BioE 1330 - Review Chapters 4, 5, and 6 (X-ray and CT) 9/27/2018

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

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your signature

1. 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?

A. The filtering removes X-rays with undesirable frequencies.

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 Fourier transforms of the individual projections are further apart as one moves further from the origin in the frequency domain.

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. Characteristic radiation peaks

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

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

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

D. are filtered out before reaching the patient.

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

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

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

B. The risk of cancer increases with each 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.

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

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

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

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 allows us to perform image reconstruction using filtered backprojection in the frequency domain.

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.

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

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

D. 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.

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

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

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

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

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

21. 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 produce less Compton interaction at higher energies.

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

E. They allow more x-rays to pass.

22. 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. 1.33×10^{-15} Hz to 1.33×10^{-17} Hz

B. 7.5×10^{14} Hz to 7.5×10^{16} Hz.

C. 1.2 GHz to 120 GHz

D. 1.2 Hz to 120 Hz

E. 7.5 Hz to 7.5 MHz

23.

A. B. C. D. E.

24. Which of the following photons constitutes ionizing radiation?

A. Infrared radiation with energy of 1.24 eV.

B. X-ray with energy of 45 KeV.

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

D. Ultraviolet light with energy of 4.1 eV

E. All of the above.

25. 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. Use a smaller object.

D. Move the object away from the detector.

E. Use a higher radiation dose.

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

A. It has an inverse transform.

B. It is the basis for filtered back projection.

C. It is a linear operator.

D. All are true.

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

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

A. Air.

B. Iodine.

C. Metal.

D. Water.

E. Barium.

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

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

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

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

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

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

29. 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

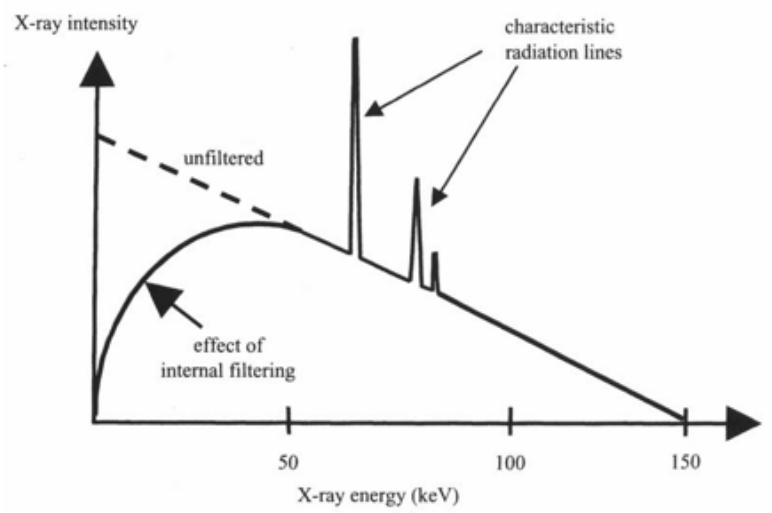
B. I, II, and III

C. II and III

D. I

E. I and III

30. In the graph below, why does the source have internal filtering at low energies?



A. None of the other choices

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

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

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

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

31. With reference to the graph above, decreasing the accelerating voltage (kVp) would cause all of the following EXCEPT:

A. Reduced number of high-energy photons

B. Decreased effective X-ray energy of the beam

C. Decreased or absent characteristic radiation lines

D. None of the other choices

E. Increased radiation dose to the patient

32. With reference to the graph above, decreasing the tube current (Amperes) would cause which of the following?

A. Absence of characteristic radiation lines

B. Absence of high-energy photons

C. None of the other choices

D. Increased radiation dose to the patient

E. Decreased effective X-ray energy of the beam

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

E. Have too much energy to be useful for imaging

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

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

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

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

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

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

35. All of the following statements about the photoelectric effect are true, *except*:

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

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

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

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

E. The net result of a photoelectric interaction is that the incident X-ray does *not* reach the detector.

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

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

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

C. Only 2-D information is available

D. Only tissues with different attenuation coefficients can be distinguished

E. The risk of cancer increases with each scan

37. 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. Greater than 99%

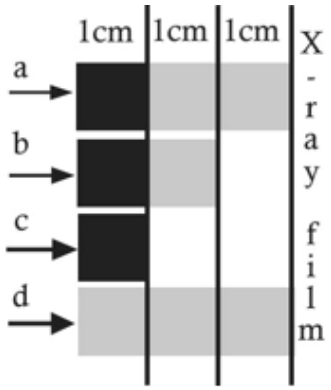
B. About 43%

C. Less than 1%

D. About 57%

E. About 83%

38. 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 b

B. Beam c

C. Beam d

D. Beam a

E. The beams will have the same transmitted intensity

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

A. It says that the 1D Fourier transform of the projection of an image equals a line passing through the origin of the 2D Fourier transform of that image, at the same angle as the 1D projection.

B. It is related to the Radon transform.

C. All are true.

D. It is central to image reconstruction in CT.

E. It under-represents higher frequencies, producing a blurred backprojection, requiring an additional filtering step.

40. 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 - II - I - IV - V

D. V - IV - II - I - III

E. III - I - II - V - IV

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

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

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

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

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

A. None of the other answers.

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

C. The peak x-ray tube voltage

D. The sum of characteristic x-ray spectra

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

43. 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 IV

B. II and IV

C. I and III

D. None of them

E. II and III

44. 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. 6 R

B. 1 R

C. 1.5 R

D. 4 R

E. 3 R

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

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

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

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

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

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

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

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

D. 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.

E. 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.

48. 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. 27.0 m

C. 3.0 m

D. 0.33 m

E. 9.0 m

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

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

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

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

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

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

D. Projection and tomographic images are both obtainable.

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

51. 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, II, and III

B. I and II

C. III

D. II and III

E. I and III

52. 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 object further from the X-ray source.

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

E. Move the object further from the detector.

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

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

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

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

D. Reduced number of high-energy photons.

E. Decrease the radiation dose to the patient.

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

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

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

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

D. All are true.

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

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

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

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.

