Iodine.

C. Metal.

D. Water.

E. Air.

29. The following are true about Beam Hardening *except*

A. It is more of a problem for planar radiography than for CT.

B. It is especially a problem around metal and dense bone.

C. It constitutes energy-selective attenuation of x-rays.

D. It causes a breakdown in the simplifying assumption of a single "effective" energy in the absorption along a given projection path.

E. It results in a net increase in the mean energy of x-ray photons.

30. Which of the following is (are) true? In the atom, the binding energy for an electron

I - is specific to a given element, shell, and quantum state.
II - generally decreases with increasing shell number (further from nucleus) .
III - increases with lower atomic number (less positive charge in nucleus).

A. I

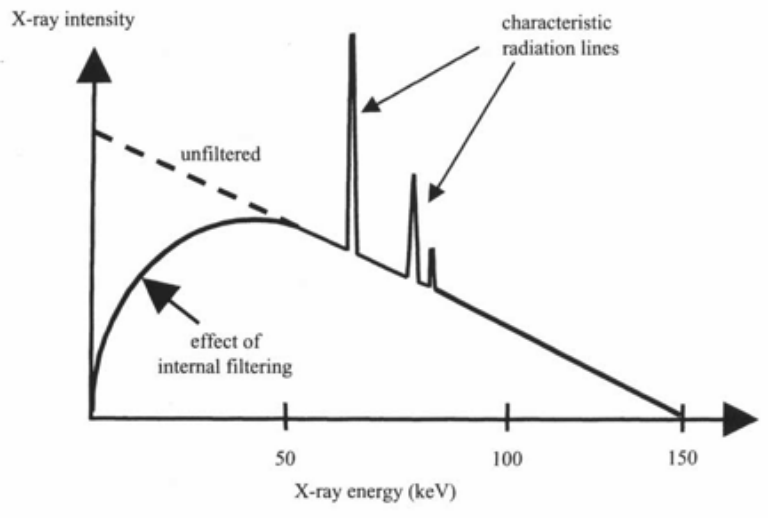
B. I and II

C. II and III

D. I, II, and III

E. I and III

31. In the histogram below, why does the source have internal filtering at low energies?



A. The filtered X-rays have alpha-particles which must be stopped from reaching the patient.

B. The filtered X-rays are part of the correction for beam-hardening.

C. The filtered X-rays would provide useful imaging information, but would cause too much damage in the patient.

D. None of the other choices

E. The filtered X-rays would not get through the patient to the detector, so they are worthless from an imaging standpoint.

32. With reference (where appropriate) to the histogram above, decreasing the accelerating voltage (kVp) would cause all of the following EXCEPT:

A. Decreased or absent characteristic radiation lines

B. Reduced number of high-energy photons

C. Increased radiation dose to the patient

D. None of the other choices

E. Decreased effective X-ray energy of the beam

33. With reference (where appropriate) to the histogram above, decreasing the tube current (Amperes) would cause which of the following?

A. None of the other choices

B. Absence of characteristic radiation lines

C. Absence of high-energy photons

D. Increased radiation dose to the patient

E. Decreased effective X-ray energy of the beam

34. Characteristic radiation peaks:

A. Have too much energy to be useful for imaging

B. Are different from Bremsstrahlung radiation in that they are not harmful to the patient

C. Don't have enough energy to be useful for imaging

D. Are filtered out before reaching the patient

E. Make up 10-30% of the X-ray beam's intensity spectrum

35. All of the following statements about Compton scattering of X-rays are true, *except*:

A. Compton scattering is the most common interaction for a high energy X-ray.

B. Compton scattering reduces the signal-to-noise of x-ray images.

C. Compton-scattered X-rays provide the most contrast between different tissues.

D. The probability of an X-ray photon undergoing Compton scattering is essentially independent of the effective atomic number of the tissue.

E. Most Compton-scattered X-rays are hopefully absorbed by the lead septa of an antiscatter grid

36. All of the following statements about the photoelectric effect are true, EXCEPT:

A. The photoelectric effect is the interaction that allows us to make high-quality x-ray images.

B. The probability of an X-ray photon undergoing a photoelectric interaction is essentially independent of the effective atomic number of the tissue.

C. The net result of a photoelectric interaction is that the incident X-ray does NOT reach the detector.

D. The photoelectric effect is the most common interaction for a low energy X-ray.

E. The photoelectric effect provides the most image contrast between different tissues.

37. All of the following statements describe limitations of planar X-ray imaging, /it except:

A. The risk of cancer increases with each scan

B. Radiation dose can remain in the patient for days after the scan

C. Only tissues with different attenuation coefficients can be distinguished

D. Only 2-D information is available

E. Both iodine and barium are commonly used as contrast agents.

38. The linear attenuation coefficient of a gadolinium-based phosphor used for the attenuation of X-rays is $\mu = 560$ cm^{-1} at an X-ray energy of 150 keV. What percentage of these X-rays is detected by a phosphor layer of thickness 10 μm?

A. Less than 1%

B. About 57%

C. About 43%

D. Greater than 99%

E. About 83%

39. The signal-to-noise ratio of an X-ray image can be improved by which of the following?

A. Decreasing the tube current in the X-ray source

B. Increasing the grid ratio

C. Decreasing the distance from the patient to the detector

D. Decreasing the thickness of the phosphor intensifying screen

E. Increasing the obesity of the patient

40. The half-value layer (HVL) of a tissue is dependent upon the type of tissue attenuating the X-ray as well as the energy of the incident X-ray. If the linear attenuation coefficient μ for bone is 10 cm^{-1} at the effective X-ray energy of 68 keV, what is the half-value layer (HVL) of the bone for that effective energy?

A. $\frac{\ln 2}{10cm^{-1}}$

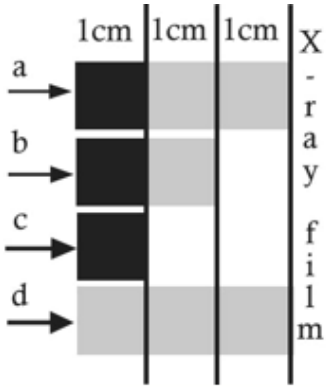
B. 0.1 cm^{-1}

C. 0.1 cm

D. $\frac{10cm^{-1}}{\ln 2}$

E. 10 cm

41. Four X-ray beams, each with intensity I_0, are incident upon the object below, in which black represents bone, gray represents muscle, and white represents fat. Which of the four beams will appear the darkest on a typical X-ray image? Assume that the linear attenuation coefficients at the effective X-ray energy of 68 keV are 10 cm^{-1}, 2 cm^{-1}, and 1 cm^{-1}, for bone, muscle, and fat, respectively.



A. Beam d

B. Beam b

C. Beam c

D. Beam a

E. The beams will have the same transmitted intensity

42. By convention, radiation with energy greater than or equal to 13.6 eV is considered *ionizing radiation.* What range of wavelengths contain the cutoff wavelength below which UV light is ionizing? $c = 2.998 \times 10^8$ meters per second, $h = 6.626 \times 10^{-34}$ Joule-sec, and 1 eV $= 1.6 \times 10^{-19}$ Joule.

A. 1 μm - 10 μm

B. 100 nm - 1 μm

C. 10 nm - 100 nm

D. 1 nm - 10 nm

E. 0.1 nm - 1 nm

43. You are designing an x-ray detector system and wish to eliminate all photons that have been scattered more than 20 degrees in an attempt to improve the resulting image quality. You are using a monoenergetic x-ray source that emits photons having wavelength $\lambda = 8.9 \times 10^{-2}$ angstroms (1 angstrom $= 10^{-10}$ meters). If your detector is capable of discriminating the energy of incoming photons, which of the following photon energies will be accepted by the system? Recall that the energy of a scattered photon is given by:

$hv^* = \frac{hv}{1+\frac{hv}{m_0c^2}(1-\cos\theta)}$

with $m_0c^2 = 511$ KeV.

A. 134 KeV

B. 140 KeV

C. 138 KeV

D. 142 KeV

E. 136 KeV

44. Which of the following statements about the Projection Slice Theorem is FALSE?

A. The 1-D Fourier transform of a projection of an object is a slice of the 2-D Fourier transform of that object.

B. The 2-D Fourier transform of the projection of an object equals a line passing through the origin of the 1-D Fourier transform of that object, at that angle corresponding to the projection.

C. The projection-slice theorem allows us to mathematically demonstrate why filtered backprojection works as a method of image reconstruction.

D. The projection-slice theorem is related to the radon transform.

E. The projection-slice theorem does explain the importance of angular sampling required for image reconstruction.

45. Place the following tissues or materials in ranked order, in terms of greatest to least X-ray absorption:

I - item fat
II - item muscle
III - air
IV - lead
V - bone

A. IV - V - II - I - III

B. IV - V - III - II - I

C. III - I - II - V - IV

D. III - II - I - IV - V

E. V - IV - II - I - III

46. The inverse square law has very practical use in radiography. Suppose an acceptable chest radiography was taken using 67.5 mAs at 80 kVp from 1.5 m. Suppose that it was now requested that be taken at 1 m at 80kVp. What mAs setting should be used to yield the same exposure?

