Cairo University **Closed-Book**
Faculty of Engineering **May 2003**

FOURTH YEAR BIOMEDICAL EQUIPMENT FINAL EXAM
PART II: MRI AND COMPUTED IMAGING

PART I. Choose the best answer for each of the following questions (2 points each)

1. To acquire a T_1-weighted image, we must use:
   a) Spin echo sequence with short TR and TE
   b) Gradient echo sequence with long TR and long TE
   c) Gradient echo sequence with short TR and short TE

2. In a T2-weighted image, tissues with long T_2 appear:
   a) Dark
   b) Bright
   c) Empty

3. T1-weighted imaging is sometimes called "fat imaging" because:
   a) fat appears only in this type of imaging
   b) fat appears the brightest tissue type
   c) fat was discovered using this technique

4. Shim coils are used to:
   a) Improve the uniformity of the magnetic field
   b) Frequency encoding gradient generation
   c) Receive the MR signal

5. Quadrature coils are used in MRI because:
   a) They allow the reception of the quadratic components in the signal thus give higher SNR
   b) They are easier to mount on the magnet
   c) They are less expensive

6. For the same matrix (N x N x N) and FOV, the ratio of the SNR for 3D acquisition to that for multi-slice acquisition is,
   a) $1/N$
   b) $\sqrt{N}$
   c) $1/\sqrt{N}$

7. PET technique relies on:
   a) Tomographic reconstruction of photon emission sources
   b) Tomographic reconstruction of annihilation radiation using coincidence detection
   c) Tomographic reconstruction of attenuated beta particles

8. SPECT reconstruction is more difficult than conventional CT reconstruction because:
   a) The detectors used to collect the data are less efficient
   b) It is required to compute both attenuation and photon source intensity maps
   c) It is required to compute higher resolution images

9. A gradient echo sequence with a short TR and long TE has:
   a) T1-weighted contrast only
   b) T2*-weighted contrast only
   c) Mixed T1- and T2*-weighted contrast

10. In order to change the flip angle of the RF pulse,
    a) Change the amplitude of the RF pulse
    b) Change the bandwidth of the RF pulse
    c) Change amplitude of the slice selection gradient

11. In order to change the slice profile of an RF pulse:
    a) Change the envelope of the RF pulse at the same bandwidth
    b) Change the RF pulse amplitude
    c) Change the slice selection gradient

12. It is possible to reverse the action of magnetic field inhomogeneity dephasing in FID signals when using,
    a) Spin-echo sequence
    b) Gradient echo sequence
    c) Inversion recovery sequence

13. The measured MR signal immediately after a perfect 180 degree RF pulse is expected to be:
    a) zero
    b) T1-weighted
    c) T2* weighted

14. Comparing a gradient-echo and a spin-echo sequences with the same parameters (TR/TE, flip angle, etc.), the signal from gradient-echo is always,
    a) Smaller
    b) Larger
    c) Equal but opposite in phase

15. The k-space trajectory of a given MR pulse sequence depends on,
    a) The history of magnetic field gradients
    b) The type and shape of RF pulses used
    c) The shape of the scanned object

16. The resolution in the read-out direction depends on,
    a) Sampling duration (k-space coverage)
    b) Sampling bandwidth (k-space sampling rate)
    c) Sampling dynamic range (number of bits of sampling A/D)

17. The FOV in the phase encoding direction depends mainly on,
    a) Phase encoding step size only
    b) Number of phase encoding steps and step size
    c) Matrix size in the phase encoding direction only

18. To maintain the same resolution in the read-out direction at a larger FOV, one can,
    a) Increase the k-space sampling bandwidth only
    b) Increase the k-space coverage in the read-out direction only
    c) Increase both k-space sampling bandwidth and k-space coverage

19. To increase the FOV in the read-out direction without affecting the SNR, we can,
    a) Use the same sampling BW with lower read-out gradient
    b) Use the same sampling BW with higher read-out gradient
    c) Use a higher bandwidth with the same read-out gradient

20. Magnetic resonance spectroscopy can be used for,
    a) Mapping concentration of different metabolites in the human body noninvasively
    b) Mapping concentration of different nuclei in the human body noninvasively
    c) Mapping magnetic field inhomogeneity in PPM scale inside the magnet

21. To reconstruct a 128×128 image in CT, assuming that each projection is detected using 64 independent detectors, the minimum number of projections needed is,
    a) 256
    b) 128
    c) 512