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

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

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

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

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

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

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

C. 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.

D. 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.

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

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

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

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

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

59. 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. 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. 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.

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

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

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

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 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.

61. 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 heating of the target.

D. Increase percentage of high-energy photons.

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

62. 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 increase 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 and II

B. III

C. I and III

D. II and III

E. I

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

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

E. 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.

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

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

D. All are true.

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.

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

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

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

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

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

B. 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.

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

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

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

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

D. Reduced number of high-energy photons.

E. Decrease the radiation dose to the patient.

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

A. None of the other answers is correct.

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

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

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

E. Move the object further from the detector.

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

A. All are true.

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

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

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

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.

70. 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. 0.1 m

C. 0.3 m

D. 0.9 m

E. 8.1 m

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

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

B. The risk of cancer increases with each scan.

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

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

E. Projection and tomographic images are both obtainable.

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

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

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

E. 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.

73. 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. I and III

C. II and III

D. I

E. I, II, and III.

74. 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, II, and III

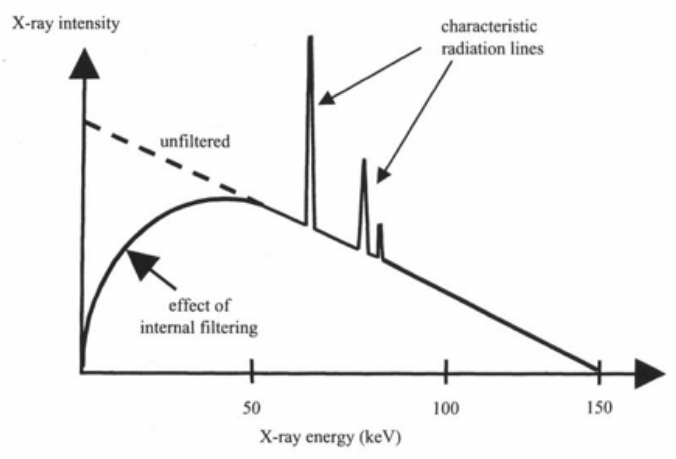
B. I

C. I and III

D. I and II

E. II and III

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



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

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

C. No change in the graph.

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

E. None of the other choices

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

E. All are true

77. 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, II

C. I and III

D. II and III

E. I

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

A. All are true

B. Fluoroscopy permits rapidly moving X-ray images.

C. 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.

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

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.

79. The following are all true about tomographic images, *except*

A. They are called 'tomographic' because *tomos* is Greek for 'slice'.

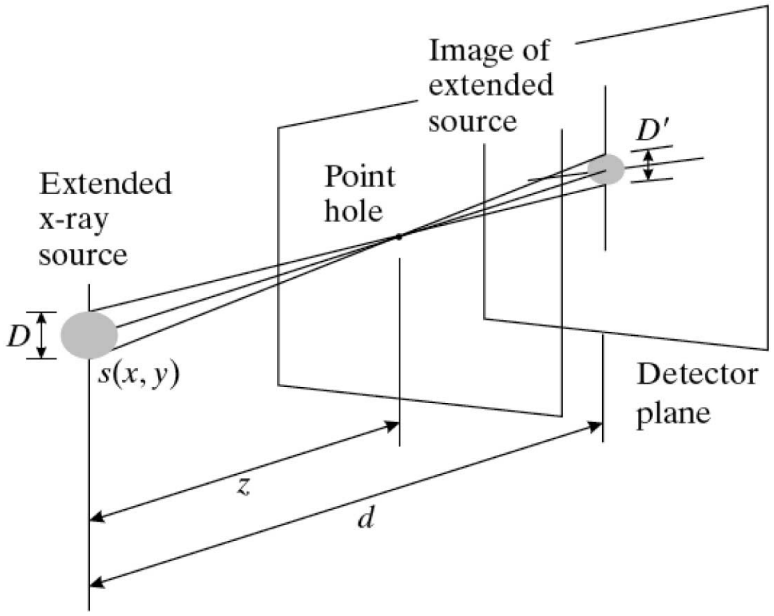
B. Examples of tomographic image modalities includes fluoroscopy and CT.

C. Each pixel represents a localized sample in space.

D. They can be coronal, sagittal, or axial.

E. 2D tomographic images may be subsets of 3D tomographic images.

80. In the following figure from the text, which of the following statements is *false*, or all are true?



A. All are true.

B. As z is reduced from d towards 0 the image gets blurrier.

C. It illustrates how, for a given value of z, the image represents a convolution of a scaled version of $s(x, y)$ with the transmittivity at each point in the object being imaged.

D. It illustrates how both source magnification and object magnification effect the image.

E. As z approaches d, the image of $s(x, y)$ through the point hole approaches an impulse function.

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

A. It relies on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

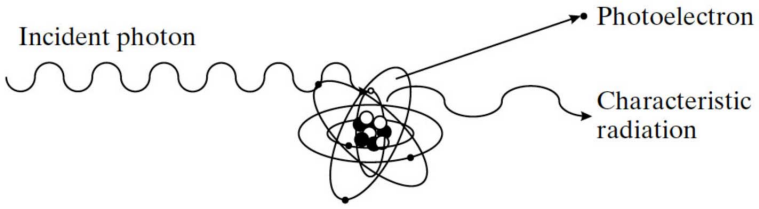
B. All are true.

C. It applies only to projections onto the x or y axes.

D. 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 orthogonal to the direction of the projection.

E. It allows us to perform image reconstruction using filtered backprojection in the frequency domain.

82. The following figure from the text represents which of the following?



A. Compton scatter.

B. Collision transfer.

C. Bremsstrahlung radiation.

D. Photoelectric effect.

E. None of the others.

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

I - Attenuation of x-rays within the body is the primary phenomenon resulting in image contrast.
II - Practical radiography depends upon *fluorescence* to produce light photons from x-ray photons.
III - Collimating grids reduce the number of Compton scattered photons reaching the detector and thus increase image contrast.

