

**BioE 1330 - Exam 2**      2/28/2011  
**Answer Sheet - Correct answer is A for all questions**

1. 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* ]

2. 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* ]

3. 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* ]

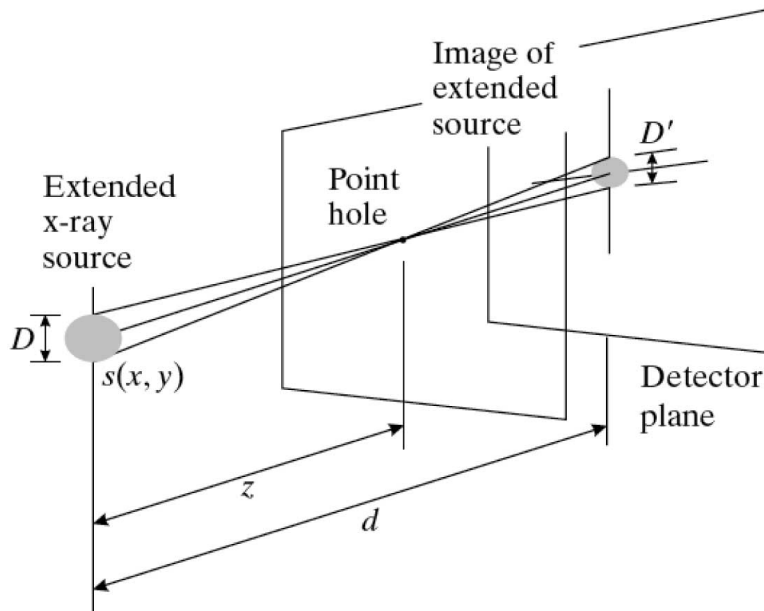
4. Which of the following is *false* about the 2D Radon Transform (or all are true)?

- 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* ]

5. 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* ]

6. 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* ]

7. 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 electrons. Magnetic fields can only exert forces on moving electrons. The other statements are all true.

[ *imaging0039.mcq* ]

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

- A. It applies only to projections onto the  $x$  and  $y$  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* ]

9. 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* ]

10. 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* ]

11. 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* ]

12. 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* ]

13. 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* ]

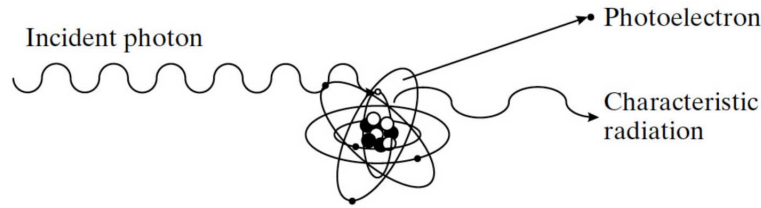
14. For a point source of radiation, the exposure at a distance  $d$  from the source follows an inverse square law. If the exposure at  $d = 3$  cm from point source is 36 R, what is the exposure at  $d = 18$  cm from the source?

- 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* ]

15. 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* ]

16. 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* ]

17. 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* ]

18. 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* ]

19. 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* ]

20. 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* ]

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

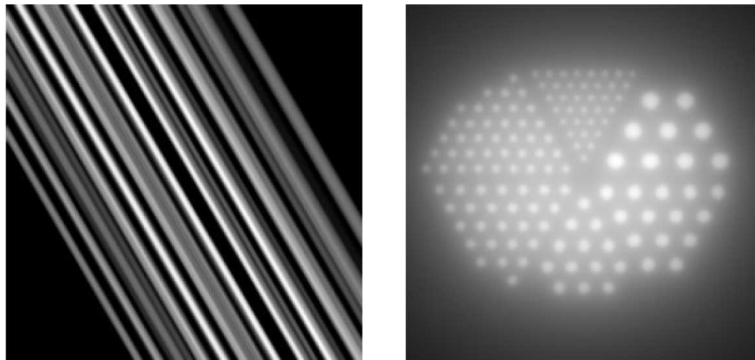
- I - item fat
- II - item muscle
- III - air
- IV - lead
- V - bone

- 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* ]

22. 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* ]

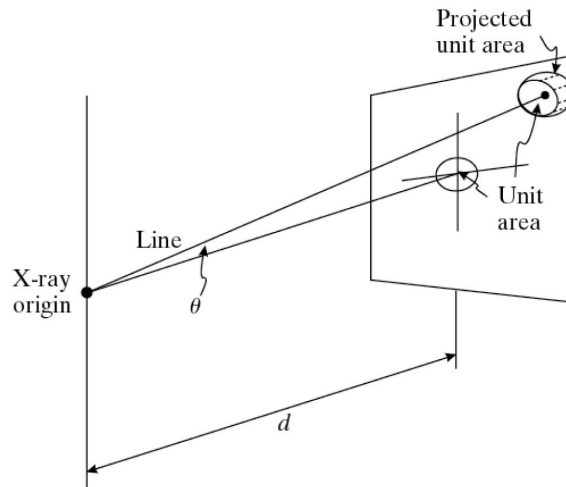
23. All of the following statements about artifacts in CT are true, *except*:

- 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* ]

24. 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  $\theta$  increases.
- II - The X-rays traveling along paths with greater  $\theta$  arrive at the detector later.
- III - The area projected by a given solid angle of the X-ray beam expands as  $\theta$  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* ]

25. 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* ]