Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEJ45103
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

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

Q1 Computed tomography (CT) imaging is a medical imaging technique that uses X-ray technology to create detailed cross-sectional images of the body and the CT number, also known as Hounsfield unit (HU), is a quantitative measure for the CT imaging used to describe the radiodensity of tissues within the body.

(a) For each of the following statements on Computed Tomography (CT) in Q1 (a) (i) – (iii), indicate whether they are **TRUE (T)** or **FALSE (F)**.

(i) In single-slice and helical CT, the slice thickness is determined by the collimated beam width, while in multi-slice CT the slice thickness is determined by the size of the detector. ____

(2 marks)

(ii) In fourth-generation scanners used in CT, x-ray tube is positioned stationary and a full circle of detector elements rotate around the scanned object, on a concentric circle. ____

(2 marks)

(iii) Z-flying spot technique can improve temporal resolution in multi-slices CT imaging.____

(2 marks)

(b) Describe the slip ring function in helical CT imaging.

(5 marks)

(c) Radiation doses are relatively high in CT in which the effective dose is a factor of 10 to 100 and more, higher than a radiographic image of the same region. Describe the reason for the higher radiation dose in CT compared to x-ray planar radiography.

(5 marks)

(d) Considering the effects of beam hardening in CT, illustrate the final image formed from a series of one-dimensional projections in **Figure Q1.1**. Assume that the sample is homogeneous, and a darker image corresponds to a higher signal intensity detected. Relate the effect of the beam hardening with the CT number.

(6 marks)

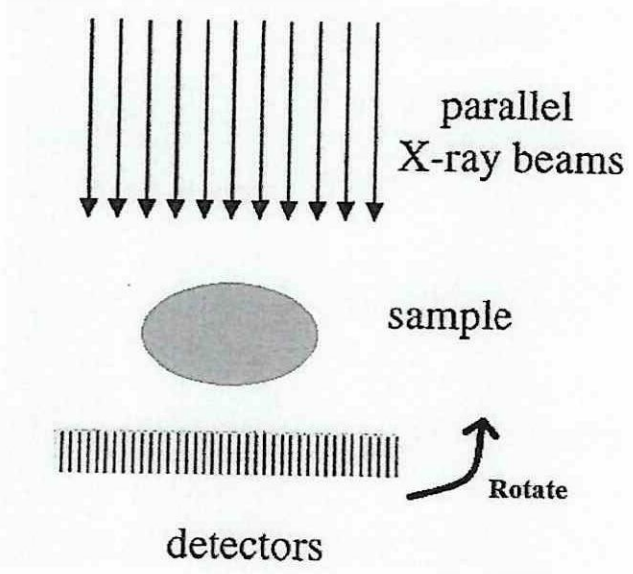

Figure Q1.1

(e) Explain the process of filtered back-projection in CT image reconstruction.

(10 marks)

Q2 Ultrasound imaging is a non-invasive medical imaging technique that uses high-frequency sound waves from a transducer to produce real-time images of the inside of the body.

(a) State the limitation of using a single crystal transducer for ultrasonic imaging.

(4 marks)

(b) State the function and the operation of time-gain compensation (TGC) unit in the receiving system of the transducer.

(4 marks)

(c) Illustrate the shape of the following artifacts:

(i) Acoustic enhancement.

(3 marks)

(ii) Acoustic shadowing.

(3 marks)

(d) The intensity of a 5 MHz ultrasound beam entering tissue is 20 mW/cm^2. Determine the intensity at a depth of 7 cm.

(6 marks)

(e) Explain the relation between the ultrasound contrast agent and effective scattering cross-section, σ_s.

(7 marks)

(f) By referring to **Table Q2.1**, calculate the intensity transmission coefficient T_I for the interface of bone/muscle for the angle of the incidence of the ultrasound beam being 60°. Determine whether the transmitted signal is refracted or not.

(7 marks)

Table Q2.1

Biological Tissue	Characteristic Accoustic 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

Q3 Magnetic resonance imaging (MRI) is a medical imaging technique that uses strong magnetic fields and radio waves to generate detailed images of the internal structures of the body.

(a) Differentiate the concepts of nuclear magnetism in quantum mechanical and classical mechanics descriptions that relate to the principle of MRI.

(4 marks)

(b) Explain the MRI image formation according to the basic imaging sequence in MRI as shown in **Figure Q3.1**.