A. 30 mAs

B. 20 mAs

C. 37.5 mAs

D. 45 mAs

E. 60 mAs

47. Which one of the following statements is true?

I - Acceptance of Compton scattered photons increases image contrast, and thus signal-to-noise ratio as well.
II - The film-screen detector produces an optical image on film; the degree of film blackening (the optical density) depends on film exposure in a nonlinear way characterized by the H-and-D curve.
III - Projection radiography produces radiographs, which are 1-D projections of a 3-D object.

A. II

B. I and II

C. I

D. II and III

E. I,II, and III

48. Ultraviolet light is defined as electromagnetic waves having wavelengths in the range of

A. 400 nm - 10 nm

B. 3 km - 0.01 m

C. 10 pm - 1 pm

D. 100 pm - 10 pm

E. 700 nm - 400 nm

49. Which one of the following statements is *false*?

A. Compton scatter results in the complete absorption of the incident photon.

B. Bremsstrahlung is a form of particulate radiation that produces a broad spectrum of X-ray photons.

C. The probability of the photoelectric effect increases with increasing effective atomic number of the material through which the particulate radiation passes.

D. Both ionization and excitation may leave a hole in an inner electron shell, which is refilled creating characteristic radiation.

E. Ionization is the ejection of an orbiting electron from an atom; ionization radiation has sufficient energy to produce ionization.

50. What determines the highest energy of x-ray photons emitted from an x-ray tube?

A. The elements of the atoms in the anode of the x-ray tube

B. The peak x-ray tube voltage

C. None of the other answers.

D. The sum of characteristic x-ray spectra

E. The integral of the bremsstrahlung x-ray spectrum.

51. What simple strategies can an x-ray technician use to reduce the magnification and distortion effects of the projection radiography system?

I - Moving the object closer to detector panel
II - Moving the object further away from the detector panel
III - Moving the X-ray source further away from the object and the detector
IV - Moving the X-ray source closer to the object and the detector

A. II and IV

B. I and IV

C. None of them

D. I and III

E. II and III

52. Which of the following actions alter the SNR as indicated?

I - Increase the scatter fraction, which causes an increase in the noise level
II - Increase the scatter fraction, which causes an decrease in the noise level
III - Decrease the absorption efficiency of the detector, which causes a decrease in the signal amplitude
IV - Decrease the absorption efficiency of the detector, which causes an increase in the signal amplitude

A. II and IV

B. None of them

C. I and III

D. I and IV

E. II and III

53. For a point source of radiation, the exposure at a distance d from the source follows an inverse square law. If the exposure at $d = 3$ cm from point source is 36 R, what is the exposure at $d = 18$ cm from the source?

A. 1.5 R

B. 1 R

C. 4 R

D. 6 R

E. 3 R

54. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation?

A. Bremsstrahlung is evident in the spectrum produced by a typical x-ray machine, while Characteristic Radiation is not.

B. X-rays from Bremsstrahlung are monoenergetic while those from Characteristic Radiation are polyenergetic.

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

D. Bremsstrahlung is due to deflections of incoming electrons around positive nuclei, while Characteristic Radiation is due to the photoelectric effect and refilling of inner shell orbitals by outer shell electrons.

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

55. The following are true about the new portable "cone-beam" scanners, described in lecture, but not in the textbook, *except*

A. They capture a 3D data set without any moving parts.

B. They are capable of reconstructing a set of tomographic slices through the patient.

C. They are basically fluoroscopic x-ray machines that can be rotated around the patient, capturing multiple projections.

D. They trade off image quality for portability, so that they can be used in the surgical suite.

E. They provide rapid real-time 3D images during an operation that can be registered with pre-aquired CT scans from a higher-quality stationary scanner.

56. Which of the following statements about the generation of x-rays is *false*?

A. The majority of energy produced within an x-ray tube is in the form of high-energy (x-ray) photons.

B. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

C. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

D. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

E. In an x-ray tube, electric fields are used to accelerate electrons from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

57. Given that one chest radiography was taken using 90 mA and 85 kVp at 3.0 m distance between the film and the x-ray source, suppose that a second chest radiograph was taken at 10 mA and 85 kVp that yielded the same exposure on the film. What distance would you expect between the film and the x-ray source?

A. 27.0 m

B. 3.0 m

C. 9.0 m

D. 0.33 m

E. 1.0 m

58. Which one of the following statements is *false*?

A. The electron beam in an x-ray tube transfers energy to the target via collisional transfer (generating heat) and radiative transfer (generating characteristic radiation and bremsstrahlung radiation).

B. Ionization is the ejection of an orbiting electron from an atom; ionizing radiation has sufficient energy to produce ionization.

C. Compton scattering, which changes the path of photons in the body rendering them useless in image formation, is particularly a problem at high x-ray energies.

D. The probability of the photoelectric effect increases non-linearly with increasing effective atomic number of the material through which the radiation passes.

E. A "K-edge" occurs in the energy spectrum of photons at the binding energies of outer shell electrons, because above these energies fewer electrons are available.

59. All of the following statements describe imaging using X-rays, *except*

A. The risk of cancer from a CT scan is negligible compared to the background radiation at the earth's surface.

B. X-rays constitute both one of the oldest and one of the most rapidly advancing forms of medical imaging.

C. Only tissues with different attenuation coefficients can be distinguished.

D. Iodine and barium are commonly used as contrast agents because of their high atomic number.

E. Projection and tomographic images are both obtainable.

60. Which of the following is (are) true? In the atom, the binding energy for an electron

I - increases with lower atomic number.
II - generally decreases with increasing shell number.
III - is specific to a given element, shell, and quantum state.

A. I and II

B. I, II, and III

C. I and III

D. III

E. II and III

61. Which of the following actions increase the SNR in a planar radiograph?

I - Increasing the detector efficiency.
II - Increase the filament current.
III - Increasing the pulse duration.

A. II and III

B. I and II

C. None of the other answers is correct.

D. I and III

E. I, II and III.

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

A. Decrease the size of the X-ray source.

B. None of the other answers is correct.

C. Move the X-ray source closer to the detector.

D. Move the object further from the detector.

E. Move the object further from the X-ray source.

63. Decreasing the accelerating voltage (kVp) in the X-ray tube would cause all of the following *except*

A. Keep the energy of the average photons the same but reduce the number of photons.

B. Reduced number of high-energy photons.

C. Decreased energy of the highest energy photons in the X-ray the beam.

D. Make characteristic radiation lines disappear as the accelerating voltage fell below the energy of the particular characteristic radiation line.

E. Decrease the radiation dose to the patient.

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

A. Compton scattering can be removed once it occurs.

B. Compton scattering is the most common interaction for high energy X-ray.

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

D. All are true.

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

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

A. They are directly proportional to the density of the material in the corresponding voxel.

B. They allow individual scanners to be calibrated, given that the effective energy of a given x-ray tube can vary.

C. 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.

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

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

66. The following are true about the sinogram, *except*

A. It contains all the information gathered during an individual CT scan.

B. It consists of the individual 1D projections through the patient stacked into a 2D image.

C. It exhibits sinusoidal 'traces' each representing the apparent motion of a point within the patient as the angle of projection rotates around the patient.

D. Rotation of the original image results in rotation of the sinogram.

E. Only angles between 0 and π need to be represented, since projection in one direction is the same as in the opposite direction.

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

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

B. Components of the sinogram that are at the fundamental frequency of rotation for the scanner must first be removed to avoid sampling artifact.

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

D. 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.

E. It's 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.

68. All of the following statements about attenuation of X-rays are true, *except*:

A. For X-rays passing through a homogeneous material, the number of photons remaining falls off as an inverse exponential function of distance.

B. The half value layer (HVL) represents the thickness of a homogeneous material that eliminates half of the X-ray photons.

C. The useful attenuation results from differences between tissues in the probability of the photoelectric effect.

D. Attenuation is assumed to be independent of X-ray photon energy in planar radiography.

E. It may be considered linear along a line of projection by integrating in the exponent of an exponential.

69. All of the following statements about artifacts in CT are true, *except*:

A. Insufficient spatial sampling by detectors can lead to streaks at small bright objects or boundaries with small radii of curvature.

B. Artifacts from heart motion can be reduced by gating acquisition to the cardiac cycle, but they cannot be avoided by filtering.

C. Artifacts from insufficient spatial sampling by detectors can be avoided by low-pass filtering each projection beforehand.

D. Artifacts from insufficient numbers of projections can be avoided by filtering.

E. One generally must keep the number of detectors times the number of projections in the same range as the number of pixels in the image.

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

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

D. None is true.

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

71. Increasing the accelerating voltage (kVp) in the X-ray tube would cause all of the following *except*, (or all the others are true)

A. All the others are true.

B. Increase energy of the highest energy photons in the X-ray the beam.

C. Increase the number of photons but keep the energy of the average photons the same.

D. Increase the heating of the target.

E. Increase percentage of high-energy photons.

72. Which one of the following statements is true about projection radiography?

I - Collimating grids reduce the number of Compton scattered photons reaching the detector and thus increases image contrast.
II - Digital Subtractive Radiography uses two energies of x-ray to intensify particular structures whose attenuation depends on photon energy.
III - Practical film radiography depends upon *phosphorescence* to produce light photons from x-ray photons.

