Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEU 40403
PROGRAMME	:	4 BEJ
EXAMINATION DATE	:	DECEMBER 2014 / JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) X-ray contrast agents are designed to be very efficient at absorbing X-rays.

(i) Describe two basic classes of X-ray contrast agent.

(3 marks)

(ii) In investigation for gastrointestinal (GI) tract disorders, double contrast agent approach is used to characterize small pathologies in the large intestine, colon and rectum which can provide important information about colonic stricture or obstruction. Point out on how it works.

(4 marks)

(b) The linear attenuation coefficient of a gadolinium-based phosphor in computed radiography (CR) used for detection of X-rays is 500 cm^{-1} at an X-ray energy of 100 keV.

(i) Calculate percentage of X-rays absorbed by phosphor layers of 5 μm and 50 μm thickness.

(8 marks)

(ii) Evaluate on how the thickness of the X-ray detector can effect the quality of the diagnostic image in terms of the Signal-to-Noise Ratio (SNR) and the spatial resolution.

(5 marks)

(c) Digital fluoroscopy is one of specialized techniques in X-ray imaging. Explain on its method and applications.

(3 marks)

(d) X rays radiation will results in the ionization of body tissue that causes chemical changes in the irradiated cells. Describe the possible biologic damages that can be caused by the ionization effect.

(2 marks)

Q2 (a) Describe the principle of helical Computed Tomography (CT) and the significance improvement of the helical scanning mode compared to axial scanning mode.

(5 marks)

(b) For each of the following statements in **Q2(b)(i)–(v)**, indicate whether they are **True (T)** or **False (F)** and propose the right statement for the false.

(i) A CT image is genuinely display a map of the spatially-dependent tissue attenuation coefficients.

(3 marks)

(ii) Data from a CT signal produced in each element of the detector array arises from fan beam X-rays can be simply filtered and backprojected to give the image.

(3 marks)

(iii) According to beam hardening effect, the x-ray gets more attenuated gradually while it penetrating materials which results in the effective attenuation coefficient is smaller for 'thicker' areas of the body.

(3 marks)

(iv) In cerebral CT scans, blood shows up as a high signal compared to the surrounding tissue therefore appeared darker in the image, whereas edema has a somewhat lower intensity than tissue therefore give a whiter image.

(3 marks)

(v) In cardiac imaging, CT is not suitable when pacemakers or defibrillators are present.

(3 marks)

(c) Describe briefly the clinical application of CT in pulmonary imaging.

(5 marks)

Q3 (a) By referring to Table **Q3(a)**, calculate the intensity transmission coefficient, T_I, for the interface of muscle/air, according to the following condition;

(i) The ultrasound beam is exactly perpendicular to the interface.

(2 marks)

(ii) The angle of incidence of the ultrasound beam being 45°.

(5 marks)

(b) Discover why a very fast or very slow tissue relaxation time, τ results in a very small amount of energy being lost due to absorption.

(6 marks)

(c) Discuss briefly the mechanism of the contrast agent in ultrasound imaging working as a harmonic oscillator in significantly increase the backscattered signal from blood.

(4 marks)

(d) Harmonic imaging technique creates images that are derived solely from the harmonic frequency. It offers several advantages over conventional pulse-echo imaging because tissue harmonic signals have less side lobes, less noise, and improved contrast resolution. Generalise the idea on how the tissue harmonic signals have less side lobes, less noise, and improved contrast resolution.

(4 marks)

(e) "Ultrasound is generally used for diagnosis but it also can be used for tumor therapy". Justify the statement.

(4 marks)

Q4 (a) List **THREE (3)** basic components make up the Magnetic Resonance Imaging (MRI) scanner.

(6 marks)

(b) Discuss the use of paramagnetic and superparamagnetic contrast agents in tumor detection.

(6 marks)

(c) Analyse the specific functions and contributions between the Magnetic Resonance Spectroscopy (MRS) and the Functional Magnetic Resonance Imaging (fMRI).

(7 marks)

(d) Justify the biological effect and safety in MRI.

(6 marks)

- END OF QUESTION –

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Biological Tissue	Characteristic Acoustic Impedance x10^5 (g cm^{-2} s^{-1})	Speed of sound (ms^{-1})
Air	0.0004	330
Blood	1.61	1550
Bone	7.8	3500
Fat	1.38	1450
Brain	1.58	1540
Muscle	1.7	1580
Vitreous humor (eye)	1.52	1520
Liver	1.65	1570
Kidney	1.62	1560

1. Ratio of x-rays transmitted through a certain thickness $= \dfrac{N}{N_0} = e^{-\mu(E)x}$

   N_0 : the number of incident X-ray
   N : the number of X-ray at a distance x from the source
   μ : the tissue linear attenuation coefficient which depends upon the energy, E of the incident X-rays
   x : the thickness of tissue

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2. When the angle between incident ultrasound beam and boundary between two tissues is 90°:

Ultrasound wave pressure reflection coefficient, $R_p = \frac{p_r}{p_i} = \frac{Z_2 - Z_1}{Z_2 - Z_1}$

p_i : the pressure of the incident wave
p_r : the pressure of the reflected wave
Z_1 : the characteristic acoustic impedance of tissue 1
Z_2 : the characteristic acoustic impedance of tissue 2

When the angle between incident ultrasound beam and boundary is not 90°:

$$R_P = \frac{p_r}{p_i} = \frac{Z_2 \cos\theta_i - Z_1 \cos\theta_t}{Z_2 \cos\theta_i + Z_1 \cos\theta_t}$$

$$\frac{\sin\theta_i}{\sin\theta_t} = \frac{c_1}{c_2}$$

R_P : the pressure reflection coefficient
θ_i : the angle of incident wave
θ_t : the angle of transmission wave
c_1 : the speed of sound in tissue 1
c_2 : the speed of sound in tissue 2

$$R_I = R_P^2$$

$$T_I + R_I = 1$$

$$T_P = R_P + 1$$

R_I : the intensity reflection coefficient
T_I : the intensity transmission coefficient
T_p : the pressure transmission coefficient