UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2017/2018

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEU 40403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2017/JANUARY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

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

Q1 (a) List out the instrumentation of Magnetic Resonance Imaging (MRI) system.

(4 marks)

(b) Analyze the pulse sequence diagram of MRI imaging sequences as shown in **Figure Q1(b)**.

(10 marks)

(c) Explain on how to set the Repetition Time (TR) and Echo Time (TE); shorter or longer, in order to generate contrast based on the following imaging sequences:

(i) T_1-Weighted imaging sequence.
(ii) T_2-Weighted imaging sequence.
(iii) Mixed T_1-and T_2-Weighted imaging sequence.

(3 marks)

(d) A brain tumor has a lower concentration of water than surrounding healthy tissue. The T1 value of protons in the tumor is shorter than that of the protons in healthy tissue, but the T2 value of the tumor protons is longer. Justify which kind of weighting (values for TE and TR) should be introduced into the spin echo imaging sequence in order to ensure that there is contrast between the tumor and healthy tissue.

If a large concentration of superparamagnetic contrast agent is injected and accumulated only in the tumor. Suggest the optimal weighting.

(8 marks)

Q2 (a) State **FOUR (4)** limitations of ultrasound imaging.

(4 marks)

(b) Describe the objective of using each of the ultrasound scanning modes: A-mode, M-mode and B-mode.

(3 marks)

(c) By referring to **Table Q2(c)** and the related formulas given, solve the following problems:

(i) The relative intensity of reflected ultrasound wave that is perpendicular to the interface of blood/air.

(3 marks)

(ii) The relative intensity of transmitted ultrasound wave with the angle of the incidence of the ultrasound beam is 40°. Determine if the transmitted ultrasound wave would be refracted.

(7 marks)

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

(i) Calculate the remaining intensity of a 75-mW ultrasound pulse that losses 50 dB while traveling through tissue.

(3 marks)

(ii) The intensity of a 10 MHz ultrasound beam entering tissue is 30 mW/cm^2. Determine the intensity at a depth of 20 cm. (Hint: the attenuation coefficient for soft tissue is 1 dB cm^{-1} MHz^{-1})

(5 marks)

Q3 (a) (i) Draw a schematic diagram of an X-ray tube which consists of its major components.

(3 marks)

(ii) Propose a design of an anode in the X-ray tube in order to produce an effective focal spot of the X-ray beam.

(4 marks)

(b) With the aid of diagram(s), list down the importance of K-edge phenomenon in X-ray imaging. (Hint: use bone, soft tissue and lipid in your explanation)

(8 marks)

(c) 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.

(i) Determine the percentage of X-rays absorbed by the gadolinium-based phosphor layer with the thickness of 4 μm and 50 μm.

(6 marks)

(ii) Assess on how the thickness of the X-ray detector can affect the quality of the diagnostic image.

(4 marks)

Q4 (a) (i) Describe in brief the principle of imaging with Computed Tomography (CT).

(3 marks)

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

(4 marks)

(iii) Justify the reason CT scan is more appropriate to be used in emergency rooms compared to MRI.

(3 marks)

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

(i) With the aid of diagram, demonstrate the phenomenon of beam hardening in CT imaging.

(6 marks)

(ii) Discuss **TWO (2)** ways to overcome this issue.

(2 marks)

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

(3 marks)

(c) Radiation doses in CT is comparatively higher than the doses required by a radiographic image of the same region (the effective doses in a factor of 10 to 100 or more). Explain the reason the radiation dose in the CT is higher compared to the conventional x-ray imaging.

(4 marks)

– END OF QUESTIONS –

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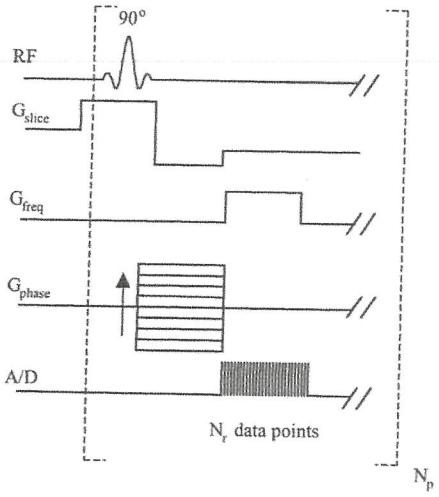

Figure Q1(b)

Table Q2(c)

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

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RELATED FORMULAE

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

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

$$T_I + R_I = 1$$

$$T_P - R_P = 1$$

$$I \propto P^2$$

Where;

R_P	: the pressure reflection coefficient of ultrasound wave
θ_i	: the angle of incident ultrasound wave
θ_t	: the angle of transmission ultrasound wave
c_1	: the speed of ultrasound wave in tissue 1
c_2	: the speed of ultrasound wave in tissue 2
R_I	: the intensity reflection coefficient of ultrasound wave
T_I	: the intensity transmission coefficient of ultrasound wave
T_p	: the pressure transmission coefficient of ultrasound wave
I	: the intensity of ultrasound wave
P	: the pressure of ultrasound wave