A. III

B. II and III

C. I

D. I and II

E. I and III

73. Which of the following statements about the Projection Slice Theorem is *false*, (or all are true)?

A. It states that the 1-D Fourier transform of the projection through a 2-D image is a line through the origin of the 2-D Fourier transform of that image.

B. The Projection Slice Theorem is based on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

C. A set of lines in the frequency domain is produced using the Projection Slice Theorem that are filtered to "fill in" the high frequency regions between those lines to reconstruct CT images.

D. The Projection Slice Theorem allows us to perform image reconstruction using filtered backprojection in the frequency domain.

E. All are true.

74. Which of the following statements is *false*, or all are true.

A. The Radon Transform relates the projections through a slice to the underlying values at locations within the slice.

B. The projection-slice theorem allows us to mathematically demonstrate why backprojection must be filtered to boost high frequencies in image reconstruction.

C. All are true.

D. Rotating an image results in an equal rotation of the image's Fourier Transform.

E. The 1D Fourier transform of the projection of a slice equals a line passing through the origin of the 2D Fourier transform of that slice, at that angle corresponding to the projection.

75. All of the following statements about attenuation of X-rays are true, *except*:

A. The useful attenuation results from differences between tissues in the probability of the photoelectric effect.

B. They interact with the patient's tissue primarily by the process known as Bremsstrahlung.

C. Attenuation is dependent on the X-ray photon energy.

D. For X-rays passing through a homogeneous material, the number of photons remaining falls off as an inverse exponential function of distance.

E. The half value layer (HVL) represents the thickness of a homogeneous material that eliminates on average half of the X-ray photons.

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

A. 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.

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

E. They permit interpretation of local tissue attenuation from a single planar X-ray scan (projection radiograph).

77. Decreasing the accelerating voltage (kVp) in the X-ray tube would cause all of the following *except*

A. Decreased energy of the highest energy photons in the X-ray the beam.

B. Keep the energy of the average photons the same but reduce the number of photons.

C. Reduced number of high-energy photons.

D. Decrease the radiation dose to the patient.

E. Make characteristic radiation lines disappear as the accelerating voltage fell below the energy of the particular characteristic radiation line.

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

A. Move the X-ray source further from the detector.

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

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

D. Move the object further from the detector.

E. None of the other answers is correct.

79. Which of the following statements is *false* (or all are true)?

A. Varying tube current is used to control the number, but not the energy, of X-ray photons.

B. The average energy of photons produced by an X-ray tube is equal to the kVp between the cathode and anode of the tube.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic X-ray source.

D. All are true.

E. In an x-ray tube, electrostatic fields are used to accelerate electrons from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

80. Given that one chest radiography was taken using 10 mA and 65 kVp at 0.9 m distance between the film and the x-ray source, suppose that a second chest radiograph was taken at 90 mA and 65 kVp that yielded the same exposure. What distance would you expect between the film and the x-ray source (answer may be rounded)?

A. 2.7 m

B. 0.9 m

C. 8.1 m

D. 0.3 m

E. 0.1 m

81. All of the following statements describe imaging using X-rays, *except*

A. The risk of cancer increases with each scan.

B. Only tissues with different attenuation coefficients can be distinguished.

C. Iodine and boron are commonly used as contrast agents because of their high atomic number.

D. Projection and tomographic images are both obtainable.

E. Unlike nuclear medicine, radiation sources do not remain active within the patient after a scan.

82. All of the following statements are true about the sinogram, *except* (or all are true):

A. The sinogram of a uniformly gray (circular) 2-D image will be a 2-D image whose intensity is constant in the θ (angle) direction.

B. The sinogram results from applying the Radon transform to a 2-D image, and as such has an inverse transform to recreate the original image.

C. One axis of the sinogram represents distance along the projection.

D. All are true

E. Only angles $0 \leq \theta < \pi$ need to be represented, since projection in one direction is the same as in the opposite direction.

83. Which of the following portions of the electromagnetic spectrum include photons that are classified as ionizing radiation?

I. X-rays
II. Gamma photons
III. Ultraviolet light

A. I and II

B. II and III

C. I

D. I and III

E. I, II, and III.

84. Which of the following is (are) true? In the atom, the binding energy for an electron

I - is specific to a given element, shell, and quantum state.
II - generally increases with increasing shell number.
III - generally decreases with lower atomic number.

A. I

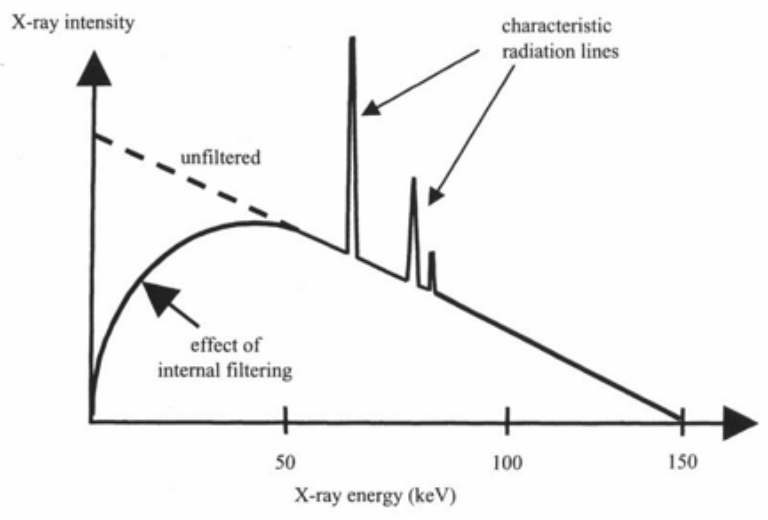
B. II and III

C. I, II, and III

D. I and II

E. I and III

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



A. No change in the graph.

B. None of the other choices

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

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

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

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

A. All are true

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

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

D. 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.

E. 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.

87. 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. II

B. I

C. II and III

D. I and III

E. I, II

88. The following are true about fluoroscopy *except* (or all are true)

A. Electrons are accelerated by electrostatic lenses and focused at the anode on an output phosphor.

B. The front of the fluoroscope tube uses an input phosphor to convert x-rays to light photons, which hit a photocathode generating electrons within the tube.

C. All are true

D. Fluoroscopy entails relatively high doses of radiation to the patient, and may even pose a risk to the clinician using it to guide procedures in real time.

E. Fluoroscopy permits rapidly moving X-ray images.

For official use only
permutation number = 1235

BioE 1330 - Review Chapters 4, 5, and 6 (X-ray and CT) 1/17/2011
Answer Sheet - Correct answer is A for all questions

1. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation?

A. X-rays from Bremsstrahlung are polyenergetic while those from Characteristic Radiation are monoenergetic.

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

C. Bremsstrahlung and Characteristic Radiation are both due to the photoelectric effect.

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

E. Bremsstrahlung is evident in the spectrum produced by a typical x-ray machine, while Characteristic Radiation is not.

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.
[*imaging0036.mcq*]

2. To minimize blur in planar radiography it is best to

A. minimize the source spot size, maximize the distance from the source to the patient, and minimize the distance from the patient to the film.

B. maximize the source spot size, minimize the distance from the source to the patient, and minimize the distance from the patient to the film.

C. minimize the source spot size, maximize the distance from the source to the patient, and maximize the distance from the patient to the film.

D. minimize the source spot size, minimize the distance from the source to the patient, and minimize the distance from the patient to the film.

E. maximize the source spot size, maximize the distance from the source to the patient, and minimize the distance from the patient to the film.

Explanation: the best geometry for a sharp shadow is to have the patient near the film and far from a small spot source.
[*imaging0037.mcq*]

3. Which of the following statements is false?

A. After both ionization and excitation, a "hole" is formed in the electron shell, which is filled via a process that does not involve characteristic radiation.

B. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the electron is ejected from the atom.

C. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the electron may be raised to a higher energy state (a more outer orbit), but is not ejected.

D. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the result is ionization.

E. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the result is excitation.

Explanation: "Holes" in electron shells are in fact filled via a process that comprises a source of secondary radiation known as characteristic radiation. (See Prince, Chapter 4, section 4.2.3.) The other statements are all true.
[*imaging0038.mcq*]

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

A. In an x-ray tube, magnetic fields are used to accelerate electrons from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

B. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

D. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

E. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

Explanation: Electrostatic fields, not magnetic fields, are used to accelerate the eletrons. Magnetic fields can only exert forces on moving electrons. The other statements are all true.
[*imaging0039.mcq*]

5. Which of the following statements is true about filtered backprojection and convolution backprojection?

A. The filtering is needed to fill out high frequency portions of the Fourier transform of the image, because the transforms of the individual projections are only lines through the origin and are further apart as one moves further from the origin.