A. I and III

B. II and III

C. III

D. I and II

E. I, II and III

84. Which of the following statements about the following equation is *true* (or none is true)?

$$I(x,y) = \int_0^{E_{\max}} S_0(E')E' \exp\left\{-\int_0^{r(x,y)} \mu(s;E',x,y)ds\right\} dE'$$

where $r(x,y)$ is the length of the path,
$S_0(E)$ is spectrum of the incident x-rays,
s is the distance from the x-ray source along the path
and $I(x,y)$ is the intensity of x-rays remaining.

A. None of the others is true.

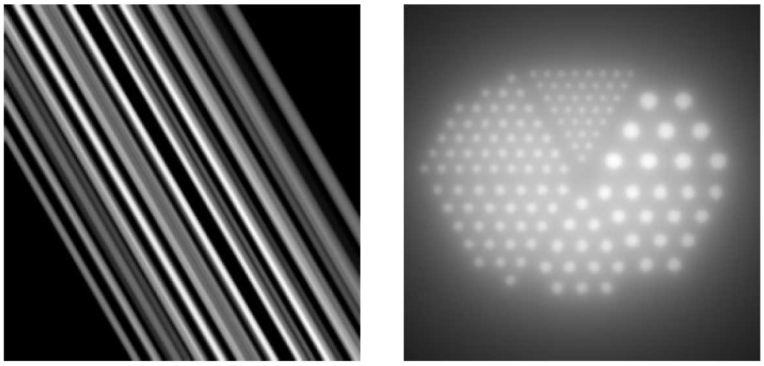
B. It represents attenuation of a monoenergetic x-ray source by a non-homogeneous structure.

C. It represents attenuation of a monoenergetic x-ray source by a homogeneous structure.

D. It represents attenuation of a polyenergetic x-ray source by a homogeneous structure.

E. It represents attenuation of a polyenergetic x-ray source by a non-homogeneous structure.

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



A. The figure on the right is the summation of many back projections.

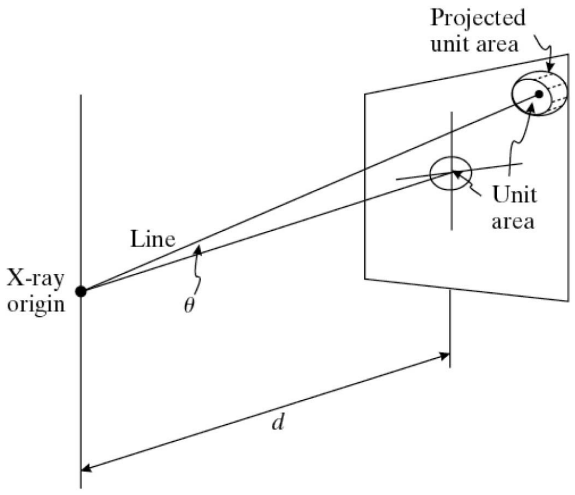
B. The figure on the right demonstrates a loss of high-frequency information.

C. All are true.

D. The figure on the right demonstrates the presence of a DC (average) value that is not in the original image.

E. The figure on the left is the back projection from a particular projection, representing the fact that one projection alone does not include information about where along the projection line the attenuation occurs.

86. The figure below shows a projection radiograph detector a distance d from an X-ray origin. In addition to the intensity falling off by a factor of d^2, it also falls off as a factor of $\cos^3\theta$, due to which of the following considerations?



I - The distance to points on the film is greater as θ increases.
II - The X-rays traveling along paths with greater θ arrive at the detector later.
III - The area projected by a given solid angle of the X-ray beam expands as θ increases.

A. I and III

B. I, II, and III

C. I

D. II and III

E. I, II

87. In a hydrogen atom, an electron in which orbital can absorb a photon, but cannot emit a photon?

A. 3s

B. 3f

C. 3p

D. 2s

E. 1s

88. Which of the following has a wavelength *shorter* than visible light?

A. Microwave.

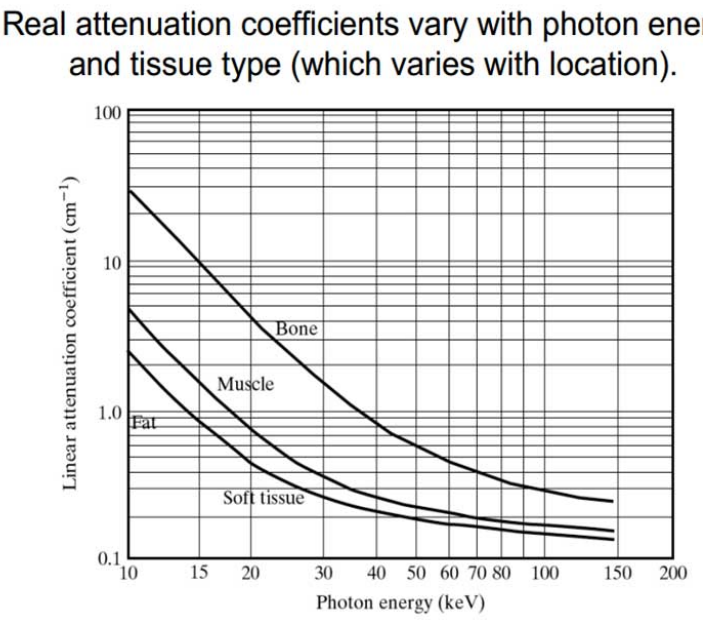
B. Radio waves.

C. X-rays.

D. None of the others have a wavelength shorter than visible light.

E. Infrared light.

89. Given the graph of the linear attenuation coefficient at different photon energies for different tissues, which of the following is *incorrect*?



A. Image contrast is low in the low energy case since the photons have less penetration.

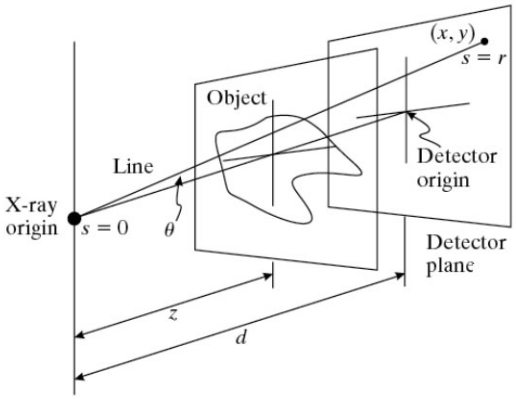
B. The patient radiation dose is high in low energy case because the body is highly absorbent to these x-ray photons.

