

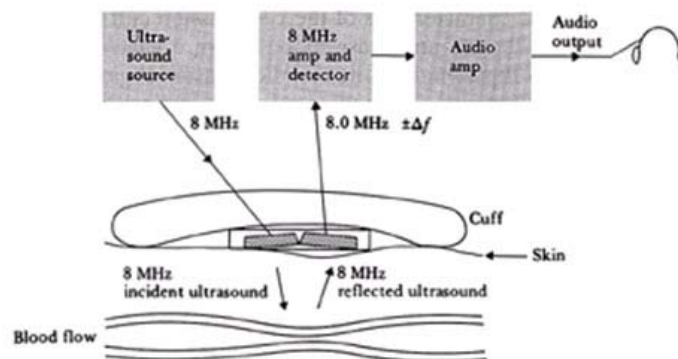
Introduction to Biomedical Engineering: 2011 fall Final

January 12, 2011

Close book, 140 minutes (PM 13:10~AM 15:30), 102 points in total

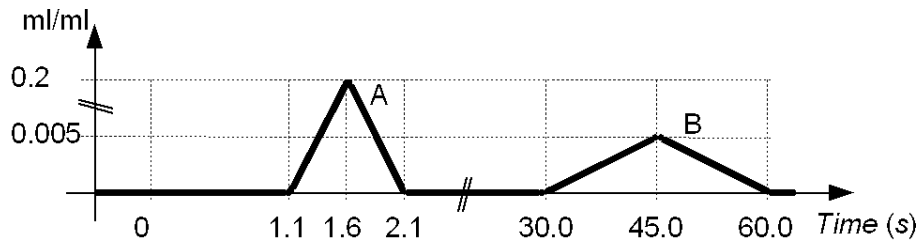
一、選擇題 (66% , 單選不倒扣)

1. As the patient moves and changes posture during measurement of bio-potential signals, electrodes tend to become detached. In order to detect this, some manufacturers apply a 5mA current through the electrodes. When the impedance to current flow increases greatly, the electrode is detected as disconnected. What type of electrical shock hazard does this possibly represent? (A) Macroshock hazard; (B) Microshock hazard; (C) Both of them; (D) None of them.
2. As known, heart sounds are the noises generated by the beating heart and the flowing blood through it. The first hear sound (S1) is mainly caused by (A) the opening of bicuspid (or Mitral) valve; (B) the closing of bicuspid (or Mitral) valve; (C) the opening of aortic valve; (D) the closing of aortic valve.
3. 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.
4. A Doppler ultrasonic sphygmomanometry is illustrated as below. The reflected signal ($8 \text{ MHz} \pm \Delta f$) 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? (A) The flowing blood in the underlying vessel; (B) The blood cells distributed in subcutaneous (皮下的) tissue; (C) The opening and closing of the vessel due to variation of blood pressure; (D) The mismatch of acoustic impedance between different tissues.



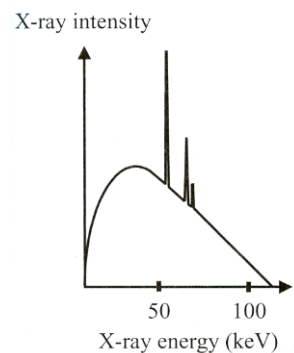
5. A fine fiber-optic sensor is usually used to detect the blood pressure and classified as (A) direct and intravascular measurement; (B) direct and extravascular measurement; (C) indirect measurement; (D) non-invasive measurement.

6. In an indicator dilution system, a 10 ml bolus of liquid indicator is injected (at Time=0) rapidly into the pulmonary artery using a Swan-Ganz catheter (心導管). The indicator concentration (in units of ml-indicator/ ml-blood) is measured at the left ventricle output and shown in the following graph. What is the average cardiac output in unit of liter per minute? (A) 0.6; (B) 1.0; (C) 6; (D) 8.



7. Flow volume curve is a graphic plot that provides useful information about lung functions and is achieved during inspiration and expiration using maximum effort. What can NOT be measured by the flow volume curve? (A) The maximal rate of airflow; (B) Vital capacity; (C) Total lung capacity; (D) All of the above can be measured.
8. Pulse oximetry is a non-invasive device used to detect the blood oxygenation level of (A) any artery or vein attached by the sensor; (B) the closest vessel under the sensor; (C) venous blood in subcutaneous tissue; (D) arterial blood in subcutaneous tissue.

