



UNIVERSITI TUN HUSSEIN ONN MALAYSIA

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

COURSE NAME : MEDICAL IMAGING

COURSE CODE : BEJ 45103

PROGRAMME CODE : BEJ

EXAMINATION DATE : FEBRUARY 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 **FIVE (5)** PAGES

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- Q1** (a) In the ultrasound system, damping material, an epoxy substrate impregnated with metal powder is usually used to absorb the energy from the vibrating ultrasound transducer.
- (i) With the help of diagrams, show the effect of lower and higher amount of damping material in frequency domain, respectively. (4 marks)
- (ii) Discuss the effect of different amount of damping materials towards the bandwidth, BW and quality factor of the transducer, Q.
(Hint: $Q = \frac{2\pi f_0}{BW}$) (4 marks)
- (b) The main ultrasound beam consists of near field boundary (NFB) zone and far field boundary (FFB) zone. Assuming that the speed of sound in tissue is 1540 ms^{-1} ,
- (i) Calculate the transducer operating frequency, if the given length of the NFB zone is 16 cm and the crystal radius is 0.7 cm. (4 marks)
- (ii) Determine the angle of the divergence for the FFB zone. (3 marks)
- (c) Describe any **TWO (2)** of the ultrasound basic scanning modes. (4 marks)
- (d) Spatial resolution is defined as the ability to distinguish small structures with clarity. There are three distinct measures in spatial resolution. Explain briefly those three measures. (6 marks)
- Q2** (a) With the help of illustration, explain in general the working principle of X-Ray machine. (7 marks)
- (b) In addition to the X-ray tube, analyse the function of **THREE (3)** other basic components of a planar X-ray radiography system. (6 marks)
- (c) In X-ray imaging, to achieve a well-defined small area of X-ray beam, the anode of the X-ray tube is usually bevelled. Assume that the bevel angle is 17° and the distance between the X-ray source and the patient is 28 cm,
- (i) Determine the width of actual focal spot needed to achieve the effective focal spot of 1 mm. (3 marks)
- (ii) Calculate the coverage of the X-ray beam. (3 marks)

- (d) Compare **FOUR (4)** technical aspects between the regular planar X-ray imaging and digital mammography, respectively. (4 marks)
- (e) Lists down **TWO (2)** factors affecting the Contrast to Noise Ratio (CNR) in x-ray imaging. (2 marks)

Q3 (a) With illustration, discuss the differences of the first, second, third and fourth generation Computed Tomography (CT) scanners. (8 marks)

(b) The reconstruction of CT image from a series of projections is generated via inverse Radon transform, performed using filtered backprojection techniques. With the aid of suitable illustration, describe the process of backprojection. (4 marks)

(c) During a body CT scan, the linear attenuation coefficient, μ_0 of the particular voxel of tissue A and B are 0.01 and 0.5, 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 images. (3 marks)

(d) Fill in the blanks with appropriate answers.

(i) Helical CT is the _____-generation scanners. It has multiple _____ which are used for power and signal transmission. (2 marks)

(ii) A bow-tie filter made of a metal such as _____ can reduce the effect of _____. (2 marks)

(iii) Fourth-generation CT scanners operate with a _____ X-Ray tube and a _____ ring of detectors. (2 marks)

Q4 (a) Describe **THREE (3)** disadvantages of Magnetic Resonance Imaging (MRI) in comparison to Computed Tomography (CT). (3 marks)

(b) By using the block diagram and illustrations, construct the idea of Magnetic Resonance Imaging (MRI) working principle.

(5 marks)

- (c) **Figure Q4(c)** shows a block diagram of a receiver used in standard Magnetic Resonance Imaging (MRI) system.
- (i) State the name of the component in (i) and (ii) in **Figure Q4(c)** respectively. (2 marks)
 - (ii) Explain the function of (i) and (ii) respectively. (2 marks)
 - (iii) Illustrate a circuit diagram containing both components (i) and (ii). Label all the related signals and components. (6 marks)
- (d) Calculate the Larmor frequencies (in MHz), for magnetic fields, B_0 of 3.5 Tesla and 7.5 Tesla, respectively. Use $\gamma = 267.54 \times 10^6 \text{ Hz/T}$. (4 marks)
- (e) Identify the type of magnet used in designing the Magnetic Resonance Imaging (MRI) based on conditions below:
- (i) The magnet has two pole pieces, above and below patient bed, an arrangement that allows easy access to the patient. (1 mark)
 - (ii) The magnetic field of the magnet is created by the passage of a constant current through a conductor such as copper. (1 mark)
 - (iii) The magnets are used for most systems above 0.35 T. (1 mark)

– END OF QUESTIONS –

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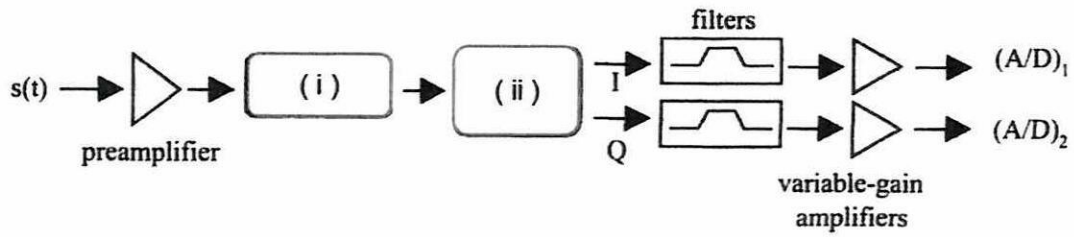


Figure Q4(c)

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