B. The Radon transform does not work at low frequencies as well as at high frequencies.

C. Hounsfield units do not correct for the inherent loss of high frequency in the image.

D. Line integrals along the paths of the x-rays spread out as they reach the detector elements, and this loss or resolution needs to be compensated for.

E. None of the other answers are correct.

Explanation: The construction of the entire Fourier domain from individual projections needs to "splat" larger areas at high frequencies.
[*imaging0040.mcq*]

6. The following are true about Helical (Spiral) CT scanners, *except*

A. Because they require slip-ring electrical connectors, which produce electrical noise and Bremsstrahlung, they are not suitable for clinical use.

B. They are inherently smoother than older scanners in that the patient moves continuously through the scanner without stopping and starting.

C. They can produce scans of the entire torso in under 30 seconds, reducing motion artifact due to breathing by allowing the patient to hold his breath.

D. Filtered backprojection is still possible, by interpolating several spiral "cuts" into a flat slice.

E. Although they are more expensive than conventional CT scanners, they pay for themselves by permitting faster patient throughput.

Explanation: The Bremsstrahlung answer is completely bogus.
[*imaging0041.mcq*]

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

A. They allow filtered backprojection to compensate for motion artifact due to the patient breathing.

B. They allow individual scanners to be calibrated, given that the effective energy of a given x-ray tube can vary.

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 ± 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: Breathing artifact cannot be corrected by the use of HU.
[*imaging0042.mcq*]

8. The following are true about the sinogram, *except* (or all are true)

A. All are true.

B. It contains all the information gathered during an individual CT scan of a slice.

C. It exhibits sinusoidal 'traces' each representing the apparent motion of a point within the patient as the angle of projection rotates around the patient.

D. It consists of the individual 1D projections through the patient stacked into a 2D image.

E. It is a pictorial representation of the Radon transform.

Explanation: All are true
[*imaging0043.mcq*]

9. Bremsstrahlung describes a process in which

A. an electron beam is used to create high energy photons.

B. high energy photons are used to create photoelectrons.

C. high energy photons interact with outer shell electrons.

D. energy is released through nuclear decay.

E. electrons created in the x-ray tube interact directly with atoms in the patient.

Explanation: Electrons are accelerated in the x-ray tube to hit a target in the tube, creating x-ray photons that interact with atoms in the patient.
[*imaging0093.mcq*]

10. The following are true of Filtered Back Projection *except*

A. It is used to maximize resolution in Planar Radiography.

B. It constitutes a process for creating a tomographic image from a series of projections.

C. It is based on the inverse Radon transform and the fact that the Fourier transform of a projection through a 2D image is a line through the origin of the 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: Planar Radiography does not rely on Filtered Back Projection.
[*imaging0096.mcq*]

11. The following are true about x-rays *except*

A. They penetrate the body better than visible light because they have a *longer* wavelength than visible light.

B. They can be thought of as particles or waves.

C. They may reflect off the tiles on the walls of the room in which the scan is taking place.

D. They are produced in an x-ray tube by Bremsstrahlung over a continuous band of frequencies and by Characteristic Radiation at specific frequencies.

E. The cause damage to the body because they can produce ions.

Explanation: They penetrate the body better than visible light because they have a *shorter* wavelength than visible light.
[*imaging0098.mcq*]

12. The following are true about the dual-energy x-ray scan *except*

A. It produces tomographic images to separate the lungs from the ribs.

B. It can be used to "subtract"" the bones away from a chest x-ray to better see the underlying lungs.

C. It is an adaptation to the classical planar radiograph that has recently been introduced into clinical practice.

D. It uses two different scans of the same patient at two different x-ray energies, which produce different relative sensitivities to bone and soft tissues.

E. It depends on the patient not moving between the two different scans.

Explanation: It does not produced tomographic images; it is still a projection. The ribs may be "subtracted" because of they respond differently than lung at the two energies.
[*imaging0099.mcq*]

13. The healthy kidney is visible on the x-ray radiograph because

A. the healthy kidney is surrounded by fat, which exhibits less attenuation to x-rays than the kidney itself.

B. x-rays bend around the surface of the kidney.

C. x-rays reflect off the shiny surface of the kidney.

D. the kidney is completely opaque to x-rays.

E. the kidney filters radioactive tracers.

Explanation: Organ tissue such as kidney has a higher average atomic mass than fat (fat has a disproportionately high hydrogen content) and thus kidney absorbs x-ray more than fat.
[*imaging0100.mcq*]

14. Given that one chest radiography was taken using 25 mA and 75 kVp at 1.0 m distance between the film and the x-ray source, suppose that a second chest radiograph was taken at 100 mA and 75 kVp that yielded the same exposure. What distance would you expect between the film and the x-ray source?

A. 2.0 m

B. 4.0 m

C. 0.5 m

D. 0.25 m

E. 1.0 m

Explanation: Exposure (numbers of photons per second) is directly proportional to tube current. The inverse square law states that exposure varies inversely with the square of the distance. Therefore the effect on exposure from using 4 times the current (100 mA / 25 mA) would be cancelled by being twice as far away.
[*imaging0101.mcq*]

15. Which one of the following statements is *false*?

A. Compton scattering, which changes the path of photons in the body rendering them useless in image formation, is particularly a problem at low x-ray energies.

B. The probability of the photoelectric effect increases non-linearly with increasing effective atomic number of the material through which the radiation passes.

C. Ionization is the ejection of an orbiting electron from an atom; ionizing radiation has sufficient energy to produce ionization.

D. A "K-edge" occurs in the energy spectrum of photons at the binding energies of inner shell electrons, because above these energies many electrons become available and the probability of the photoelectric effect rises sharply.

E. The electron beam in an x-ray tube transfers energy to the target via collisional transfer (generating heat) and radiative transfer (generating characteristic radiation and bremsstrahlung radiation).

Explanation: Compton scattering is particularly a problem at *high* x-ray energies.
[*imaging0102.mcq*]

16. Which of the following actions increase the SNR in a planar radiograph?

I - Increasing the scatter fraction.
II - Decreasing the scatter fraction.
III - Increasing the absorption of the tissue.
IV - Decreasing the absorption of the tissue.

A. II and IV

B. I and III

C. II and III

D. I and IV

E. None has any effect on SNR.

Explanation: Decreasing scatter fraction lowers noise, and decreasing absorption raises signal (more than it increases noise). Both increase SNR.
[*imaging0103.mcq*]

17. Characteristic radiation peaks

A. result from electrons moving from one orbit to another of greater binding energy.

B. don't have enough energy to be useful for imaging.

C. are filtered out before reaching the patient.

D. have too much energy to be useful for imaging.

E. are different from Bremsstrahlung radiation in that they are not harmful to the patient.

Explanation: Characteristic radiation is extremely important in medical image formation. It is ionizing just like Bremsstrahlung and thus is potentially harmful to patients. They have characteristic energies, being the difference between the binding energy of one orbit vs. another.
[*imaging0104.mcq*]

18. All of the following statements describe imaging using X-rays, *except*

A. Radiation sources remain active within the patient after the scan.

B. Projection and tomographic images are both obtainable.

C. Only tissues with different attenuation coefficients can be distinguished.

D. The risk of cancer increases with each scan.

E. Iodine and barium are commonly used as contrast agents because of their high atomic number.

Explanation: Radiation doses may remain active within the patient after the scan with nuclear medicine, but X-rays are gone immediately.
[*imaging0105.mcq*]

19. Which of the following statements about the Projection Slice Theorem is *false*?

A. The Projection Slice Theorem requires the projection to be along one of the cardinal axes, i.e., the x-axis or the y-axis.

B. It states that the 1-D Fourier transform of the projection through a 2-D image is a line through the origin of the 2-D Fourier transform of that image.

C. A set of lines is produced using the Projection Slice Theorem that must be filtered to "fill in" the high frequency regions between those lines.

D. The Projection Slice Theorem depends on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

E. The Projection Slice Theorem allows us to perform image reconstruction using filtered backprojection in the frequency domain.

Explanation: Any angle of projection is allowed. The cardinal axes of the image are, after all, arbitrary. Rotating the 2-D image results in rotating the 2-D Fourier transform of that image.
[*imaging0106.mcq*]

20. All of the following statements are true about the sinogram, *except*:

A. The sinogram of a uniformly gray 2-D image does not exist.

B. It represents a collection of 1-D projections through a 2-D image.

C. The sinogram results from applying the Radon transform to a 2-D image, and as such has an inverse transform to recreate the original image.

D. One axis of the sinogram represents the angle of projection.

E. Only angles between 0 and π need to be represented, since projection in one direction is the same as in the opposite direction.