C. The advantage of dual Energy is that it allows radiologists to view soft-tissue entities in images with the bones effectively removed.

D. Bone has the largest attenuation coefficients because calcium absorbs X-rays the most, so bones look bright on the conventional chest radiograph.

E. Air absorbs the least X-ray, so lungs look dark on the conventional chest radiograph.

90. The figure below shows a projection radiograph detector in a distance d from an X-ray origin. If we set the intensity of the X-ray origin as I_S and the intensity of detector origin as I_0, the intensity at an arbitrary point in the detector at (x, y) is given by $I_r = \frac{I_S}{4\pi d^2}\cos^3(\theta)$. Which of the following is *not* a contributing factor in this equation (or all are contributing factors)?



A. The inverse square law for the distance from the X-ray origin to the detector origin.

B. The inverse square law for the extra distance from the X-ray origin to point (x, y) if it is not at the detector origin

C. All are contributing factors.

D. Attenuation by the object between the source and detector.

E. The fact that a circular beam of radiation would project as an non-circular shape on the detector when (x, y) is not at the detector origin.

91. The following are all true about the attenuation coefficient μ as applied to x-rays, *except*

A. Variation in attenuation coefficient μ between tissue types makes it more difficult to create an x-ray image with high contrast.

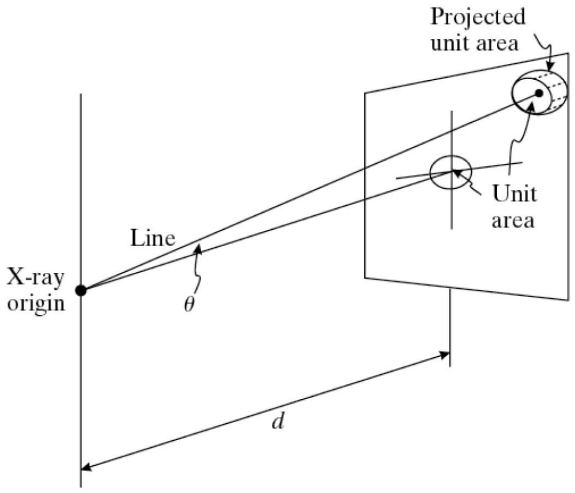
B. In reality, μ for a given tissue type is a function of x-ray photon energy E.

C. To use the Radon transform in CT, we make the assumption that all x-ray photons have an average energy $\overline{E}$, so we can make μ depend solely on location.

D. Assuming a homogeneous slab and a beam of monoenergetic photons perpendicular to the slab, we have a total attenuation of $e^{-\mu\Delta x}$ through a slab Δx thick.

E. Attenuations along the path of the x-ray beam are combined by multiplication, since they each represent a certain percentage (per unit length) of photons removed from the beam.

92. The figure below shows a projection radiograph detector a distance d from an X-ray origin. The intensity at the detector decreases by a factor of $\cos^3\theta$, due to which of the following considerations?



I - The distance to points on the detector is greater as θ increases, causing reduced intensity due to the inverse square law.
II - The angle at which the x-rays hit the detector is no longer perpendicular as θ increases, causing greater reflection of x-ray photons.
III - The area of the detector projected onto by a given solid angle of the X-ray beam expands as θ increases.

A. I, II, and III

B. II and III

C. I

D. I and III

E. I, II

93. Which of the following has an energy per photon *less* than infrared?

A. Gamma rays.

B. X-rays.

C. Visible light.

D. Microwave.

E. Ultraviolet light.

94. All of the following statements about exposure and dose are true, *except*

A. Radiation continues to be emitted from within the patient after the scan with nuclear medicine, but not with X-rays.

B. The average yearly dose from the background at sea level is greater than from a typical chest x-ray.

C. Effective dose, the unit that correlates most closely with the appearance of cancer, is determined solely by the number of ion pairs created in a gas-filled tube by high-energy photons.

D. Greater exposure causes greater likelihood, but not severity, of cancer

E. A latent period of decades may intercede between the scan and the appearance of cancer.

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

$$f(x,y) = \int_0^{\pi} \int_{-\infty}^{\infty} |\varrho| G(\varrho,\theta) e^{j2\pi\varrho(x\cos\theta + y\sin\theta)}\, d\varrho\, d\theta$$

A. All are true.

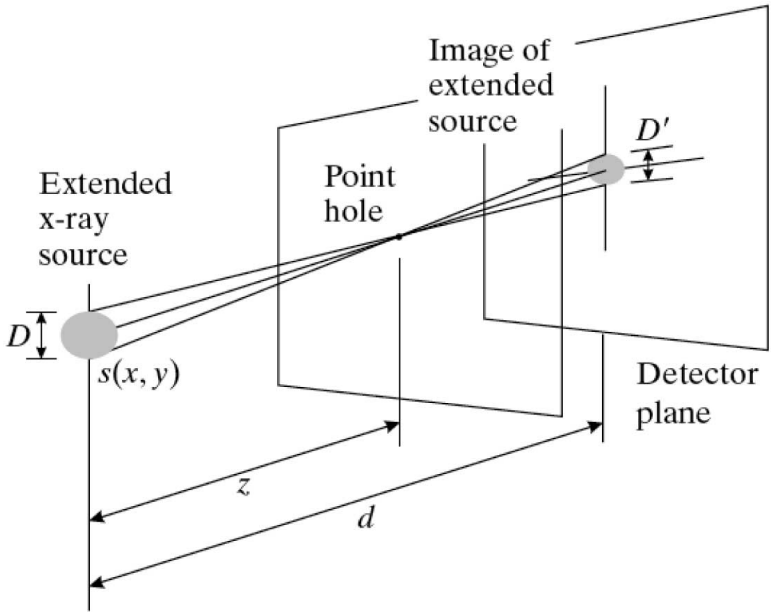
B. It represents filtered back-projection.