22. The reconstruction problem of SPECT imaging can be simplified by assuming that,
    a) The attenuation is negligible throughout the slice of interest
    b) The incident x-ray energy is known
    c) The emitted photons locations are known

23. The image of CT is composed of,
    a) A map of the attenuation of the body
    b) A map of the photon source intensity inside the body
    c) A map of the x-ray signal intensity inside the body

24. The T2-weighted MR image depends on,
    a) Both spin density and T2 inside the body
    b) Only T2 values inside the body
    c) Only spin density inside the body

25. The PET imaging relies on the following physical process,
    a) Pair production
    b) Compton scattering
    c) Characteristic line spectra

26. The gradient that is on during the data acquisition of an echo is usually for:
    a) Slice selection
    b) Frequency encoding
    c) Phase encoding

27. To collect a 256x128 MR image using Fourier imaging with NEX=2, the number of RF pulses used is,
    a) 128
    b) 256
    c) 512

28. To create a projection image in MRA, the technique most commonly employed is:
    a) Multiplanar reconstruction
    b) Maximum intensity projection
    c) Summation pixel projection

29. The time between excitation pulses is known as:
    a) TI
    b) TE
    c) TR

30. In a spin echo sequence, the time between the 90 deg pulse and the 180 pulse is:
    a) TE/2
    a) TI
    b) T2

31. Decreasing the MR receiver bandwidth:
    a) Decreases SNR
    b) Increases SNR
    c) Has no effect on SNR

32. The total acquisition time for a 3-D Fourier acquisition of a volume of matrix size 128×128×256 with TR/TE: 100/15ms and NEX=1 is approximately,
    a) 14 minutes.
    b) 27 minutes.
    c) 54 minutes.

33. To null a tissue with T1=300 ms using inversion recovery, we should use a TI equal to approximately,
    a) 200 ms
    b) 300 ms
    c) 400 ms

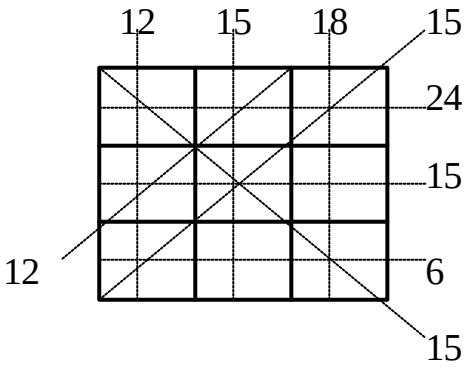
PART II. Answer the following with either True (T) or False (F) (1 point each),

1. With 1T magnets, RF pulses are usually modulated with frequencies around 42.6MHz.
2. Acquisition time may vary with both TR and TE in 3-D Fourier volumetric acquisition.

3. The different generations in CT vary in the geometry and numbers of sources and detectors.
4. We always use a number of RF pulses that is equal to number of phase encoding steps in the image
5. Increasing the read-out magnetic field gradient at the same sampling bandwidth reduces SNR.
6. PET relies on incidence detection of radiated pairs of photons emerging from the object.
7. 8. People with pace makers can undergo MRI scans.
8. The MRI scanning room contains the operating console and the gantry.
9. CRT monitors are preferred to LCD monitors for MRI.
10. For a small MRI clinic in the second floor in a building, open MRI is a good option.
11. Dynamic range describes how small image pixel size is.
12. The required sampling rate in the k-space is proportional to FOV.
13. Noise in the image depends mainly on your sampling bandwidth.
14. Phase encoding can be used to spatially encode any number of image/volume dimensions needed.
15. Frequency encoding characteristics determine the total acquisition time.
16. Sampling period determines the resolution in the read-out direction.
17. T1-weighted imaging is slower than T2-weighted imaging.
18. Phase encoding step that is too large results in an aliased image.
19. SNR depends on the number of phase encoding steps.
20. The B0 magnetic field is turned on and off to start and end a scan
21. The shim coils are used to improve the homogeneity of B0 field
22. The B1 field is generated using two coils in the x- and y-directions
23. The k-space trajectory depends on the flip angle of the RF pulse
24. T2* is completely independent from T2 relaxation
25. CT can be used effectively near air or bone tissue interfaces

PART III. [10 points] Draw a properly labeled T1-weighted magnetic resonance imaging sequence that can be used for imaging 3-D volume using 3-D Fourier imaging. Draw a clear diagram of its k-space trajectory.

PART IV. [10 points] Solve the following reconstruction problem using a single iteration of the algebraic reconstruction technique.



Best of Luck