Explanation: Any 2-D image has a sinogram, since projections can always be computed.
[*imaging0107.mcq*]

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

A. X-rays and gamma rays represent distinct and non-overlapping regions of the electromagnetic spectrum.

B. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

D. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

E. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

Explanation: X-rays and gamma rays overlap in the the electromagnetic spectrum, differing fundamentally only in their source, x-rays coming from Bremsstrahlung and gamma rays from nuclear reactions.
[*imaging0108.mcq*]

22. Why do barium and iodine (contrast agents) appear white on x-ray?

A. They have a high atomic number and have K edges in the diagnostic x-ray range.

B. They equally reflect all wavelengths of visible light.

C. They allow more x-rays to pass.

D. They produce less Compton interaction at higher energies.

E. They form ions in the normal environment of the body.

Explanation: Barium and iodine both have a relatively high atomic number and have K edges in the useful range of photon energies.
[*imaging0109.mcq*]

23. Ultraviolet light has a wavelength in the range of 4-400 nanometers, what is the frequency range? (speed of light $= 3 \times 10^8$ m/s)

A. 7.5×10^{14} Hz to 7.5×10^{16} Hz.

B. 1.33×10^{-15} Hz to 1.33×10^{-17} Hz

C. 1.2 Hz to 120 Hz

D. 7.5 Hz to 7.5 MHz

E. 1.2 GHz to 120 GHz

Explanation: Frequency = velocity/wavelength.
[*imaging0110.mcq*]

24. The following is *not true* about Characteristic Radiation

A. It is caused by the interaction of an electron with a nucleus of an atom.

B. The intensity spectrum exhibits discrete narrow bands.

C. It is a form of radiative transfer.

D. A K-shell hole is created prior to the emission of the characteristic x-ray.

E. The incoming electron collides with a K-shell electron.

Explanation: The incoming electron interacts with a K-shell electron, not with the nucleus.
[*imaging0111.mcq*]

25. Which of the following photons constitutes ionizing radiation?

A. X-ray with energy of 45 KeV.

B. Ultraviolet light with energy of 4.1 eV

C. Infrared radiation with energy of 1.24 eV.

D. Radio Waves with energy of 120×10^{-6} eV.

E. All of the above.

Explanation: Radiation with energy greater than 13.6 eV is considered ionizing.
[*imaging0112.mcq*]

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

A. Move the object closer to the detector.

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

C. Move the object away from the detector.

D. Use a higher radiation dose.

E. Use a smaller object.

Explanation: Moving the object closer to the detector, or moving the source *away from* the detector and object will minimize magnification.
[*imaging0113.mcq*]

27. Which of the following is *false* about the 2D Radon Transform (or all are true)?

A. All are true.

B. It is the basis for filtered back projection.

C. It is a linear operator.

D. It has an inverse transform.

E. It relates multiple 1D projections to a 2D tomographic slice.

Explanation: All are true of the 2D Radon Transform.
[*imaging0114.mcq*]

28. Hounsfield units are defined relative to the CT absorption coefficient of

A. Water.

B. Air.

C. Metal.

D. Iodine.

E. Barium.

Explanation: Water is the standard: $h = 1000 \times \frac{\mu - \mu_{water}}{\mu_{water}}$.
[*imaging0115.mcq*]

29. The following are true about Beam Hardening *except*

A. It is more of a problem for planar radiography than for CT.

B. It constitutes energy-selective attenuation of x-rays.

C. It results in a net increase in the mean energy of x-ray photons.

D. It is especially a problem around metal and dense bone.

E. It causes a breakdown in the simplifying assumption of a single "effective" energy in the absorption along a given projection path.

Explanation: Beam Hardening is a problem primarily in CT, where filtered backprojection relies on the simplifying assumption of a single "effective" energy in the absorption along a given projection path. In projection radiography no such assumption is required to produce an image, because each projection path contributes to the image independently.
[*imaging0116.mcq*]

30. Which of the following is (are) true? In the atom, the binding energy for an electron

I - is specific to a given element, shell, and quantum state.
II - generally decreases with increasing shell number (further from nucleus) .
III - increases with lower atomic number (less positive charge in nucleus).

A. I and II

B. II and III

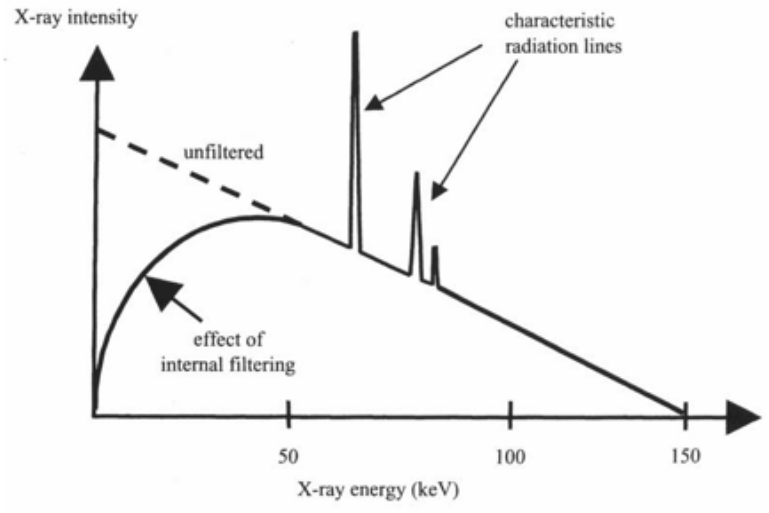
C. I and III

D. I, II, and III

E. I

Explanation: Binding energy *decreases* with lower atomic number (less positive charge in nucleus) because it takes less energy to remove them from the atom.
[*imaging0117.mcq*]

31. In the histogram below, why does the source have internal filtering at low energies?



A. The filtered X-rays would not get through the patient to the detector, so they are worthless from an imaging standpoint.

B. The filtered X-rays would provide useful imaging information, but would cause too much damage in the patient.

C. The filtered X-rays have alpha-particles which must be stopped from reaching the patient.

D. The filtered X-rays are part of the correction for beam-hardening.

E. None of the other choices

Explanation: Low-energy x-rays do not penetrate far enough to form images, and therefore a filter is built to remove them from the X-ray beam profile, preventing unnecessary exposure.
[*imaging0159.mcq*]

32. With reference (where appropriate) to the histogram above, decreasing the accelerating voltage (kVp) would cause all of the following EXCEPT:

A. Increased radiation dose to the patient

B. Decreased or absent characteristic radiation lines

C. Reduced number of high-energy photons

D. Decreased effective X-ray energy of the beam

E. None of the other choices

Explanation: Recall the relationship that X-ray intensity is proportional to the square of the accelerating voltage times the tube current. Decreasing the kVp of the X-ray machine would do all of these things except increase the radiation dose (it would decrease the radiation dose).
[*imaging0160.mcq*]

33. With reference (where appropriate) to the histogram above, decreasing the tube current (Amperes) would cause which of the following?

A. None of the other choices

B. Absence of characteristic radiation lines

C. Absence of high-energy photons

D. Decreased effective X-ray energy of the beam

E. Increased radiation dose to the patient

Explanation: Recall the relationship that X-ray intensity is proportional to the square of the accelerating voltage times the tube current. Decreasing the tube current of the X-ray machine would do none of these things – it simply means that more photons are coming per second.
[*imaging0161.mcq*]

34. Characteristic radiation peaks:

A. Make up 10-30% of the X-ray beam's intensity spectrum

B. Don't have enough energy to be useful for imaging

C. Are filtered out before reaching the patient

D. Have too much energy to be useful for imaging

E. Are different from Bremsstrahlung radiation in that they are not harmful to the patient

Explanation: Characteristic radiation is extremely important in medical image formation. It is ionizing just like Bremsstrahlung and thus is potentially harmful to patients.
[*imaging0162.mcq*]

35. All of the following statements about Compton scattering of X-rays are true, *except*:

A. Compton-scattered X-rays provide the most contrast between different tissues.

B. Most Compton-scattered X-rays are hopefully absorbed by the lead septa of an antiscatter grid

C. Compton scattering is the most common interaction for a high energy X-ray.

D. The probability of an X-ray photon undergoing Compton scattering is essentially independent of the effective atomic number of the tissue.

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

Explanation: The photoelectric effect provides the most contrast between tissues. Compton scattering is generally bad for imaging and thus we seek to reduce its effect on the image via antiscatter grids.
[*imaging0163.mcq*]

36. All of the following statements about the photoelectric effect are true, EXCEPT:

A. The probability of an X-ray photon undergoing a photoelectric interaction is essentially independent of the effective atomic number of the tissue.

B. The net result of a photoelectric interaction is that the incident X-ray does NOT reach the detector.

C. The photoelectric effect is the most common interaction for a low energy X-ray.

D. The photoelectric effect provides the most image contrast between different tissues.

E. The photoelectric effect is the interaction that allows us to make high-quality x-ray images.

Explanation: PE effect is dependent on the cube of the effective atomic number of the tissue. That's why bones appear so white (high calcium) while air appears so black (mostly nitrogen and oxygen).
[*imaging0164.mcq*]

37. All of the following statements describe limitations of planar X-ray imaging, /it except:

A. Radiation dose can remain in the patient for days after the scan

B. Only 2-D information is available

C. Only tissues with different attenuation coefficients can be distinguished

D. The risk of cancer increases with each scan

E. Both iodine and barium are commonly used as contrast agents.

Explanation: Radiation doses stay in patients for days with nuclear medicine, not with X-rays.
[*imaging0165.mcq*]

38. The linear attenuation coefficient of a gadolinium-based phosphor used for the attenuation of X-rays is $\mu = 560$ cm^{-1} at an X-ray energy of 150 keV. What percentage of these X-rays is detected by a phosphor layer of thickness 10 μm?