C. This is an inverse Radon transform.

D. The ϱ symbol represents the distance from the origin in the 2D Fourier transform in units of spatial frequency.

E. $G(\varrho,\theta)$ is the 1D Fourier transform a particular projection through $f(x,y)$.

96. In the following figure from the text, which of the following statements is *false*, or all are true?



A. It illustrates how, for a given value of z, the image represents a convolution of a scaled version of $s(x,y)$ with the transmittivity at each point in the object being imaged.

B. It illustrates how both source magnification and object magnification effect the image.

C. All are true.

D. As z is reduced from d towards 0 the image gets blurrier.

E. As z approaches 0, the image of $s(x,y)$ through the point hole approaches an impulse function.

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BioE 1330 - Review Chapters 4, 5, and 6 (X-ray and CT) 9/27/2018
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?

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

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

C. The filtering removes X-rays with undesirable frequencies.

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 emphasize 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. 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*]

17. 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*]

18. 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*]

19. 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*]

20. 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*]

21. 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*]

22. 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*]

23.

A. B. C. D. E.

Explanation:
[*imaging0111.mcq*]

24. 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*]

25. 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*]

26. 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*]

27. 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*]

28. 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*]

29. 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

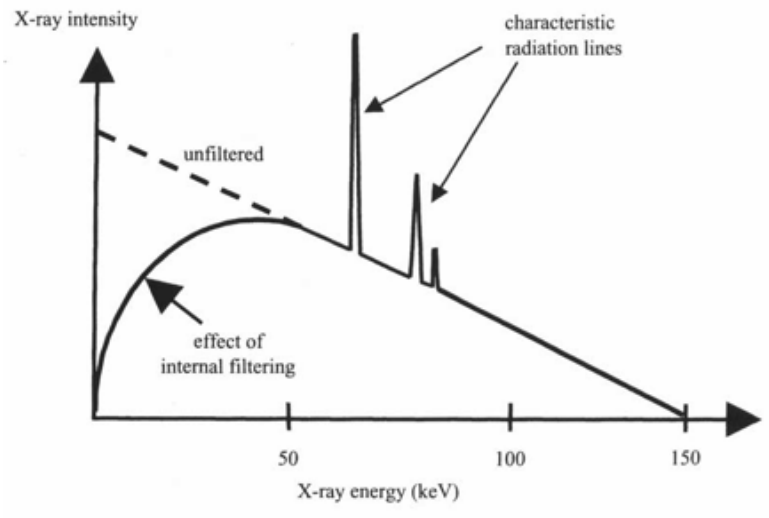
C. I and III

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*]

30. In the graph 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*]

31. With reference to the graph 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*]

32. With reference to the graph 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 fewer photons are coming per second.
[*imaging0161.mcq*]

33. 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*]

34. 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*]

35. 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: The 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*]

36. 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*]

37. 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%

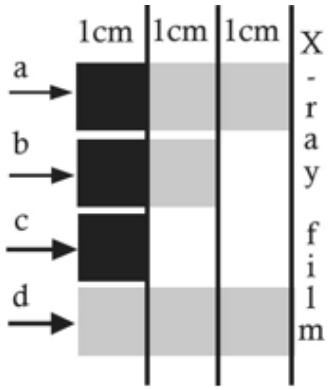
C. Less than 1%

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*]

38. 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*]

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

A. All are true.

B. It says that the 1D Fourier transform of the projection of an image equals a line passing through the origin of the 2D Fourier transform of that image, at the same angle as the 1D projection.

C. It is central to image reconstruction in CT.

D. It is related to the Radon transform.

E. It under-represents higher frequencies, producing a blurred backprojection, requiring an additional filtering step.

Explanation: All are true.
[*imaging0172.mcq*]

40. 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*]

41. 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*]

42. 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*]

43. 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*]

44. 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*]

45. 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*]

46. 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*]

47. 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*]

48. 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*]

49. 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*]

50. 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*]

51. 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*]

52. 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*]

53. 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*]

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

A. All are true.

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

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

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

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

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

55. 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*]

56. 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*]

57. 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*]

58. 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*]

59. 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*]

60. 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*]

61. 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*]

62. 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 increase 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 *fluorescence* to produce light photons from x-ray photons.
[*imaging0290.mcq*]

63. 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*]

64. 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*]

65. 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*]

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

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

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

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

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

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

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

67. 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*]

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

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

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

C. Move the object further from the detector.

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

E. None of the other answers is correct.

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

69. 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*]

70. 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*]

71. 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*]

72. 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*]

73. 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*]

74. 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

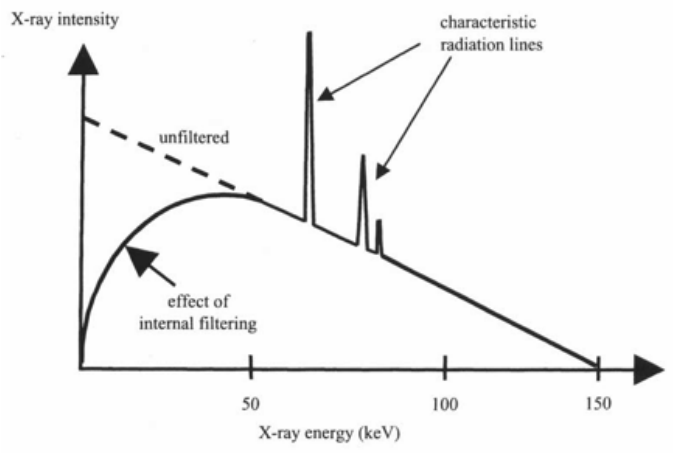
C. I and II

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*]

75. 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*]

76. 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*]

77. 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*]

78. 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*]

