



UTHM

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023**

COURSE NAME : MEDICAL IMAGING

COURSE CODE : BEJ 45103/ BEU 40403

PROGRAMME CODE : BEJ

EXAMINATION DATE : JULY/AUGUST 2023

DURATION : 3 HOURS

INSTRUCTION : 1. ANSWER ALL QUESTIONS.

2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**.

3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTIONS PAPER CONSISTS OF **FOUR (4)** PAGES

- Q1** (a) In an ultrasound transducer system, a plastic matching layer is usually added to the external face of the piezoelectric crystal.
- (i) State **TWO (2)** functions of the plastic matching layer. (2 marks)
- (ii) Justify the need for the acoustic impedance of the matching layer, Z_{ML} value to be as in the equation $Z_{ML} = \sqrt{Z_c Z_s}$, where Z_c is acoustic impedance of the crystal and Z_s is the acoustic impedance of the skin. (4 marks)
- (b) Calculate the transducer operating frequency, f if given that the length of the near field boundary (NFB) zone is 15 cm and the crystal radius, r is 0.7 cm. By maintaining the same operating frequency, determine the new length of NFB zone if the crystal radius is changed to 1.0 cm. If the crystal radius is to be maintained at 1.0 cm, and the NFB zone length is 15 cm, calculate the new operating frequency. Conclude your findings. (Assume that the speed of sound in tissue is 1540 ms^{-1}) (10 marks)
- (c) There are three basic ultrasound diagnostic scanning modes available, namely A-mode, B-mode, and M-mode. Differentiate all **THREE (3)** modes in terms of their definition, application, and output signal, respectively. You may use any appropriate figure/illustration to differentiate the output signal. (9 marks)
- Q2** (a) With the help of appropriate illustration, explain the working principle of X-Rays. (7 marks)
- (b) **Figure Q2(b)** shows the energy spectrum of a beam emitted from an X-rays tube with a tungsten anode operating at 140 kVp. The spectrum represents a plot of the relative number of X-rays produced as a function of their energy.
- (i) Name **TWO (2)** separate mechanisms by which X rays are produced. (2 marks)
- (ii) Relate the mechanisms mentioned in **Q2(b)(i)** with the energy spectrum shown in **Figure Q2(b)**. Give proper explanations to justify your answer. (6 marks)
- (c) **Figure Q2(c)** shows the output image of a specialized X-rays imaging technique. Name the technique and explain the procedures involved to acquire the output image in **Figure Q2(c)**. (5 marks)
- (d) A patient is planning for a chest X-Ray procedure. If that patient is bigger in size as compared to others, evaluate the effect towards the signal-to-noise (SNR) ratio and contrast-to-noise (CNR) ratio. (5 marks)

- Q3** (a) Discuss the differences of the first, second, third and fourth generation Computed Tomography (CT) scanners. Use any appropriate illustration to support your answers. (10 marks)
- (b) Analyze **THREE (3)** hardware and image processing issues of helical Computed Tomography (CT) scanning mode. (6 marks)
- (c) During a body CT scan, the linear attenuation coefficient, μ_0 of the voxel of tissue A and B are 0.18 and 0.45, respectively. If the μ of water for this scanner is known to be 0.181,
- (i) Calculate the CT number for both tissue A and B, respectively. (4 marks)
- (ii) Based on the values of both CT numbers of tissue A and B in **Q3(c)(i)**, justify their relation to the appearance of the CT output image. (2 marks)
- (iii) If another tissue C appears to be the darkest in that same output image, predict its possible linear attenuation coefficient, μ_0 value. Give your reason. (3 marks)
- Q4** (a) List **THREE (3)** disadvantages of magnetic resonance imaging (MRI) in comparison to ultrasound imaging. (3 marks)
- (b) Explain the effect of external magnetic field, B_0 towards the energy, E of a magnetic moment. (4 marks)
- (c) Differentiate between quantum mechanical description and classical mechanical description. (4 marks)
- (d) In a MRI system, it is important to be able to measure spin-lattice, T_1 and spin-spin, T_2 relaxation time values for different tissues.
- (i) Describe both terms of T_1 and T_2 , respectively. (3 marks)
- (ii) Justify the importance of measuring both T_1 and T_2 values for different tissues. (3 marks)
- (e) In the MRI receiver system, two major components are signal demodulator and quadrature mixer. State the function and sketch the circuit diagram of both components respectively. (8 marks)

– END OF QUESTIONS –

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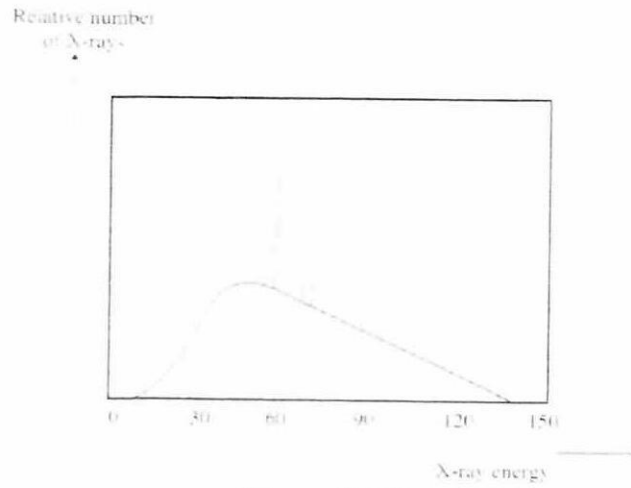


Figure Q2(b)

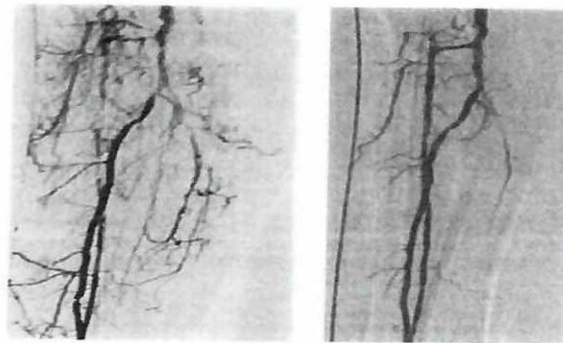


Figure Q2(c)