UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEJ 45103/ BEU 40403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS **OPEN BOOK EXAMINATION**

THIS QUESTIONS PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) **Table Q1(a)** shows the acoustic impedance, Z and speed of sound, c of different biological tissues. Given the incident intensity, I_i is 50 mW and the angle between the incident wave and the boundary is 90°. Based on the **Table Q1(a)**,

(i) Calculate the transmitted intensity, I_t if the ultrasound wave travels from fat to muscle, and fat to bone, respectively.

(6 marks)

(ii) If the angle between the incident wave and the boundary is not 90°, deduce the interaction process that may occur when ultrasound wave travels from fat to liver. Use appropriate illustration to show the interaction process.

(4 marks)

(iii) Discuss why imaging through air or bone is generally not possible.

(2 marks)

(b) The main ultrasound beam can be divided into Near Field Boundary (NFB) and Far Field Boundary (FFB). NFB is situated adjacent to the transducer face and has a converging beam profile while FFB diverges in lateral direction and the axial intensity of the ultrasound beam decreases smoothly. Assuming that the speed of sound in tissue is 1540 ms^{-1},

(i) Determine the length of the NFB for a transducer operating at 5 MHz, with a crystal diameter of 1 cm.

(4 marks)

(ii) Calculate the approximate beam width at 15 cm from the transducer surface.

(5 marks)

(c) Explain the minimal required separation distance between two boundaries of objects to be distinguishable in lateral and axial resolution.

(4 marks)

Q2 (a) **Figure Q2(a)** shows the energy spectrum of a beam emitted from an X-ray tube with a tungsten anode operating at 140 kVp.

(i) Discuss the situation circled in red.

(4 marks)

(ii) The energy at which these peaks in **Figure Q2(a)** occur is depending on the metal used in the anode. As in this case, it is tungsten. By using appropriate calculation, illustration, and labelling, explain the events involved in the production of such peak values.

(9 marks)

(b) A patient with the chest thickness of 18 cm will undergo a chest X-ray scan. Given that the half-value layer (HVL) of muscle is 3.9 cm, HVL of bone is 2.3 cm, and the thickness ratio of muscle to bone is 15 cm:3 cm. Estimate the percentage of X-rays that will be transmitted through the patients' chest at an incident X-ray energy of 100 keV.

(5 marks)

(c) Digital mammography is one of the x-ray imaging applications to detect small tumors and microcalcifications in the breast.

(i) Differentiate **THREE (3)** technical aspects between the regular planar X-Ray imaging and specialized techniques of Digital Mammography.

(3 marks)

(ii) Discuss the importance of breast compression technique in conducting digital mammography procedures.

(4 marks)

Q3 (a) The reconstruction of Computed Tomography (CT) image from a series of projections is generated via inverse Radon transform, performed using filtered backprojection techniques.

(i) With the aid of suitable illustration, describe the process of backprojection.

(4 marks)

(ii) To implement filtered backprojection technique, the components of the X-ray beam striking each detector element need to be in parallel. Describe on how to produce parallel projections from fan beam data.

(4 marks)

(b) 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(b)(i)**, explain their relation to the appearance of the CT output images.

(3 marks)

(c) 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) Streak artifacts can be reduced by increasing the number of _____.
(1 mark)

(iii) The _____ artifact is visible in 3D images as a spiral winding along inclined surface.
(1 mark)

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

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

(d) List any **TWO (2)** actions that could be done to keep the radiation dose as low as possible.
(2 marks)

Q4 (a) By using the block diagram and illustrations, construct the idea of Magnetic Resonance Imaging (MRI) working principle.
(5 marks)

(b) **Figure Q4(b)** shows a standard block diagram of the MRI receiver.

(i) State the components for A and B, respectively.
(2 marks)

(ii) Explain the function of A and B, respectively.
(2 marks)

(iii) Construct **ONE (1)** complete circuit diagram combining both A and B components. Label also all the related input and output signals.
(8 marks)

(c) Calculate the Larmor frequencies (in MHz), for magnetic fields, B_0 of 2 Tesla and 6 Tesla, respectively. Use γ = 267.54 x 106 Hz/T.
(4 marks)

(d) Differentiate between quantum mechanical description and classical mechanical description.
(4 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2020/2021
COURSE NAME : MEDICAL IMAGING
PROGRAMME CODE : BEJ
COURSE CODE : BEJ45103/BEU40403

Table Q1(a)

	Characteristic Acoustic Impedance x 10^5 (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

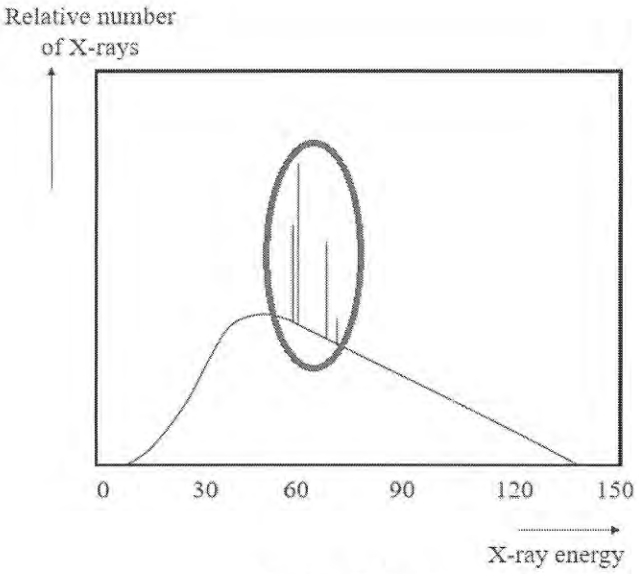

Figure Q2(a)

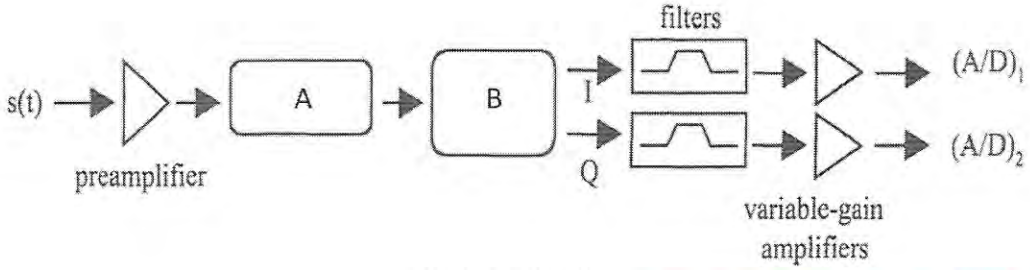

Figure Q4(b)