



Ultrasound Bioinstrumentation (SBME 606) Term Exam

January 2010

Solve As Much As You Can – Maximum Grade: 80 Points

Part I: Multiple Choice Questions [1point each]

1. Ultrasound field from a focused array of transducers can be computer by ...
 - a. Fresnel formula
 - b. Fraunhofer formula (*)
 - c. Fourier transformation
2. The effect of aperture apodization is to ...
 - a. Suppress side lobes magnitude
 - b. Increase main lobe width
 - c. Both of the above (*)
3. Phase aberration correction has a great value when the imaging in ... media.
 - a. Homogeneous
 - b. Inhomogeneous (*)
 - c. Scattering
4. M-mode acquires and displays ... with time.
 - a. A single B-mode line (*)
 - b. A sample volume
 - c. An azimuthal line
5. Doppler-mode computes and displays a spectrogram from ... with time.
 - a. A single B-mode line
 - b. A sample volume (*)
 - c. An azimuthal line
6. Parseval's theorem means that ...
 - a. Energy can be computed from either the spatial or spatial frequency domains. (*)
 - b. Area of spatial domain can be computed from spatial frequency domains.
 - c. Standard deviation of spatial domain is the same as that of the spatial frequency domain.
7. To detect a Doppler shift of 1 KHz using PW-Doppler with ultrasound center frequency of 5 MHz without aliasing, the pulse repetition rate should not be less than ...
 - a. 2 kHz (*)
 - b. 2 MHz
 - c. 10 MHz
8. Phase array ultrasound imaging probes generate sector images using ...
 - a. Focusing
 - b. Steering (*)
 - c. Mechanical motion
9. 4D ultrasound imaging means ...
 - a. Two perpendicular 2D slices spanning a volume.
 - b. Volume imaging with time. (*)
 - c. Image display with time and frequency.

10. The shown ultrasound image is for ...
 - a. B-mode ultrasound (*)
 - b. Color flow mapping
 - c. Triplex mode
11. In expanding aperture ultrasound beamforming (ultrasound system with 32 channel aperture, element width=0.5 mm, and kerf=0.1mm, center frequency= 3.5 MHz, target F#=2, and a field of view depth of 20 cm), the number of active elements at a depth of 10 cm will be ...
 - a. 8 elements
 - b. 16 elements
 - c. 32 elements (*)
12. Phase aberration correction methods rely mainly on ...
 - a. Correlation (*)
 - b. Interpolation
 - c. Focusing and steering delay terms
13. Harmonic imaging is preferred because it offers better ... than fundamental frequency.
 - a. axial resolution
 - b. azimuthal resolution (*)
 - c. elevation resolution
14. Concurrent multi-line acquisition is utilized in ultrasound imaging to obtain ...
 - a. Better SNR (*)
 - b. Better spatial resolution
 - c. Better beam pattern
15. Scalar diffraction theory is valid for medical ultrasound imaging because ...
 - a. Observations are near and aperture is large compared to wavelength
 - b. Observations are far and aperture is small compared to wavelength
 - c. Observations are far and aperture is large compared to wavelength (*)
16. The computation of the beam in the near field of a focused aperture is done using ...
 - a. Fresnel formula
 - b. Fraunhofer formula (*)
 - c. Huygen's principle
17. It is not very useful to increase the number of channels beyond 128 elements due to ...
 - a. Errors from phase aberration (*)
 - b. Cost increases a lot beyond 128 elements
 - c. Size of system becomes too big
18. Apodization serves to ...
 - a. Increase main lobe magnitude
 - b. Decrease side lobe magnitude (*)
 - c. Increase main lobe width
19. Effect of grating lobes can be suppressed by controlling ... of array probe.
 - a. Kerf (*)
 - b. Element width
 - c. Element height
20. Dynamic focusing offers ... for each point.
 - a. Accurate receive focusing (*)
 - b. Accurate transmit focusing
 - c. Accurate transmit and receiving focusing

21. Acquiring an ultrasound image with 4 transmit focal zones result in ...
 - a. Better axial resolution
 - b. Better image uniformity
 - c. Reduced frame rate (*)
22. Phase array differs from linear array in that it has ...
 - a. A number of elements equal to the beamformer number of channels (*)
 - b. A number of elements much higher than the beamformer number of channels
 - c. Elements much closer together
23. The main source of useful signal information in Doppler ultrasound is ...
 - a. Reflection from blood vessel walls
 - b. Scattering from RBCs (*)
 - c. Reflection from blood flow
24. Coded excitation can be used to ...
 - a. Improve lateral resolution
 - b. Lower grating lobes
 - c. Increase penetration depth (*)
25. Ultrasound beam compounding is used to ...
 - a. Suppress speckle (*)
 - b. Increase SNR
 - c. Increase spatial resolution
26. 2D ultrasound imaging arrays are used to allow ...
 - a. Better elevation beamforming (*)
 - b. Better lateral imaging
 - c. Better axial beamforming
27. Hadamard encoding is simple to use because ...
 - a. It has a simple decoding process
 - b. It is easy to implement in hardware
 - c. Both of the above (*)
28. Doppler formula for many randomly positioned scatterers in the blood is derived using ...
 - a. Doppler shift formula integration
 - b. Central limit theorem (*)
 - c. Fourier transformation
29. In the Doppler spectrogram, there is a trade-off between ...
 - a. Time and frequency resolutions (*)
 - b. Pulse repetition period and frequency resolution
 - c. Doppler pulse length and time resolution
30. Clutter in Doppler ultrasound can be removed by using ...
 - a. High-pass filter. (*)
 - b. Low-pass filter.
 - c. Band-reject filter.
31. In color flow mapping, the main technique used to compute the mean velocity is ...
 - a. Fourier transformation
 - b. Cross-correlation method (*)
 - c. Doppler shift