(10 marks)

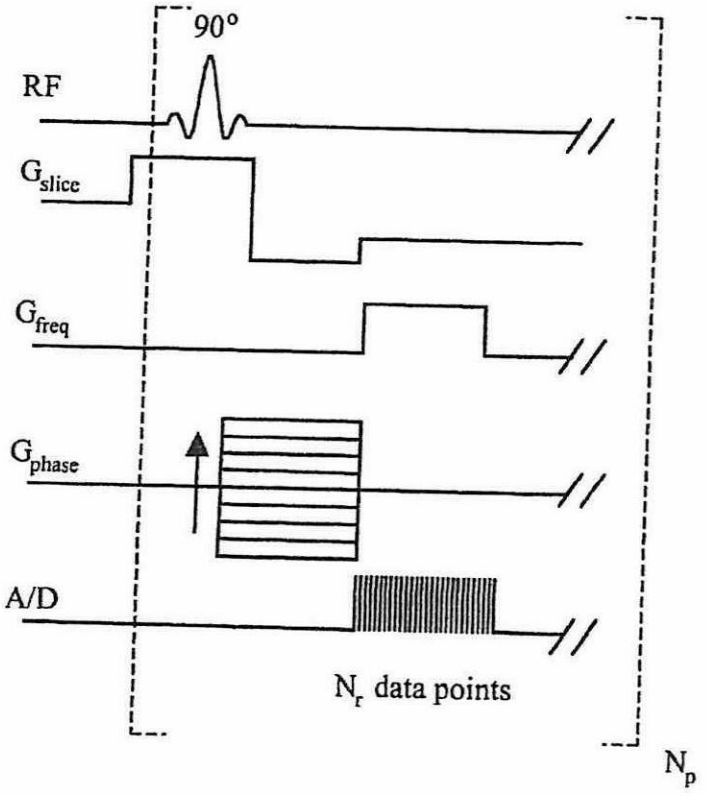

Figure Q3.1

(c) MRI contrast agents are used to increase the CNR between healthy and diseased tissue. There are two basic classes of MRI contrast agents which are paramagnetic and superparamagnetic agents. Distinguish between the paramagnetic and superparamagnetic as the contrast agents for MRI.

(10 marks)

(d) For the five frequencies (1-5) shown in **Figure Q3.2**, deduce the order of Spin-Lattice T_1 and Spin-spin T_2 relaxation time values, for example, T_1 (brain) > T_1 (cerebrospinal fluid) > T_1 (aqueous humor)) and T_2 (brain) < T_2 (cerebrospinal fluid) < T_2 (aqueous humor).

(10 marks)

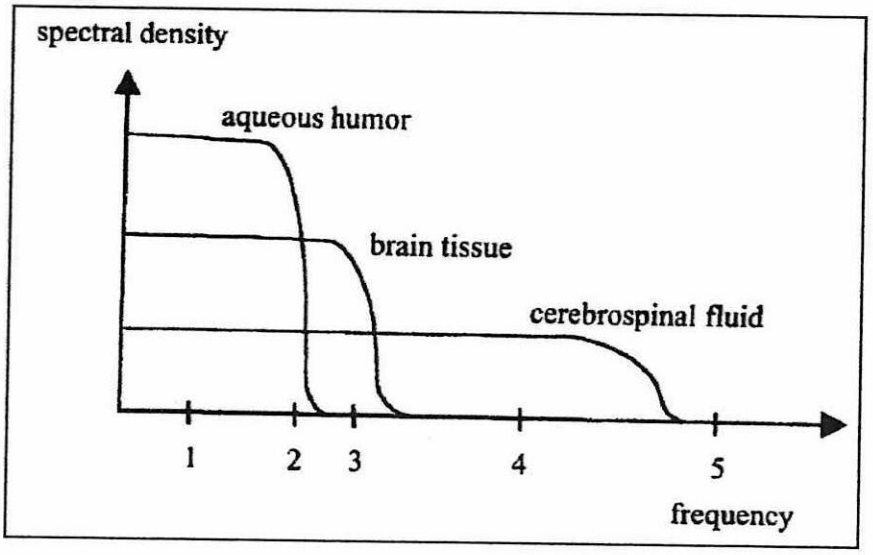

Figure Q3.2

- END OF QUESTIONS -