A. About 43%

B. About 57%

C. Less than 1%

D. Greater than 99%

E. About 83%

Explanation: Use the Beer-Lambert equation $\frac{I}{I_0} = \exp(-\mu\Delta x)$ to find that 57% penetrates the phosphor layer, leaving 43% to be deposited.
[*imaging0166.mcq*]

39. The signal-to-noise ratio of an X-ray image can be improved by which of the following?

A. Decreasing the distance from the patient to the detector

B. Decreasing the tube current in the X-ray source

C. Decreasing the thickness of the phosphor intensifying screen

D. Increasing the grid ratio

E. Increasing the obesity of the patient

Explanation:
[*imaging0167.mcq*]

40. The half-value layer (HVL) of a tissue is dependent upon the type of tissue attenuating the X-ray as well as the energy of the incident X-ray. If the linear attenuation coefficient μ for bone is 10 cm^{-1} at the effective X-ray energy of 68 keV, what is the half-value layer (HVL) of the bone for that effective energy?

A. $\frac{\ln 2}{10cm^{-1}}$

B. $\frac{10cm^{-1}}{\ln 2}$

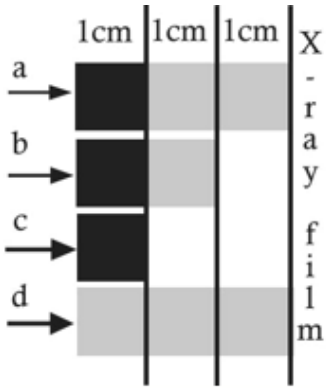
C. 0.1 cm

D. 10 cm

E. 0.1 cm^{-1}

Explanation: HVL = $\frac{\ln 2}{\mu}$
[*imaging0168.mcq*]

41. Four X-ray beams, each with intensity I_0, are incident upon the object below, in which black represents bone, gray represents muscle, and white represents fat. Which of the four beams will appear the darkest on a typical X-ray image? Assume that the linear attenuation coefficients at the effective X-ray energy of 68 keV are 10 cm^{-1}, 2 cm^{-1}, and 1 cm^{-1}, for bone, muscle, and fat, respectively.



A. Beam d

B. Beam c

C. Beam b

D. Beam a

E. The beams will have the same transmitted intensity

Explanation: Use Beer-Lambert equation again, with three $\mu\Delta x$ terms summed in the argument of the exponent.
[*imaging0169.mcq*]

42. By convention, radiation with energy greater than or equal to 13.6 eV is considered *ionizing radiation.* What range of wavelengths contain the cutoff wavelength below which UV light is ionizing? $c = 2.998 \times 10^8$ meters per second, $h = 6.626 \times 10^{-34}$ Joule-sec, and 1 eV $= 1.6 \times 10^{-19}$ Joule.

A. 10 nm - 100 nm

B. 1 nm - 10 nm

C. 0.1 nm - 1 nm

D. 100 nm - 1 μm

E. 1 μm - 10 μm

Explanation: Using $E = h\nu$, we solve for the frequency of the UV light as $\nu = 3.284 \times 10^{15}$ Hz. Then we use $c = \lambda\nu$ to solve for $\lambda = 91.4$ nm, below which UV light is ionizing.
[*imaging0170.mcq*]

43. You are designing an x-ray detector system and wish to eliminate all photons that have been scattered more than 20 degrees in an attempt to improve the resulting image quality. You are using a monoenergetic x-ray source that emits photons having wavelength $\lambda = 8.9 \times 10^{-2}$ angstroms (1 angstrom = 10^{-10} meters). If your detector is capable of discriminating the energy of incoming photons, which of the following photon energies will be accepted by the system? Recall that the energy of a scattered photon is given by:

$h\nu^* = \frac{h\nu}{1+\frac{h\nu}{m_0c^2}(1-\cos\theta)}$

with $m_0c^2 = 511$ KeV.

A. 138 KeV

B. 134 KeV

C. 136 KeV

D. 140 KeV

E. 142 KeV

Explanation: See homework problem 4.11. Calculate the energies of an unscattered photon ($\theta = 0$) and one maximally scattered by $\theta = 20$, using the given equation. The range is between 137.2 KeV and 139.4 KeV, making the answer 138 KeV the only energy within that range.
[*imaging0171.mcq*]

44. Which of the following statements about the Projection Slice Theorem is FALSE?

A. The 2-D Fourier transform of the projection of an object equals a line passing through the origin of the 1-D Fourier transform of that object, at that angle corresponding to the projection.

B. The 1-D Fourier transform of a projection of an object is a slice of the 2-D Fourier transform of that object.

C. The projection-slice theorem does explain the importance of angular sampling required for image reconstruction.

D. The projection-slice theorem is related to the radon transform.

E. The projection-slice theorem allows us to mathematically demonstrate why filtered backprojection works as a method of image reconstruction.

Explanation: See section 6.3 in Prince.

Errata: There are several poorly worded answers in this question and it should not be used.
[*imaging0172.mcq*]

45. Place the following tissues or materials in ranked order, in terms of greatest to least X-ray absorption:

I - item fat
II - item muscle
III - air
IV - lead
V - bone

A. IV - V - II - I - III

B. V - IV - II - I - III

C. III - II - I - IV - V

D. III - I - II - V - IV

E. IV - V - III - II - I

Explanation: Lead has the highest attenuation coefficient (which is why it is used to protect people from unnecessary radiation exposure). Bone is next. Air has the smallest attenuation coefficient. Muscle is slightly more absorptive than fat, but the key is knowing that lead is more absorptive than bone while air is much less absorptive than the others.
[*imaging0193.mcq*]

46. The inverse square law has very practical use in radiography. Suppose an acceptable chest radiography was taken using 67.5 mAs at 80 kVp from 1.5 m. Suppose that it was now requested that be taken at 1 m at 80kVp. What mAs setting should be used to yield the same exposure?

A. 30 mAs

B. 37.5 mAs

C. 60 mAs

D. 45 mAs

E. 20 mAs

Explanation: For explanation look at example 5.2
[*imaging0196.mcq*]

47. Which one of the following statements is true?

I - Acceptance of Compton scattered photons increases image contrast, and thus signal-to-noise ratio as well.
II - The film-screen detector produces an optical image on film; the degree of film blackening (the optical density) depends on film exposure in a nonlinear way characterized by the H-and-D curve.
III - Projection radiography produces radiographs, which are 1-D projections of a 3-D object.

A. II

B. I,II, and III

C. II and III

D. I and II

E. I

Explanation: II is true.
[*imaging0198.mcq*]

48. Ultraviolet light is defined as electromagnetic waves having wavelengths in the range of

A. 400 nm - 10 nm

B. 700 nm - 400 nm

C. 100 pm - 10 pm

D. 3 km - 0.01 m

E. 10 pm - 1 pm

Explanation: 10-400 nanometers. Ultraviolet is just shorter than visible, which is 700 nm - 400 nm.
[*imaging0199.mcq*]

49. Which one of the following statements is *false*?

A. Compton scatter results in the complete absorption of the incident photon.

B. The probability of the photoelectric effect increases with increasing effective atomic number of the material through which the particulate radiation passes.

C. Ionization is the ejection of an orbiting electron from an atom; ionization radiation has sufficient energy to produce ionization.

D. Both ionization and excitation may leave a hole in an inner electron shell, which is refilled creating characteristic radiation.

E. Bremsstrahlung is a form of particulate radiation that produces a broad spectrum of X-ray photons.

Explanation: In Compton scatter, the incident photon is deflected by the outer shell electrons, and is not completely absorbed. It therefore may continue on its altered path to reach the detector and produce unwanted exposure in the image.
[*imaging0201.mcq*]

50. What determines the highest energy of x-ray photons emitted from an x-ray tube?

A. The peak x-ray tube voltage

B. The sum of characteristic x-ray spectra

C. The integral of the bremsstrahlung x-ray spectrum.

D. The elements of the atoms in the anode of the x-ray tube

E. None of the other answers.

Explanation: The peak x-ray tube voltage determines how fast the electrons hit the anode, and thus the maximum x-ray photon energy produced.
[*imaging0202.mcq*]

51. What simple strategies can an x-ray technician use to reduce the magnification and distortion effects of the projection radiography system?

I - Moving the object closer to detector panel
II - Moving the object further away from the detector panel
III - Moving the X-ray source further away from the object and the detector
IV - Moving the X-ray source closer to the object and the detector

A. I and III

B. I and IV

C. II and III

D. II and IV

E. None of them

Explanation: Answer is I and III. For explanation look at homework solution.
[*imaging0203.mcq*]

52. Which of the following actions alter the SNR as indicated?

I - Increase the scatter fraction, which causes an increase in the noise level
II - Increase the scatter fraction, which causes an decrease in the noise level
III - Decrease the absorption efficiency of the detector, which causes a decrease in the signal amplitude
IV - Decrease the absorption efficiency of the detector, which causes an increase in the signal amplitude

A. I and III

B. I and IV

C. II and III

D. II and IV

E. None of them

Explanation: Answer is I and III. Decreasing the absorption efficiency of the detector decreases signal (as well as noise somewhat, but noise exists from other sources as well that don't go away).
[*imaging0204.mcq*]

53. For a point source of radiation, the exposure at a distance d from the source follows an inverse square law. If the exposure at $d = 3$ cm from point source is 36 R, what is the exposure at $d = 18$ cm from the source?