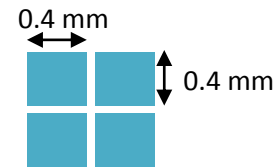
32. Laproscopic application in ultrasound imaging is used to ...
- Imaging of the interior of arteries and veins
 - Imaging of internal organs
 - Guide and evaluate laparoscopic surgery (*)
33. Multi-frequency probes use ...
- Different center frequencies/bandwidth within the probe bandwidth (*)
 - Different probe center frequencies/bandwidth beyond probe bandwidth
 - Harmonics of the probe center frequency.
34. The intensity of the B-mode ultrasound image corresponds to ...
- Received signal after beamforming
 - Envelope of received signal after beamforming (*)
 - Quadrature demodulated beams after beamforming
35. Speckle pattern differs from noise in that ...
- It has a courser size components
 - It cannot be removed by averaging (*)
 - It does not vary from one location to another

Part II: True/False Questions [½ point each]

36. The Doppler effect is a scaling of the transmitted wave. (T)
37. The beamforming delay value for steering is quadratic across the aperture. (F)
38. It is possible to compute the local spatial frequency of an image. (T)
39. The transfer function of a linear system is defined only for spatially-invariant systems. (T)
40. Multiple probe connectors in ultrasound machines allow simultaneous multiple imaging modes such as B/D mode. (F)
41. Variation of sample volume is possible in PW-Doppler. (T)
42. The quality of ultrasound images depends linearly on the number of beamformer channels. (F)
43. It is not possible to compute the Doppler spectrogram from a single excitation. (T)
44. Ultrasound imaging uses electromagnetic waves in the MHz range. (F)
45. Array probes are used to send and receive ultrasound at the same time. (F)
46. Expanding aperture is used in transmit beamforming to improve beam shape. (F)
47. It is possible to describe any ultrasound aperture in terms of a summation of plane wave components. (T)
48. Ultrasound wave propagation can be described as a nonlinear filter of input aperture. (F)
49. Fresnel formula is the paraxial approximation to free space propagation transfer function. (T)
50. Rectangular window is used for apodization in many ultrasound imaging systems. (F)
51. Grating lobes are problematic for single crystal mechanical transducers. (F)
52. Static focusing is simpler to implement than dynamic focusing in ultrasound beamforming. (T)
53. Scattering from the blood depends nonlinearly on the hematocrit value. (T)
54. The most demanding imaging mode from the safety point of view is color flow mapping. (F)
55. Sector images always come from a convex array probe. (F)
56. Multi-frequency probes must have a high fractional bandwidth that is close to 100%. (T)
57. Ultrasound B-mode image values may take positive and negative values. (F)
58. The speed of ultrasound in tissues is assumed constant by ultrasound systems regardless of application. (T)
59. The main application of transesophageal ultrasound probe is to image the heart. (T)
60. It is possible to combine imaging modes without loss of frame rate. (F)

Part III: Miscellaneous Problems

61. [10 points] Derive the formula for the beam of an ultrasound imaging system aperture shown with the following parameters: center frequency 5 MHz, $z = 10$ cm, square elements of width=0.4 mm, kerf= 0.1 mm. Assume any missing information



Will be graded based on idea

-
62. [15 points] Derive an analytical model for PW-Doppler with the following parameters: center frequency: 5 MHz, number of excitation cycles within each transmission: 8, window used to compute the spectrogram: 128 point, sample volume depth: 10 cm, sample volume size= 1 cm. Assuming that the vessel makes 45° with the ultrasound beam, derive an expression for the maximum detectable velocity. Also, based on your analytical model, estimate the value of the minimum detectable ultrasound velocity for this system.

Derivation given in lecture. Minimum ultrasound velocity is related to sinc function main lobe width in the response (corresponding to inverse of window size in time).

-
63. [9 Points] Compare between the following (provide your opinion about which is better and 3 reasons for your choice):
- A. Analog vs. digital beamforming
 - B. Fundamental vs. Harmonic imaging
 - C. PW-Doppler vs. CW-Doppler

Any choice supported by 3 technically accurate reasons should be correct in each.

Best of Luck!

Professor Yasser Mostafa Kadah