79. The following are all true about tomographic images, *except*

A. Examples of tomographic image modalities includes fluoroscopy and CT.

B. They can be coronal, sagittal, or axial.

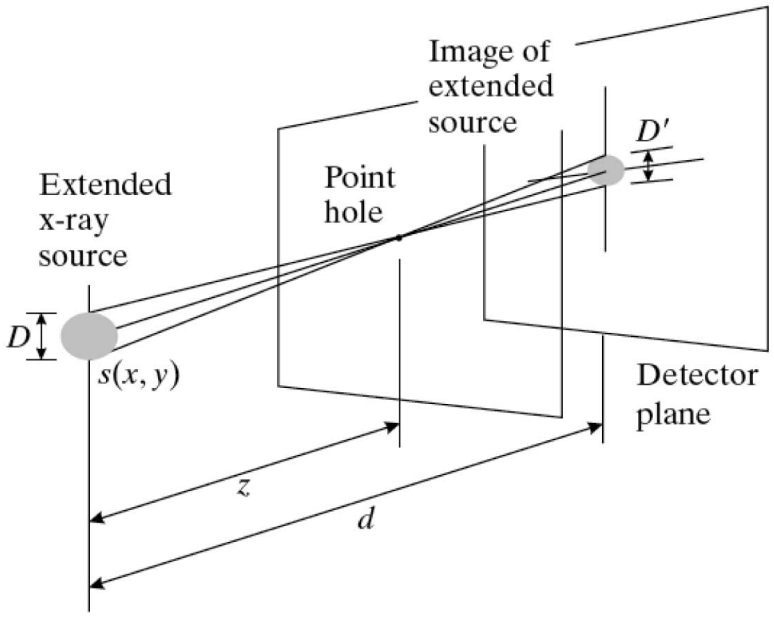
C. Each pixel represents a localized sample in space.

D. They are called 'tomographic' because *tomos* is Greek for 'slice'.

E. 2D tomographic images may be subsets of 3D tomographic images.

Explanation: Fluoroscopy is a projection imaging modality.
[*imaging0388.mcq*]

80. In the following figure from the text, which of the following statements is *false*, or all are true?



A. All are true.

B. It illustrates how, for a given value of z, the image represents a convolution of a scaled version of $s(x, y)$ with the transmittivity at each point in the object being imaged.

C. It illustrates how both source magnification and object magnification effect the image.

D. As z approaches d, the image of $s(x, y)$ through the point hole approaches an impulse function.

E. As z is reduced from d towards 0 the image gets blurrier.

Explanation:
[*imaging0407.mcq*]

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

A. It applies only to projections onto the x or y axes.

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 orthogonal to the direction of the projection.

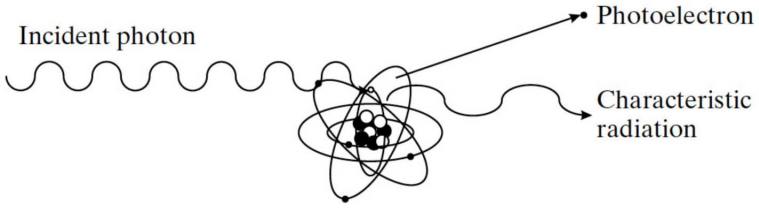
C. All are true.

D. It relies on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

E. It allows us to perform image reconstruction using filtered backprojection in the frequency domain.

Explanation: Because of answer D, answer A is false. Projections in any direction result in what is stated in answer B.
[*imaging0408.mcq*]

82. The following figure from the text represents which of the following?



A. Photoelectric effect.

B. Compton scatter.

C. Collision transfer.

D. Bremsstrahlung radiation.

E. None of the others.

Explanation: Answers C and D involve bombardment by electrons, not photons. Answer B produces a scattered "Compton" photon.
[*imaging0409.mcq*]

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

I - Attenuation of x-rays within the body is the primary phenomenon resulting in image contrast.
II - Practical radiography depends upon *fluorescence* to produce light photons from x-ray photons.
III - Collimating grids reduce the number of Compton scattered photons reaching the detector and thus increase image contrast.

A. I, II and III

B. I and III

C. II and III

D. I and II

E. III

Explanation: All are true.
[*imaging0410.mcq*]

84. Which of the following statements about the following equation is *true* (or none is true)?

$$I(x,y) = \int_0^{E_{\max}} S_0(E')E' \exp\left\{-\int_0^{r(x,y)} \mu(s;E',x,y)ds\right\} dE'$$

where $r(x,y)$ is the length of the path,
$S_0(E)$ is spectrum of the incident x-rays,
s is the distance from the x-ray source along the path
and $I(x,y)$ is the intensity of x-rays remaining.

A. It represents attenuation of a polyenergetic x-ray source by a non-homogeneous structure.

B. It represents attenuation of a monoenergetic x-ray source by a non-homogeneous structure.

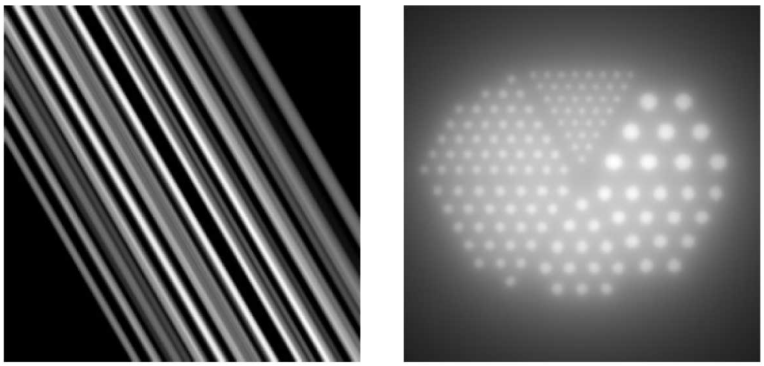
C. It represents attenuation of a polyenergetic x-ray source by a homogeneous structure.

D. It represents attenuation of a monoenergetic x-ray source by a homogeneous structure.

E. None of the others is true.

Explanation: The equation includes a double integration, one over the x-ray spectrum and one along the individual paths through a non-homogeneous structure.
[*imaging0411.mcq*]

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



A. All are true.

B. The figure on the left is the back projection from a particular projection, representing the fact that one projection alone does not include information about where along the projection line the attenuation occurs.

