

Medical Equipment II Term Exam – May 2008

Solve as Much as You Can – Maximum Grade: 50 Points

Q1. Answer the following questions by marking the best answer among the choices given (3 points each):

1. The slice selection process relies on applying a ... during RF pulse transmission.
 - a. Magnetic field gradient (*)
 - b. Static magnetic field
 - c. Magnetic dipole moment
2. The bandwidth of the applied RF pulse in slice selection determines ...
 - a. Slice location
 - b. Slice thickness (*)
 - c. Slice flip angle
3. Applying a magnetic field gradient during reception results in ... of the signal from different spatial locations.
 - a. Slice selection
 - b. Frequency encoding (*)
 - c. Relaxation
4. Static fields used in MRI are in the Tesla range to ensure ...
 - a. Single direction for the net magnetization
 - b. High uniformity of magnetic field
 - c. High signal-to-noise ratio of the received MR signal (*)
5. The maximum pulse repetition frequency of an ultrasound system used to image a field of view of depth 10 cm is ...
 - a. 7700 (*)
 - b. 15400
 - c. 30800
6. The spatial resolution (defined as half the spatial pulse length) of an ultrasound system with a pulse length of 300 ns is ...
 - a. 0.23 mm (*)
 - b. 0.46 mm
 - c. 0.92 mm
7. Received signal in MRI represent the component of the net magnetization in the ...
 - a. Equilibrium ground state position
 - b. Transverse (x-y) plane (*)
 - c. Longitudinal (z) direction
8. The Larmor frequency of Hydrogen nuclei at 1.5T is approximately ...
 - a. 64 MHz (*)
 - b. 96 MHz
 - c. 128 MHz
9. Bremsstrahlung involves ...
 - a. Braking or deceleration of moving electrons (*)
 - b. Emission of electrons when a photon is absorbed
 - c. An electron and a positron interacting to generate gamma radiation
10. If the fluorescence yield is 0.1, the Auger yield is ...
 - a. 0.01
 - b. 0.1
 - c. 0.9 (*)
11. Interaction total cross section from multiple mechanisms such as photoelectric effect and Compton scattering is ...
 - a. The vector sum of all cross sections.
 - b. The geometric mean of all cross section.
 - c. The sum of all individual cross sections. (*)
12. Energy fluence rate from a Lambertian surface is ...
 - a. direction-independent (*)
 - b. source-independent

- c. wavelength-independent
- 13. In deriving the wave equation in solids, the following parameter is used ...
 - a. Young's modulus (*)
 - b. Compressibility
 - c. Viscosity
- 14. Absorption of near infrared light in blood depends on ...
 - a. Wavelength
 - b. Blood oxygenation level
 - c. Both of the above (*)
- 15. Pauli exclusion principle states that ...
 - a. The interactions that take place in one atom may not occur at the same time.
 - b. No two electrons in an atom can have the same values for all their quantum numbers. (*)
 - c. The probability of having a net magnetization without an external magnetic field is remote.
- 16. Interaction cross section defines ...
 - a. The area in front of the main beam
 - b. The probability of that particular interaction taking place (*)
 - c. The area in front of the broad beam including scattering
- 17. The main tissue property behind B-mode imaging is ...
 - a. Acoustic impedance (*)
 - b. Speed of ultrasound
 - c. Attenuation
- 18. The time for ultrasound to travel back and forth through 1 cm of human soft tissues is ...
 - a. 26 μ s
 - b. 13 μ s (*)
 - c. 6.5 μ s
- 19. To produce an $N \times N$ CT image, we need to have at least ... equations.
 - a. 2 N
 - b. $N \log N$
 - c. N^2 (*)
- 20. Traveling acoustic waves have ...
 - a. Locations with zero field regardless of the time.
 - b. Locations with zero field at periodic time intervals. (*)
 - c. Locations with peak field magnitude regardless of time.
- 21. Optical coherence tomography practically measures range using ...
 - a. Time delay measurement
 - b. coherence measurement between the received wave and a reference wave (*)
 - c. IR absorption measurement
- 22. The blackbody radiation function is ...
 - a. 1
 - b. 0
 - c. Dependent on λ (*)
- 23. When an acoustic wave reaches a soft-tissue / air interface ...
 - a. Almost total reflection occurs (*)
 - b. It is significantly attenuated
 - c. Its frequency changes
- 24. A nearsighted person whose relaxed eye focuses at a distance of 0.4 m needs a corrective lens of strength ... diopters.
 - a. 2
 - b. 2.5
 - c. -2.5 (*)