A. 1 R

B. 6 R

C. 3 R

D. 4 R

E. 1.5 R

Explanation: The exposure at d = 3 cm is 36 (1/36) times that at d = 18 cm. So the exposure at d = 18 cm is R.
[*imaging0205.mcq*]

54. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation?

A. Bremsstrahlung is due to deflections of incoming electrons around positive nuclei, while Characteristic Radiation is due to the photoelectric effect and refilling of inner shell orbitals by outer shell electrons.

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

C. X-rays from Bremsstrahlung are monoenergetic while those from Characteristic Radiation are polyenergetic.

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

E. Bremsstrahlung is evident in the spectrum produced by a typical x-ray machine, while Characteristic Radiation is not.

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.
[*imaging0245.mcq*]

55. The following are true about the new portable "cone-beam" scanners, described in lecture, but not in the textbook, *except*

A. They capture a 3D data set without any moving parts.

B. They are basically fluoroscopic x-ray machines that can be rotated around the patient, capturing multiple projections.

C. They are capable of reconstructing a set of tomographic slices through the patient.

D. They trade off image quality for portability, so that they can be used in the surgical suite.

E. They provide rapid real-time 3D images during an operation that can be registered with pre-aquired CT scans from a higher-quality stationary scanner.

Explanation: The new cone-beam scanners are basically fluoroscopy machines with a C-arm that rotates around the patient capturing a series of 2D projections that are reconstructed into a set of tomographic slices.
[*imaging0246.mcq*]

56. Which of the following statements about the generation of x-rays is *false*?

A. The majority of energy produced within an x-ray tube is in the form of high-energy (x-ray) photons.

B. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

C. In an x-ray tube, electric fields are used to accelerate electrons from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

D. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

E. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

Explanation: The majority of energy produced within an x-ray tube is in the form of heat. The other statements are all true.
[*imaging0247.mcq*]

57. Given that one chest radiography was taken using 90 mA and 85 kVp at 3.0 m distance between the film and the x-ray source, suppose that a second chest radiograph was taken at 10 mA and 85 kVp that yielded the same exposure on the film. What distance would you expect between the film and the x-ray source?

A. 1.0 m

B. 9.0 m

C. 0.33 m

D. 27.0 m

E. 3.0 m

Explanation: Exposure (numbers of photons per second) is directly proportional to tube current. The inverse square law states that exposure varies inversely with the square of the distance. Therefore the effect on exposure from using 1/9 the current would be cancelled by being 3 times as close.
[*imaging0248.mcq*]

58. Which one of the following statements is *false*?

A. A "K-edge" occurs in the energy spectrum of photons at the binding energies of outer shell electrons, because above these energies fewer electrons are available.

B. The probability of the photoelectric effect increases non-linearly with increasing effective atomic number of the material through which the radiation passes.

C. Ionization is the ejection of an orbiting electron from an atom; ionizing radiation has sufficient energy to produce ionization.

D. Compton scattering, which changes the path of photons in the body rendering them useless in image formation, is particularly a problem at high x-ray energies.

E. The electron beam in an x-ray tube transfers energy to the target via collisional transfer (generating heat) and radiative transfer (generating characteristic radiation and bremsstrahlung radiation).

Explanation: A "K-edge" occurs in the energy spectrum of photons at the binding energies of inner shell electrons, because above these energies many electrons become available and the probability of the photoelectric effect rises sharply.
[*imaging0249.mcq*]

59. All of the following statements describe imaging using X-rays, *except*

A. The risk of cancer from a CT scan is negligible compared to the background radiation at the earth's surface.

B. Projection and tomographic images are both obtainable.

C. Only tissues with different attenuation coefficients can be distinguished.

D. X-rays constitute both one of the oldest and one of the most rapidly advancing forms of medical imaging.

E. Iodine and barium are commonly used as contrast agents because of their high atomic number.

Explanation: Radiation doses, especially from fluoroscopy and CT, are not negligible and constitute a significant risk of cancer. Invented in 1895, X-ray devices such as multi-slice CT are rapidly changing and pushing the envelope of clinical imaging capabilities.
[*imaging0250.mcq*]

60. Which of the following is (are) true? In the atom, the binding energy for an electron

I - increases with lower atomic number.
II - generally decreases with increasing shell number.
III - is specific to a given element, shell, and quantum state.

A. II and III

B. I and II

C. I and III

D. I, II, and III

E. III

Explanation: Binding energy *decreases* with lower atomic number (less positive charge in nucleus) because it takes less energy to remove them from the atom.
[*imaging0251.mcq*]

61. Which of the following actions increase the SNR in a planar radiograph?

I - Increasing the detector efficiency.
II - Increase the filament current.
III - Increasing the pulse duration.

A. I, II and III.

B. I and III

C. II and III

D. I and II

E. None of the other answers is correct.

Explanation: All three increase the detected signal while at least some of the sources of noise remain unchanged.
[*imaging0252.mcq*]

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

A. Move the object further from the X-ray source.

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

C. Move the object further from the detector.

D. Decrease the size of the X-ray source.

E. None of the other answers is correct.

Explanation: Moving the X-ray source closer to the detector also brings it closer to the object. Likewise, moving the object further from the detector brings the object closer to the X-ray source. Both *increase* magnification. The size of the X-ray source has no effect on magnification.
[*imaging0253.mcq*]

63. Decreasing the accelerating voltage (kVp) in the X-ray tube would cause all of the following *except*

A. Keep the energy of the average photons the same but reduce the number of photons.

B. Reduced number of high-energy photons.

C. Decrease the radiation dose to the patient.

D. Decreased energy of the highest energy photons in the X-ray the beam.

E. Make characteristic radiation lines disappear as the accelerating voltage fell below the energy of the particular characteristic radiation line.

Explanation: Decreasing the kVp of the X-ray machine would reduce the average energy of the photons. Answer A describes what happens when the tube current is reduced.
[*imaging0254.mcq*]

64. 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 high energy X-ray.

D. Compton scattering can be 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.

Alternate acceptable answer: D

Errata: Answer D should read, "Compton scattering can be *at least partially* removed once it occurs."
[*imaging0255.mcq*]

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

A. They are directly proportional to the density of the material in the corresponding voxel.

B. They allow individual scanners to be calibrated, given that the effective energy of a given x-ray tube can vary.

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: Although they tend to be higher in denser material, the relationship is more complicated, involving the atomic number raised to approximately the 4th power, and involving K-edges in the spectrum.
[*imaging0256.mcq*]

66. The following are true about the sinogram, *except*

A. Rotation of the original image results in rotation of the sinogram.

B. It contains all the information gathered during an individual CT scan.

C. It exhibits sinusoidal 'traces' each representing the apparent motion of a point within the patient as the angle of projection rotates around the patient.

D. It consists of the individual 1D projections through the patient stacked into a 2D image.

E. Only angles between 0 and π need to be represented, since projection in one direction is the same as in the opposite direction.

Explanation: Rotation of an image does result in rotation of its 2D Fourier transform, but it would actually result in translation (and wrapping around) of the sinogram along the axis representing the angle of projection.
[*imaging0257.mcq*]

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

A. Components of the sinogram that are at the fundamental frequency of rotation for the scanner must first be removed to avoid sampling artifact.

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. It's 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: Answer A is utter nonsense.
[*imaging0258.mcq*]

68. All of the following statements about attenuation of X-rays are true, *except*:

A. Attenuation is assumed to be independent of X-ray photon energy in planar radiography.

B. The useful attenuation results from differences between tissues in the probability of the photoelectric effect.

C. It may be considered linear along a line of projection by integrating in the exponent of an exponential.

D. The half value layer (HVL) represents the thickness of a homogeneous material that eliminates half of the X-ray photons.

E. For X-rays passing through a homogeneous material, the number of photons remaining falls off as an inverse exponential function of distance.

Explanation: Attenuation may sometimes be assumed to be independent of X-ray photon energy in CT, but no such assumptions are used in planar radiography, which does not require computation.
[*imaging0259.mcq*]

69. All of the following statements about artifacts in CT are true, *except*:

A. Artifacts from insufficient numbers of projections can be avoided by filtering.

B. Insufficient spatial sampling by detectors can lead to streaks at small bright objects or boundaries with small radii of curvature.

C. Artifacts from insufficient spatial sampling by detectors can be avoided by low-pass filtering each projection beforehand.

D. Artifacts from heart motion can be reduced by gating acquisition to the cardiac cycle, but they cannot be avoided by filtering.

