



UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022**

COURSE NAME : MEDICAL IMAGING
COURSE CODE : BEJ 45103/ BEU 40403
PROGRAMME CODE : BEJ
EXAMINATION DATE : JULY 2022
DURATION : 3 HOURS
INSTRUCTION : 1. ANSWER ALL QUESTIONS.
2. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**.

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

- Q1** (a) A machine vision system is a combination of hardware and software designed to solve problems involving the analysis of visual scenes using intelligence algorithms.

Problem 1: Separate a set of database containing kidney ultrasound images into two categories of cystic kidney (CAT1), and normal kidney (CAT2), respectively.

Problem 2: From a mammography image database, distinguish between images with breast cancer (CAT1) and images of non-cancerous breast (CAT2).

Problem 3: A set of database contains brain magnetic resonance imaging (MRI) images. Classify the images into two groups of brain with tumor (CAT1) and brain without tumor (CAT2), respectively.

- (i) Based on any **ONE (1)** of the problems given, design a block diagram of a machine vision system. Explain each block in the diagram specific to solve the problem that you have chosen. (8 marks)
- (ii) Table **Q1(a)(ii)** shows the outcomes coming from the classification stage of your developed system in **Q1(a)(i)**. Determine the accuracy of the system. Conclude your findings. (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 given that the length of the NFB zone is 14.5 cm and the crystal radius is 0.8 cm. (4 marks)
- (ii) Determine the angle of the divergence for the FFB zone. (3 marks)
- (iii) Find the lateral beamwidth at a distance of 18 cm from the transducer surface. (3 marks)
- (c) List any **TWO (2)** artifacts in ultrasound imaging and suggest the way to reduce the effect of those mentioned artifacts. (3 marks)

- Q2** (a) The X-ray tube is the source of X-ray and one of the main components inside the tube is the anode.

(i) Propose a design of an anode in the X-ray tube in order to produce an effective focal spot of 0.8 mm, if the width of the electron beam is set at 3.5 mm. Include related calculations and appropriate illustrations to support the design. (6 marks)

(ii) Find the coverage of the X-ray beam, given that the distance between the source and the patient is 30 cm. (3 marks)

- (b) **Figure Q2(b)** shows the graph of the energy of a Compton-scattered X-ray as the function of the scatter angle for a 70 keV incident energy. By using the energy of the scattered X-ray, $E_{X,scat}$ formula, prove the graph plot is as given. Assume the value of m_0 is 511 keV/c². (5 marks)
- (c) Explain the effect of using the anti-scatter grid on the X-ray output images. (3 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. (4 marks)
- (e) Compare **FOUR (4)** technical aspects between the regular planar X-ray imaging and digital mammography. (4 marks)
- Q3** (a) Describe the principle of helical Computed Tomography (CT) and the significant improvement of the helical scanning mode compared to the axial scanning mode. (4 marks)
- (b) Image reconstruction is preceded by a series of corrections. One of the corrections is made for the effects of beam hardening. Describe the phenomenon of beam hardening and its effect on the image. (4 marks)
- (c) With illustration, discuss the differences between the first, second, third and fourth generation CT scanners. (10 marks)
- (d) Machine learning is a method of developing algorithms or statistical models based on data to analyse and draw inferences from patterns in the data. It is considered as a branch of artificial intelligence. Discuss the advantages and disadvantages of machine learning and by giving an example, explain how machine learning can be used for medical imaging. (7 marks)
- Q4** (a) List down **TWO (2)** advantages and disadvantages of MRI. (4 marks)
- (b) According to classical mechanics of nuclear magnetism, the effect of placing a proton in a magnetic field is that it precesses around the axis of that field at a frequency proportional to the strength of the magnetic field and the frequency is termed as Larmor frequency. With the aid of diagrams and related formulae, derive the Larmor frequency according to the classical mechanics of nuclear magnetism. (9 marks)