Q2. Mark the following statement as either True (T) or False (F) (1.5 point each):

- 1. Low frequency ultrasound offer lower spatial resolution **(T)**
 - 2. The radiation energy from a heated atom show splitting when atoms are brought closer together (T)
 - 3. Infant incubator rooms should not have glass windows to prevent cooling through window (T)
 - 4. Human hearing has a frequency-dependent response (T)
 - 5. The energy exchange with nuclei occurs only at the Larmor frequency. (T)
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6. Larmor frequency can be different from one location to another for the same nuclei. (T)
7. High magnetic field MR systems use permanent static field magnets (F)
8. It is possible to measure the net magnetization vector only when it is in the same direction as the static magnetic field. (F)
9. Algebraic reconstruction technique provide better image reconstruction than backprojection technique (T)
10. Laboratory frame of reference rotates at the Larmor frequency to see the net magnetization vector stationary. (F)
11. The photoelectric effect involves the emission of an Auger electron with a kinetic energy after absorbing a photon. (F)
12. After the photoelectric effect, fluorescence has a probability of taking place. (T)
13. Pair production is the main photon interaction mechanism of interest for x-ray imaging. (F)
14. Acceleration or deceleration of moving electrons produces photons. (T)
15. The cross section of the photoelectric effect is photon energy dependent. (T)
16. Photon interactions involving scattering of photons are desirable for imaging purposes. (F)
17. To estimate the heating effects of light, the bioheat equation is solved. (T)
18. Low doses of ultraviolet light damages the eye because of its heating effects. (F)
19. Raman scattering of IR light involves scattered photons that do not have same original energy as the incident. (T)
20. Astigmatism can be corrected with a spectacle lens that is symmetric about an axis through the center of the eye lens. (F)

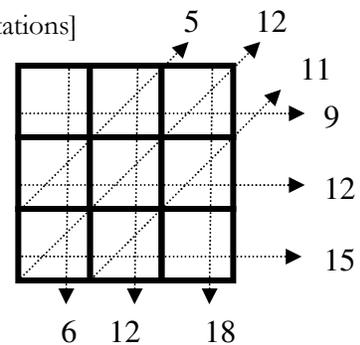
1. [5 Points] Solve the following reconstruction problem using (a) ART and (b) Backprojection.

[Hint: perform only a single iteration of each technique and show your computations]

1 3 5
2 4 6
3 5 7

3 3 3
4 4 4
5 5 5

1 3 5
2 4 6
3 5 7



Q3. [5 points] Estimate the signal-to-noise ratio (SNR) advantage of using a 3T magnetic field over that of 1.5T. Assume the noise in the two cases is the same and therefore the ratio $SNR_{3T}/SNR_{1.5T}$ is the ratio of the signals. [Hint: the signal in MRI is proportional to the net magnetization]

1. compute Boltzmann ratio for the two field strengths
2. Compute the difference between the two directions in each given that their total probability is one (i.e., along with the Boltzmann ratio you can compute their percentage of the total number of spins in the sample).
3. The signal is basically proportional to the net number of spins (i.e., number of spins in the direction along the magnet - that in the opposite direction), which is the total number of spins in the sample (N_0) x probability (P) for each strength. N_0 is unknown.
4. The $SNR_3/SNR_{1.5} = (S_3/N_1) / (S_{1.5}/N_2)$ (with $N_1=N_2$) = $S_3/S_{1.5} = P(3)/P(1.5)$

Q: How many photons per second enter the eye from a 100 W light bulb located 10 m away? Assume the pupil is 6 mm in diameter. Use an efficiency of 17 lumens/W and assume an equivalent light source at 555 nm.

This problem is very similar to another given in the problem assignments.

Best of Luck