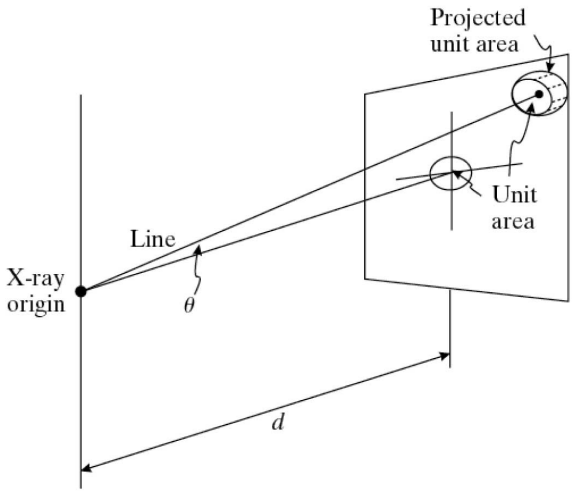
C. The figure on the right is the summation of many back projections.

D. The figure on the right demonstrates a loss of high-frequency information.

E. The figure on the right demonstrates the presence of a DC (average) value that is not in the original image.

Explanation: Both D and E are true, leading to the use of filtering before backprojection.
[*imaging0412.mcq*]

86. The figure below shows a projection radiograph detector a distance d from an X-ray origin. In addition to the intensity falling off by a factor of d^2, it also falls off as a factor of $\cos^3\theta$, due to which of the following considerations?



I - The distance to points on the film is greater as θ increases.
II - The X-rays traveling along paths with greater θ arrive at the detector later.
III - The area projected by a given solid angle of the X-ray beam expands as θ increases.

A. I and III

B. I, II

C. II and III

D. I, II, and III

E. I

Explanation: While II is true, the difference is minuscule and does not account for the factor of $\cos^3\theta$ fall-off in intensity.
[*imaging0413.mcq*]

87. In a hydrogen atom, an electron in which orbital can absorb a photon, but cannot emit a photon?

A. 1s

B. 2s

C. 3p

D. 3s

E. 3f

Explanation: The 1s orbital is the lowest energy orbital, so there is nowhere for the electron to drop to and emit a photon.
[*imaging0436.mcq*]

88. Which of the following has a wavelength *shorter* than visible light?

A. X-rays.

B. Radio waves.

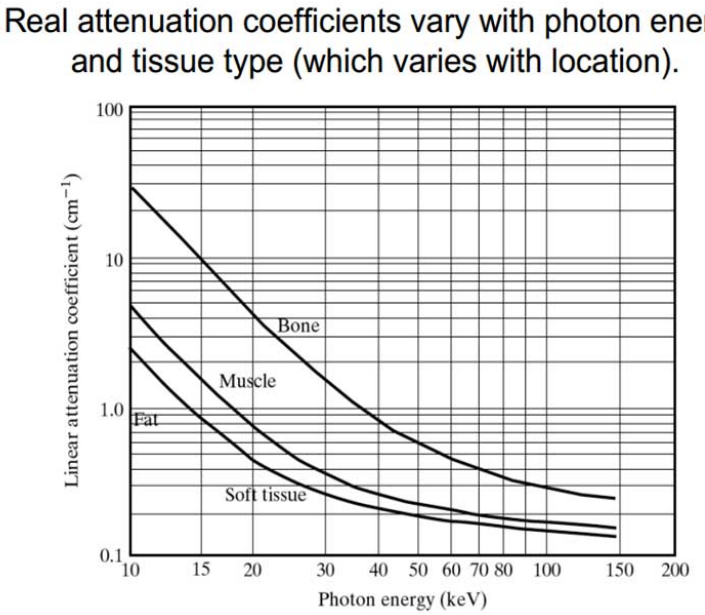
C. Microwave.

D. Infrared light.

E. None of the others have a wavelength shorter than visible light.

Explanation: Shorter wavelength means higher frequency and higher energy. Only X-rays qualify.
[*imaging0438.mcq*]

89. Given the graph of the linear attenuation coefficient at different photon energies for different tissues, which of the following is *incorrect*?



A. Image contrast is low in the low energy case since the photons have less penetration.

B. Air absorbs the least X-ray, so lungs look dark on the conventional chest radiograph.

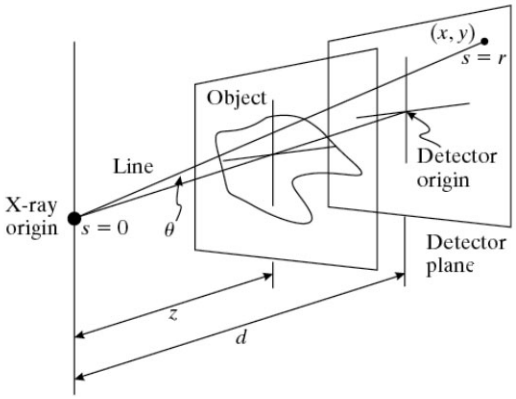
C. Bone has the largest attenuation coefficients because calcium absorbs X-rays the most, so bones look bright on the conventional chest radiograph.

D. The patient radiation dose is high in low energy case because the body is highly absorbent to these x-ray photons.

E. The advantage of dual Energy is that it allows radiologists to view soft-tissue entities in images with the bones effectively removed.

Explanation: Image contrast is high in the low energy case.
[*imaging0439.mcq*]

90. The figure below shows a projection radiograph detector in a distance d from an X-ray origin. If we set the intensity of the X-ray origin as I_S and the intensity of detector origin as I_0, the intensity at an arbitrary point in the detector at (x, y) is given by $I_r = \frac{I_S}{4\pi d^2}\cos^3(\theta)$. Which of the following is *not* a contributing factor in this equation (or all are contributing factors)?



A. Attenuation by the object between the source and detector.

B. The inverse square law for the distance from the X-ray origin to the detector origin.

C. The inverse square law for the extra distance from the X-ray origin to point (x, y) if it is not at the detector origin

D. The fact that a circular beam of radiation would project as an non-circular shape on the detector when (x, y) is not at the detector origin.

E. All are contributing factors.

Explanation: Attenuation by the object is not included in the given equation.
[*imaging0443.mcq*]

91. The following are all true about the attenuation coefficient μ as applied to x-rays, *except*

A. Variation in attenuation coefficient μ between tissue types makes it more difficult to create an x-ray image with high contrast.

