Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEU 40403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2018/JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) The interaction between the magnetic field and hydrogen nuclei, or protons in Magnetic Resonance Imaging (MRI) can be described in terms of nuclear magnetism using quantum mechanical and classical mechanics descriptions. Distinguish the concept of nuclear magnetism in quantum mechanical and classical mechanics descriptions.

(4 marks)

(b) There are a number of imaging sequences used for different clinical applications in the Magnetic Resonance Imaging (MRI). **Figure Q1(b)** shows the basic MRI sequence which also known as gradient-echo imaging sequence.

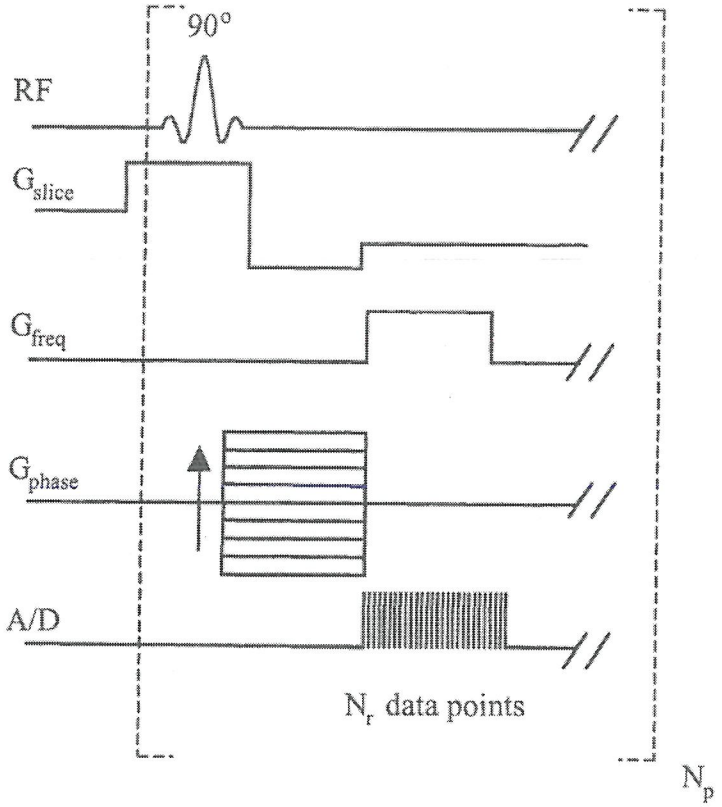

Figure Q1(b)

(i) By referring to **Figure Q1(b)**, explain the process of image formation in the MRI.

(10 marks)

(ii) The MRI can produce a series of slices through the anatomical area of interest with a well-defined orientation and thickness. According to a respective sequence in **Figure Q1(b),** describe on how the orientation of axial, sagittal and coronal can be achieved.

(3 marks)

(c) Hydrocephalus is a condition in which there is an accumulation of cerebrospinal fluid (CSF) within the brain. It is easy to diagnose using the MRI as it gives the distinct signal from water with very long T_1 and T_2 values. According to its very long T_1 and T_2 values compared to the T_1 and T_2 values of the water, predict on how the image of hydrocephalus will appear on the MRI according to the following imaging sequences.

(i) T_1-weighted imaging sequence

(2 marks)

(ii) T_2-weighted imaging sequence

(2 marks)

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

(4 marks)

Q2 (a) With the aid of an appropriate diagram(s), explain the basic principles of ultrasonic imaging.

(7 marks)

(b) Point out the significance of damping material in a single-crystal ultrasound transducer in improving spatial resolution of an ultrasound imaging.

(8 marks)

(c) 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 75 mW and $0.75\,\mu$W, respectively.

(4 marks)

(ii) Discover the depth of a 10 MHz ultrasound beam that could penetrate a soft tissue at the intensity of $3\times10^{-19}\,mW/cm^2$. The intensity of the ultrasound beam entering the tissue is 30 mW/cm^2. Assume that the attenuation coefficient for a soft tissue is 1 dB cm^{-1} MHz^{-1}.

(4 marks)

(d) The detection of blood flow in small vessels deep in tissue is very difficult due to the low SNR of the Doppler signal. In order to carry out these experiments, the backscattered signal from blood must be made larger by somehow increasing the echogenicity of blood. This can be achieved using ultrasound contrast agents, which are injected directly into the bloodstream. These contrast agents usually consist of gas-filled microspheres or micro bubbles with diameters less than 10 μm so that they pass through the pulmonary, the cardiac, and the capillary systems.

Name **TWO (2)** types of gas microbubbles or gas-filled microspheres ultrasound contrast agent.

(2 marks)

Q3 (a) List **TWO (2)** major mechanisms by which X-rays interact with tissue. Then, identify which mechanism minimizes a contrast in an X-ray image.

(4 marks)

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

(3 marks)

(ii) Discuss on how the x-ray energy spectrum could affect the contribution of Compton Scattering to the CNR of an image in x-ray imaging.

(3 marks)

(c) Highlight the importance of K-edge phenomenon in X-ray imaging. Support your explanation with an appropriate figure or diagram.

(5 marks)

(d) Propose a design of an anode in the X-ray tube in order to produce an effective focal spot of the X-ray beam. Include appropriate illustration(s) to support the design.

(4 marks)

(e) X-ray signals are detected in Computed Radiography (CR) via linear attenuation coefficient of a gadolinium-based phosphor of 450 cm^{-1} and at 80 keV. Calculate the percentage of X-rays absorbed by the gadolinium-based phosphor layer with the thickness of 6 μm and 40 μm.

(6 marks)

Q4 (a) (i) Explain in brief the basic principle of Computed Tomography (CT) scan imaging.

(4 marks)

(ii) Discuss the advantages and disadvantages of CT scan imaging.

(4 marks)

(iii) Justify the features of CT scan that make it more appropriate to be used in emergency rooms.

(3 marks)

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

(2 marks)

(c) Image reconstruction in CT is performed using filtered backprojection technique where it is preceded by a series of corrections.

(i) Based on **Figure Q4(c)(i)**, point out the phenomenon of beam hardening in CT imaging and suggest way to overcome this issue.

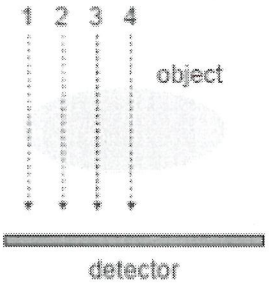

Figure Q4(c)(i)

(5 marks)

(ii) Predict whether the CT number increase or decrease due to the beam hardening.

(3 marks)

(iii) Considering the effects of the above mentioned phenomenon, predict the final image formed from series of one dimensional projections in **Figure Q4(c)(iii)**. Assume that the sample is homogeneous and a darker image corresponds to a higher signal intensity detected.

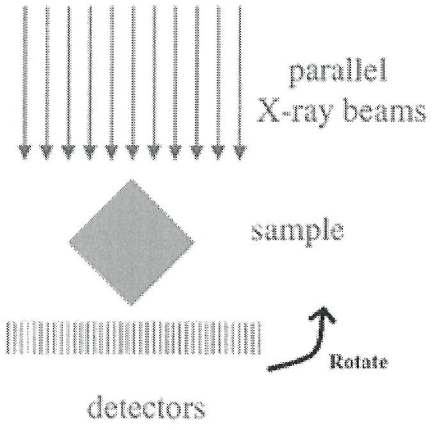

Figure Q4(c)(iii)

(4 marks)

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