E. One generally must keep the number of detectors times the number of projections in the same range as the number of pixels in the image.

Explanation: Artifacts from insufficient numbers of projections cannot be avoided by filtering; the information required for the correct backprojection is simply not there (see Answer E).
[*imaging0260.mcq*]

70. 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*]

71. Increasing the accelerating voltage (kVp) in the X-ray tube would cause all of the following *except*, (or all the others are true)

A. Increase the number of photons but keep the energy of the average photons the same.

B. Increase percentage of high-energy photons.

C. All the others are true.

D. Increase energy of the highest energy photons in the X-ray the beam.

E. Increase the heating of the target.

Explanation: Increase the kVp of the X-ray machine would do all of these things except m keep the energy of the average photons the same, which happens when you increase the tube current.
[*imaging0289.mcq*]

72. Which one of the following statements is true about projection radiography?

I - Collimating grids reduce the number of Compton scattered photons reaching the detector and thus increases image contrast.
II - Digital Subtractive Radiography uses two energies of x-ray to intensify particular structures whose attenuation depends on photon energy.
III - Practical film radiography depends upon *phosphorescence* to produce light photons from x-ray photons.

A. I

B. I and III

C. II and III

D. I and II

E. III

Explanation: Digital Subtractive Radiography uses the difference between two images, one with contrast and one without. Practical film radiography depends upon *luminescence* to produce light photons from x-ray photons.
[*imaging0290.mcq*]

73. Which of the following statements about the Projection Slice Theorem is *false*, (or all are true)?

A. All are true.

B. It states that the 1-D Fourier transform of the projection through a 2-D image is a line through the origin of the 2-D Fourier transform of that image.

C. A set of lines in the frequency domain is produced using the Projection Slice Theorem that are filtered to "fill in" the high frequency regions between those lines to reconstruct CT images.

D. The Projection Slice Theorem is based on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

E. The Projection Slice Theorem allows us to perform image reconstruction using filtered backprojection in the frequency domain.

Explanation: All are true.
[*imaging0291.mcq*]

74. Which of the following statements is *false*, or all are true.

A. All are true.

B. The 1D Fourier transform of the projection of a slice equals a line passing through the origin of the 2D Fourier transform of that slice, at that angle corresponding to the projection.

C. Rotating an image results in an equal rotation of the image's Fourier Transform.

D. The Radon Transform relates the projections through a slice to the underlying values at locations within the slice.

E. The projection-slice theorem allows us to mathematically demonstrate why backprojection must be filtered to boost high frequencies in image reconstruction.

Explanation: All are true.
[*imaging0325.mcq*]

75. All of the following statements about attenuation of X-rays are true, *except*:

A. They interact with the patient's tissue primarily by the process known as Bremsstrahlung.

B. The useful attenuation results from differences between tissues in the probability of the photoelectric effect.

C. Attenuation is dependent on the X-ray photon energy.

D. The half value layer (HVL) represents the thickness of a homogeneous material that eliminates on average half of the X-ray photons.

E. For X-rays passing through a homogeneous material, the number of photons remaining falls off as an inverse exponential function of distance.

Explanation: Bremsstrahlung is the process by which the X-rays are formed in the X-ray tube, not the interaction of X-rays with the patient's tissue.
[*imaging0326.mcq*]

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

A. They permit interpretation of local tissue attenuation 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*]

77. Decreasing the accelerating voltage (kVp) in the X-ray tube would cause all of the following *except*

A. Keep the energy of the average photons the same but reduce the number of photons.

B. Reduced number of high-energy photons.

C. Decrease the radiation dose to the patient.

D. Decreased energy of the highest energy photons in the X-ray the beam.

E. Make characteristic radiation lines disappear as the accelerating voltage fell below the energy of the particular characteristic radiation line.

Explanation: Decreasing the kVp of the X-ray machine would reduce the average energy of the photons. Answer A describes what happens when the tube current is reduced.
[*imaging0254.mcq*]

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

A. Move the X-ray source further 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.

Alternate acceptable answer: E

Errata: Answer A should read, "Move the X-ray source further from the detector *with the object remaining the same distance from the detector*."
[*imaging0328.mcq*]

79. Which of the following statements is *false* (or all are true)?

A. The average energy of photons produced by an X-ray tube is equal to the kVp between the cathode and anode of the tube.

B. All are true.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic X-ray source.

D. Varying tube current is used to control the number, but not the energy, of X-ray photons.

E. In an x-ray tube, electrostatic fields are used to accelerate electrons from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

Explanation: The *maximum*, not the average, energy of photons produced by an X-ray tube is equal to the kVp between the cathode and anode of the tube.
[*imaging0329.mcq*]

80. Given that one chest radiography was taken using 10 mA and 65 kVp at 0.9 m distance between the film and the x-ray source, suppose that a second chest radiograph was taken at 90 mA and 65 kVp that yielded the same exposure. What distance would you expect between the film and the x-ray source (answer may be rounded)?

A. 2.7 m

B. 8.1 m

C. 0.3 m

D. 0.1 m

E. 0.9 m

Explanation: Exposure (numbers of photons per second) is directly proportional to tube current. The inverse square law states that exposure varies inversely with the square of the distance. Therefore the effect on exposure from using 9 times the current (90 mA / 10 mA) would be cancelled by being three times as far away.
[*imaging0330.mcq*]

81. All of the following statements describe imaging using X-rays, *except*

A. Iodine and boron are commonly used as contrast agents because of their high atomic number.

B. Projection and tomographic images are both obtainable.

C. Only tissues with different attenuation coefficients can be distinguished.

D. The risk of cancer increases with each scan.

E. Unlike nuclear medicine, radiation sources do not remain active within the patient after a scan.

Explanation: Barium, not boron, is commonly used as a contrast agent.
[*imaging0331.mcq*]

82. All of the following statements are true about the sinogram, *except* (or all are true):

A. All are true

B. The sinogram of a uniformly gray (circular) 2-D image will be a 2-D image whose intensity is constant in the θ (angle) direction.

C. The sinogram results from applying the Radon transform to a 2-D image, and as such has an inverse transform to recreate the original image.

D. One axis of the sinogram represents distance along the projection.

E. Only angles $0 \leq \theta < \pi$ need to be represented, since projection in one direction is the same as in the opposite direction.

Explanation: B is true because each projection will be identical independent of θ.
[*imaging0332.mcq*]

83. Which of the following portions of the electromagnetic spectrum include photons that are classified as ionizing radiation?

I. X-rays
II. Gamma photons
III. Ultraviolet light

A. I, II, and III.

B. I and II

C. II and III

D. I and III

E. I

Explanation: Photons with energy greater than 13.6 eV is considered ionizing. This includes some ultraviolet light and all Gamma photons and X-rays
[*imaging0333.mcq*]

84. Which of the following is (are) true? In the atom, the binding energy for an electron

I - is specific to a given element, shell, and quantum state.
II - generally increases with increasing shell number.
III - generally decreases with lower atomic number.

A. I and III

B. II and III

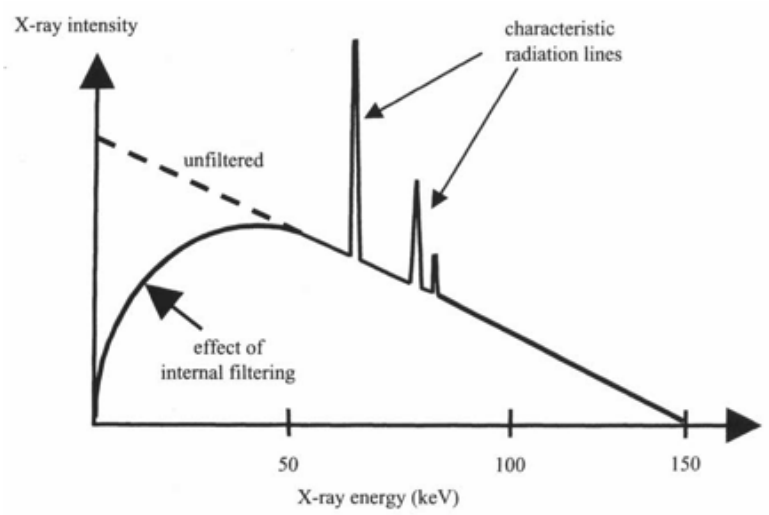
C. I and II

D. I, II, and III

E. I

Explanation: Binding energy generally *decreases* with increasing shell number (further from the nucleus) because it takes less energy to remove them from the atom.
[*imaging0334.mcq*]

85. 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*]

86. 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*]

87. 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*]

88. The following are true about fluoroscopy *except* (or all are true)

A. All are true

B. The front of the fluoroscope tube uses an input phosphor to convert x-rays to light photons, which hit a photocathode generating electrons within the tube.

C. Electrons are accelerated by electrostatic lenses and focused at the anode on an output phosphor.

D. Fluoroscopy permits rapidly moving X-ray images.

E. Fluoroscopy entails relatively high doses of radiation to the patient, and may even pose a risk to the clinician using it to guide procedures in real time.

Explanation: All are true
[*imaging0338.mcq*]