B. In reality, μ for a given tissue type is a function of x-ray photon energy E.

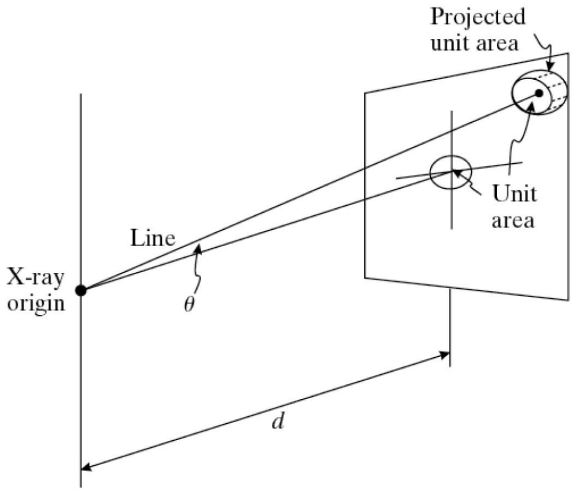
C. To use the Radon transform in CT, we make the assumption that all x-ray photons have an average energy $\overline{E}$, so we can make μ depend solely on location.

D. Assuming a homogeneous slab and a beam of monoenergetic photons perpendicular to the slab, we have a total attenuation of $e^{-\mu\Delta x}$ through a slab Δx thick.

E. Attenuations along the path of the x-ray beam are combined by multiplication, since they each represent a certain percentage (per unit length) of photons removed from the beam.

Explanation: Variation in attenuation coefficient μ between tissue types accounts for the contrast between tissues in an x-ray.
[*imaging0469.mcq*]

92. The figure below shows a projection radiograph detector a distance d from an X-ray origin. The intensity at the detector decreases by a factor of $\cos^3\theta$, due to which of the following considerations?



I - The distance to points on the detector is greater as θ increases, causing reduced intensity due to the inverse square law.
II - The angle at which the x-rays hit the detector is no longer perpendicular as θ increases, causing greater reflection of x-ray photons.
III - The area of the detector projected onto by a given solid angle of the X-ray beam expands as θ increases.

A. I and III

B. I, II

C. II and III

D. I, II, and III

E. I

Explanation: Answer II is not true. Reflection of x-rays is not dependent upon angle in incidence upon the detector surface.
[*imaging0470.mcq*]

93. Which of the following has an energy per photon *less* than infrared?

A. Microwave.

B. X-rays.

C. Gamma rays.

D. Ultraviolet light.

E. Visible light.

Explanation: Only microwave and radio have longer wavelengths (less energy per photon) than infrared.
[*imaging0471.mcq*]

94. All of the following statements about exposure and dose are true, *except*

A. Effective dose, the unit that correlates most closely with the appearance of cancer, is determined solely by the number of ion pairs created in a gas-filled tube by high-energy photons.

B. Radiation continues to be emitted from within the patient after the scan with nuclear medicine, but not with X-rays.

C. The average yearly dose from the background at sea level is greater than from a typical chest x-ray.

D. Greater exposure causes greater likelihood, but not severity, of cancer

E. A latent period of decades may intercede between the scan and the appearance of cancer.

Explanation: Effective dose takes into account the type of high-energy photon, as well as the particular tissue involved.
[*imaging0472.mcq*]

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

$$f(x,y) = \int_0^{\pi} \int_{-\infty}^{\infty} |\varrho| G(\varrho,\theta) e^{j2\pi\varrho(x\cos\theta + y\sin\theta)}\, d\varrho\, d\theta$$

A. All are true.

B. It represents filtered back-projection.

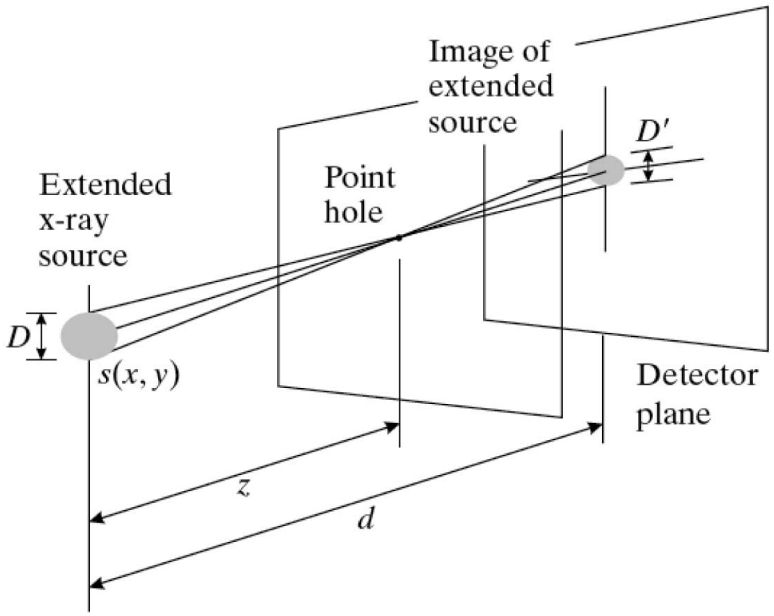
C. The ϱ symbol represents the distance from the origin in the 2D Fourier transform in units of spatial frequency.

D. $G(\varrho,\theta)$ is the 1D Fourier transform a particular projection through $f(x,y)$.

E. This is an inverse Radon transform.

Explanation:
[*imaging0494.mcq*]

96. In the following figure from the text, which of the following statements is *false*, or all are true?



A. As z approaches 0, the image of $s(x, y)$ through the point hole approaches an impulse function.

B. It illustrates how, for a given value of z, the image represents a convolution of a scaled version of $s(x, y)$ with the transmittivity at each point in the object being imaged.

C. It illustrates how both source magnification and object magnification effect the image.

D. All are true.

E. As z is reduced from d towards 0 the image gets blurrier.

Explanation: As z approaches d, the image of $s(x, y)$ through the point hole approaches an impulse function.
[*imaging0498.mcq*]