Introduction to Biomedical Engineering: 2009 fall Final

January 13, 2010

Close book, 120 minutes (PM 13:10~AM 15:10)

Do **not** leave your answer along without any brief explanation except 2(2).

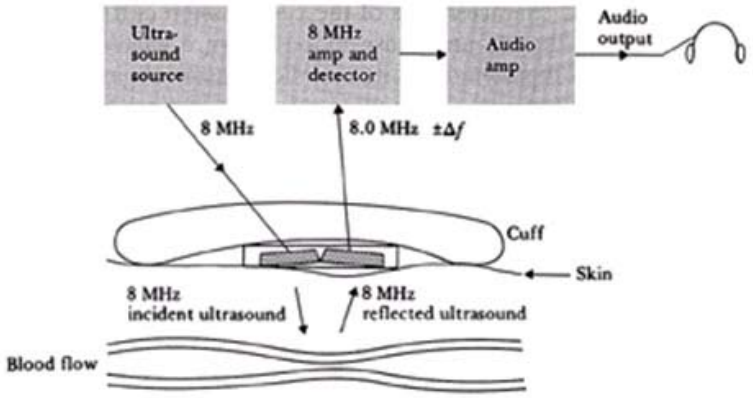
一、解釋名詞 (25%，任選五題作答即可，且以最高分的五題計分)

1. Characteristic radiation
2. Pulse Oximetry
3. Spiral CT
4. Nitrogen washout procedure
5. Macroshock and microshock
6. Matching layer of ultrasonic transducers

二、問答題

1. (Circulatory system, 12%) The maximal velocity of blood in a dog, 80 cm/sec, occurs in the dog's aorta (主動脈), which is 1.5 cm in diameter. If the magnetic flux density in an electromagnetic flowmeter is 0.03 Tesla. (Note: "Tesla" is the SI unit of magnetic flux density when "gauss" is used in the CGS system.)
   (1) What is the voltage at the electrodes?
   (2) Is the magnetic field in an electromagnetic flowmeter generated by a DC or AC power source? Why?

2. (Blood pressure, 10%) A Doppler ultrasonic sphygmomanometry is illustrated as below.
   (1) The reflected signal (8 MHz $\pm\Delta f$) is received by the transcutaneous (體表的) ultrasound crystal and demodulated to detect the difference in frequency (Δf). How does Δf mainly come from if the underlying vessel is roughly perpendicular to the direction of ultrasound? (6%)



(2) The blood pressure measured in is originated from the periodic pulsation of left ventricle. The systolic pressure (SP) and diastolic pressure (DP) in the left ventricle of a healthy adult should be closer to
   (a) SP = 120 mmHg, DP = 70 mmHg.
   (b) SP = 120 mmHg, DP = 12 mmHg.
   (c) SP = 30 mmHg, DP = 12 mmHg.
   (d) SP = 30 mmHg, DP = 6 mmHg.

3. (Radioactive medical imaging, 18%)
   (1) Describe the main mechanisms responsible for X-ray attenuation in biological tissue at the following energies: (a) 10 keV (b) 100 keV. (6%)
   (2) CT, SPECT, and PET are all medical tomography reconstructed using similar algorithms such as central slice theorem. Please make a table to compare them from the aspects of (a) signal source, (b) image resolution (解析度), (c) hardware demand, and (d) clinical applications. (12%)

4. (Magnetic resonance imaging, 15%) What are the three most important hardware/devices in a MRI system? Please explain their function.

5. (Ultrasound, 20%)
   (1) In general, ultrasound is seldom used for investigation of bone tissue since it's not efficient for ultrasonic waves to penetrate the muscle-bone interface. Please estimate the intensity of ultrasound transmission in percentage when the ultrasound beam enters the bone tissue from muscle perpendicularly.

	Density (kg/m^3)	Sound velocity (m/sec)
Muscle	1068	1600
Bone	1912	4080

   (2) A 5-MHz ultrasonic transducer is used for B-mode ultrasound with 100 lines per scan. What is the frame rate (number of scans per second) when a maximal depth of 10 cm is set according to the 100dB dynamic range of the clinical system? (Assume that the average propagation velocity of ultrasound in human tissue is 1500 m/sec.)

Enjoy your winter vacation!