Cairo University **Closed-Book**
Faculty of Engineering **June 2002**

FOURTH YEAR BIOMEDICAL EQUIPMENT FINAL EXAM
PART II

PART I. Choose the best answer for each of the following questions (1.5 points each)

1. The essential hardware tool for spatial encoding is,
   a) The static magnetic field.
   b) The magnetic field gradient.
   c) The RF coils.

2. Consider a 1.5T magnet with G_z=20 mT/m, the difference in larmor frequency between the magnet isocenter (z=0) and a position z=1 cm is equal to,
   a) 8.52 kHz
   b) 8.52 MHz
   c) 63.9 MHz

3. The axes in the rotating frame of reference differ from those in the laboratory frame of reference in that,
   a) Each of the transverse axes precess about their direction at the Larmor frequency
   b) The z-axis precess at the Larmor frequency
   c) Both x and y axes rotate around the z-axis at the Larmor frequency

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

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

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

7. The signal after a perfect 180 degree RF pulse is expected to be,
   a) zero
   b) T1-weighted
   c) T2* weighted

8. 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

9. In phase contrast MRA, the contrast is generated by means of,
   a) Special contrast agent injected to the patient
   b) Saturation pulses prior to actual acquisition
   c) Special gradient waveform in one direction

10. To measure T1, we usually use,
    a) Gradient echo pulse sequence
    b) Spin echo pulse sequence
    c) Inversion recovery pulse sequence

11. 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

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

13. 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

14. 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

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

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

17. High magnetic field strength and uniformity can be obtained using,
    a) Reisitive magnets
    b) Permanent magnets
    c) Superconducting magnets

18. MRA based on TOF can be used to image arteries in the leg by using,
    a) By injecting a special contrast agent in the arteries
    b) Saturation pulses located below the slab of interest
    c) Using MIP reconstruction

19. 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) 512
    c) 1024

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

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

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

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

24. Calculate the cardiac output given the following data: O_2 consumption 250 ml/min, arterial O_2 content 0.2 ml/ml, and venous O_2 content 0.15 ml/ml.
    a) 3 liters/min
    b) 4 liters/min
    c) 5 liters/min

25. The acquisition time for 30 128? 128 slices when NEX=2, TE=50 ms, and TR=1 sec is approximately,
    a) 4.3 min
    b) 6.4 min
    c) 8.5 min

26. The indicator-dilution method that uses continuous infusion relies on,
    a) Measuring indicator concentration at steady state
    b) Measuring indicator concentration variations with time
    c) Measuring a rate of indicator uptake by tissues

27. AC flowmeters suffer from,
    a) The problem of transformer voltage
    b) Their signal has similar frequency range to that of ECG
    c) They cannot measure DC components in the flow signal

28. Plethysmographs measure,
    a) Change in heart rate
    b) Change in volume
    c) Change in flow rate

29. Dangerous consequences occur when the current in the patient is in the range,
    a) Approximately 10-100mA
    b) Approximately 100mA-1A
    c) Approximately 1-6A

30. Suitable current range for defibrillators is between,
    a) 1A-6A
    b) 100mA-1A
    c) 10mA-100mA

31. Macroshock is defined as,
    a) The situation when an electrical shock is applied from a defibrillator to revive a patient
    b) The situation when small currents from invasive devices induce ventricular fibrillation
    c) The situation when a large current from a non-invasive device causes danger to the patient

32. Patient isolation from the attached medical equipment is usually done using,
    a) Capacitive or optical isolation barrier at input circuitry
    b) Circuit breakers in the room
    c) Isolation transformers at the entry of the mains to the equipment

33. For a multi-slice imaging sequence with parameters given as: slice thickness: 5mm, flip angle: 60?, matrix size: 128?192, FOV: 20cm?25cm, NEX: 1, and TR/TE: 600/20, the ratio of acquisition time to acquire 25 slices to that of acquiring 20 slices using this sequence is,
    a) 1
    b) 1.25
    c) 2

34. A material that is chemically shifted from water by 1.7kHz has a different resonance frequency at 4T from that of water by approximately,
    a) 1 ppm.
    b) 10 ppm.
    c) 100 ppm.

35. Active shielding limits the fringe magnetic field by using,
    a) Standard magnetic field gradients
    b) Shimming coils
    c) Special superconducting coils outside the primary B0 field coils

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

37. For a volumetric acquisition, doubling the number of phase encoding steps in the k_y direction keeping the voxel volume the same results in,
    a) Lower SNR by a factor of $\sqrt{2}$.
    b) Higher SNR by a factor of $\sqrt{2}$.
    c) The same SNR.

38. For 3-D MRA based on phase contrast, when a volume of 128?128?128 is to be acquired in a multi-slice fashion, the acquisition time is equal to,
    a) 128?128 TR
    b) 128?128/2 TR
    c) 128?128?4 TR

39. Photoplethysmography is based on the fact that light emitted through the tissue is affected by,
    a) Changes in vessel pressure
    b) Changes in vessel volume
    c) Changes in vessel illumination

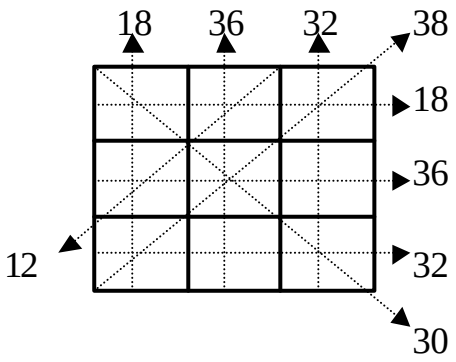
40. To null a tissue with T1=300 ms using inversion recovery, we should use a TI equal to approximately,
    a) 200 ms
    b) 300 ms
    c) 400 ms

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

1. Chamber plethysmography relies on photoelectric effects to detect volume change.
2. With 1.5T magnets, RF pulses are usually modulated with frequencies around 64MHz.
3. Acquisition time may vary with both TR and TE in 3-D Fourier volumetric acquisition.
4. The different generations in CT vary in the geometry and numbers of sources and detectors.
5. We have to use a number of RF pulses that is equal to number of phase encoding steps.
6. Increasing the read-out magnetic field gradient at the same sampling bandwidth reduces SNR.
7. PET relies on incidence detection of radiated pairs of photons emerging from the object.
8. Thermodilution is the most common method used to measure cardiac output.
9. Dye dilution technique is based on rapid injection of colored dye.
10. Microshocks result mainly from leakage currents of line-operated equipment.

PART III. Draw a properly labeled T2-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. **(3 points)**

PART IV. Solve the following reconstruction problem using a single iteration of ART **(3 points)**



BEST OF LUCK!