9. The spectrum of X-ray generated by a clinical (臨床的) X-ray tube was shown. What determines the highest energy of x-ray photons emitted from an x-ray tube? (A) the accelerating voltage; (B) the tube current; (C) the target material; (D) the emission time.



10. In the same figure, the spike or impulse component in the spectrum was induced by (A) photoelectric effect; (B) Compton scattering; (C) bremsstrahlung effect; (D) characteristic radiation.

11. The attenuation of low-energy X-ray, let say, lower than 10 keV, in human body is primarily induced by (A) photoelectric effect; (B) Compton scattering; (C) bremsstrahlung effect; (D) characteristic radiation.

12. What statement about the generation of X-ray is NOT true?

- (A) Bremsstrahlung, or braking radiation, is electromagnetic radiation produced by deceleration of a charged particle.
- (B) Bremsstrahlung has a continuous spectrum because the transition of kinetic energy is a continuous function of particle velocity and its moving trace.
- (C) The characteristic radiation is caused by electron transition from outer to inner shell.
- (D) Only the X-ray generated by bremsstrahlung effect can be used for medical imaging.

13. What is the gray scale representing in a CT image? (A) Hounsfield unit; (B) The degree of attenuation or absorption of the tissues; (C) A relative index using water and air as references; (D) All of the above.
14. What part of the following component is not required in positron emission tomography? (A) Scintillation crystal; (B) Collimator; (C) Photo multiplier tube; (D) Pulse height analyzer.
15. What state is correct about SPECT (single photon emission CT)?
- (A) A SPECT scanner should be equipped with the cyclotron inside hospital or in very close neighborhood for rapid transportation of short-lived radioactive tracer isotope.
 - (B) The collimator attenuates most (> 99%) of incident photons and thus greatly limits the sensitivity of the gamma camera.
 - (C) The ^{18}F -FDG, an analogue of glucose (葡萄糖), is one of the most popular radioactive tracer for SPECT scan to explore the possibility of cancer metastasis (轉移).
 - (D) SPECT image has better spatial resolution than PET because the scattered photon can be detected and filtered by pulse height analyzer.
16. What does the detector ring(s) in PET scanner actually capture to reconstruct a nuclear image? (A) Positrons; (B) Electrons; (C) Gamma rays; (D) X-rays.
17. The clinical MRI systems commonly in use nowadays (e.g., 1.5 Tesla) have static magnetic fields on the order of (A) 300; (B) 3,000; (C) 30,000; (D) 300,000 times of the magnetic field of the earth.
18. The flip angle of an RF excitation pulse is proportional to (A) the pulse duration; (B) gyromagnetic ratio; (C) the B_1 field strength; (D) all of the above.
19. In MRI, how should the excitation RF pulse (B_1 field) be oriented with regard to the main magnetic field? (A) Parallel and static; (B) Perpendicular and static; (C) Parallel and spinning; (D) Perpendicular and rotating.
20. Which hardware in a MRI scanner is used to generate spatially dependent magnetic field to achieve spatial encoding? (A) the superconducting electromagnet; (B) the RF excitation coil; (C) the RF receiving coil; (D) the gradient coil.
21. Which statement about MR signal is NOT true?
- (A) Bone tissue in an MR image usually appears dark because the radio-frequency pulse is unable to penetrate the bone.
 - (B) In addition to ^1H , the nucleus of fluorine ^{19}F can be used to generate MR signal due to its unpaired protons.

- (C) Although there are abundant molecules containing ^1H , such as water, in human body, the population difference of spin-up and spin-down proton which really contributes the MR signal is only 5 to 6 ppm at 1.5 Tesla.
- (D) None of the above.

22. Which kind of medical imaging modality can achieve the best temporal resolution, i.e. the shortest scan time, for one single 2D image? (A) Computed tomography; (B) PET; (C) Ultrasound; (D) Magnetic resonance imaging.

二、問答題(36%)

1. Please use one to three lines to explain the principle (how does it work?) of the following biomedical devices. Illustration with a figure or plot is welcome. (12%)
 - (1) 16-slice spiral CT
 - (2) Automatic blood pressure meter using oscillometric method

2. (Circulatory system, 12%) The maximal velocity of blood in a dog, 80 cm/sec, occurs in the its 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 measured at the electrodes?
 - (2) Is the magnetic field in an electromagnetic flowmeter usually generated by a DC or AC power source? Why?

3. (Ultrasound, 12%)
 - (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 4-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 15 cm is set according to the 100-dB 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!