Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEU 40403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2019/JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

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

Q1 (a) Discuss the temporal resolution in Magnetic Resonance Imaging (MRI).
(4 marks)

(b) The T1 and T2 values are unique to each tissue. They provide valuable information about the physiological state of tissue which is being exploited in MRI.

(i) State the definition of T1 relaxation time.
(2 marks)

(ii) Explain the possible causes of dephasing which give rise to the T2* relaxation time.
(6 marks)

(iii) Among the biological materials listed below, state the one that would be expected to have longest T2 value. Also state the one that would be have the shortest T2 value. Please provide reasons to support your answers.

Achilles tendon	Liver
Quadriceps muscle	Urine

(4 marks)

(iv) Discuss the possibility of a tissue having the relaxation time pairs of T1 = 400 ms and T2 = 500 ms.
(4 marks)

Q2 (a) There are several processing used to enhance the digital images to suit the requirement of the application. At the same time, in order to measure or characterise the image quality, three basic quantities are used.

(i) Apart from the contrast to noise ratio (CNR), state the other **TWO (2)** quantities that represent the quality of image.
(2 marks)

(ii) State **FOUR (4)** image processing techniques and explain the function of each technique.
(8 marks)

(iii) Echo Time (TE) and Repetition Time (TR) are used to obtain good contrast in MRI images. Propose a time setting for TR and TE in the following case:

Case 1: T1 weighted image
Case 2: T2 weighted image
(4 marks)

(b) You are required to obtain an MRI image of a patient's chest using a 1.5 Tesla scanner. Assume that the chest is cylindrical with diameter of 40 cm and 25 cm in height. Also assume that the centre of the chest is the centre of the gradient coil.

(gyromagnetic ratio of hydrogen = 42.58 MHz/T)

(i) Calculate the resonant frequency for protons at the top of the chest (and coordinate $z = 0$) if a y gradient of 30 mT/m is applied.

(4 marks)

(ii) Find the overall frequency spread of the chest (at coordinate $z = 0$) if the y gradient of 30 mT/m is applied.

(2 marks)

Q3 (a) Explain the basic principle of ultrasound imaging.

(6 marks)

(b) "In ultrasound imaging, a compromise has to be made between resolution and penetration depth."

With your own words, discuss the statement above.

(2 marks)

(c) Explain in depth the principles of contrast agents in assisting the detection of blood flow in small vessels deep in tissue. Name **ONE (1)** example of contrast agent that can be used for that purpose.

(4 marks)

(d) Intensity of ultrasound is measured in decibels as a relative intensity.

(i) Calculate the losses of an ultrasound pulse while travelling through tissue with the initial and remaining intensity is 35 mW and 0.35 μW, respectively.

(4 marks)

(ii) Discover the depth of a 10 MHz ultrasound beam that could penetrate a soft tissue at the intensity of 4×10^{-19} mW/cm^2. The intensity of the ultrasound beam entering the tissue is 40 mW/cm^2. Assume that the attenuation coefficient for a soft tissue is 1 dB cm^{-1} MHz^{-1}.

(4 marks)

Q4 (a) Based on **Figure Q4(a)**, discuss the mechanism by which the x-rays are produced.

(8 marks)

(b) Find the percentage of x-rays transmitted through a chest at an incident X-ray energy of 70 keV. Assume the half-value layer (HVL) values of 3.5 and 1.8 cm for muscle and bone, respectively. Given the bone and chest thickness is 4 cm and 16 cm, respectively.

(6 marks)

(c) List down **THREE (3)** factors affecting the Contrast to Noise Ratio (CNR) in x-ray imaging.

(3 marks)

(d) Explain **THREE (3)** significances of applying breast compression for a mammogram.

(3 marks)

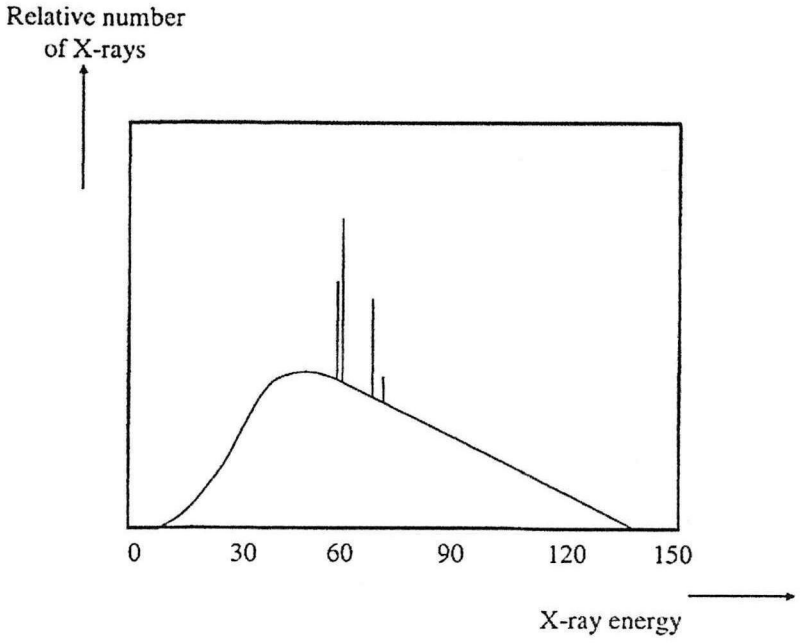

Figure Q4(a)

Q5 (a) Explain the principle of Computed Tomography (CT) imaging.

(4 marks)

(b) Discuss the significance of 'spiral' or 'helical' scanning mode in CT imaging.

(2 marks)

(c) Discuss **TWO (2)** reasons that show CT scan is more appropriate to be used in emergency rooms compared to Ultrasound.

(4 marks)

(d) A CT image displays a map of the tissue CT numbers.

(i) Calculate the CT number of a voxel of tissue in the lung with linear attenuation of 0.05 cm^{-1}. Given the linear attenuation of water is 0.1 cm^{-1}.

(3 marks)

(ii) Predict the changes of CT number if the tissue is exposed with a lower energy than the abovementioned CT scan device.

(3 marks)

(e) Radiation doses in CT is comparatively higher than the doses required by a radiographic image of the same region. Explain the reason the radiation dose in the CT is higher compared to the conventional x-ray imaging.

(4 marks)

- END OF QUESTIONS –

FINAL EXAMINATION

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FORMULAE

$$\frac{P_{antiparallel}}{P_{parallel}} = exp\left(-\frac{h\omega_L}{k_B T}\right) \approx 1 - \frac{h\omega_L}{k_B T}$$

$$N_{parallel} - N_{antiparallel} = N_S\left(\frac{h\omega_L}{2k_B T}\right)$$

$$\omega_z = \gamma B_z = \gamma(B_0 + zG_z)$$

$$N = N_0 e^{-\mu(E)x}$$