- (c) **Figure Q4(c)** shows the basic MRI sequence, which is also known as the gradient-echo imaging sequence. According to a respective sequence in **Figure Q4(c)**, describe how the image orientation of axial, sagittal and coronal in MRI can be achieved.
- (3 marks)
- (d) Time constants T_1 and T_2 give valuable information about the physiological state of tissue and knowledge of these values allow MRI imaging sequences to be designed to give maximum image contrast.
- (i) Define the terms T_1 and T_2 .
- (2 marks)
- (ii) For the five frequencies (1-5) shown in **Figure Q4(d)**, state the order of the T_1 and T_2 values, for example, at frequency 1: T_1 (tissue 1) $>$ T_1 (tissue 2) $>$ T_1 (tissue 3).
- (7 marks)

– END OF QUESTIONS –

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2021/2022
COURSE NAME : MEDICAL IMAGING

PROGRAMME CODE : BEJ
COURSE CODE : BEJ45103/BEU40403

Table Q1(a)(ii)

		Actual Situation	
		CAT1	CAT2
Classification by developed system	CAT1	2167	42
	CAT2	63	2728

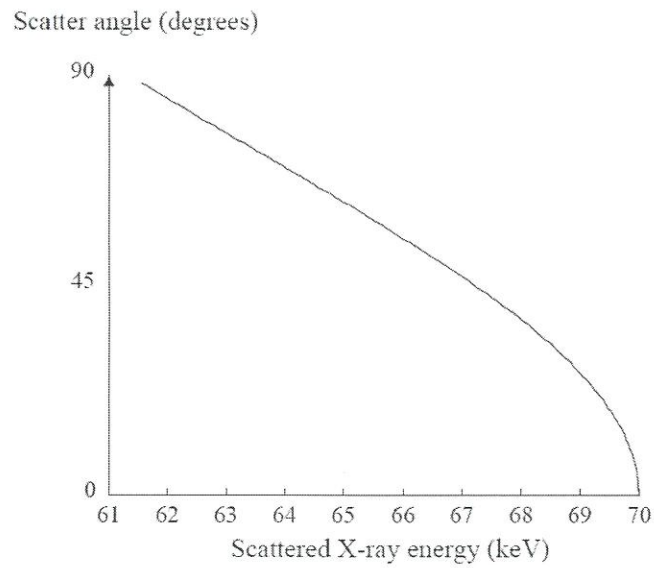


Figure Q2(b)

CONFIDENTIAL

FINAL EXAMINATION

SEMESTER / SESSION : SEM II 2021/2022
COURSE NAME : MEDICAL IMAGING

PROGRAMME CODE : BEJ
COURSE CODE : BEJ45103/BEU40403

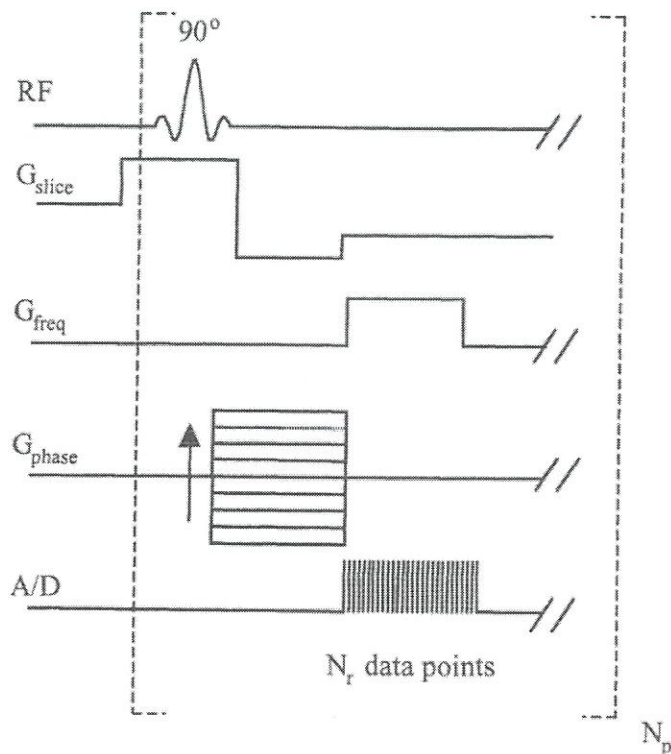


Figure Q4(c)

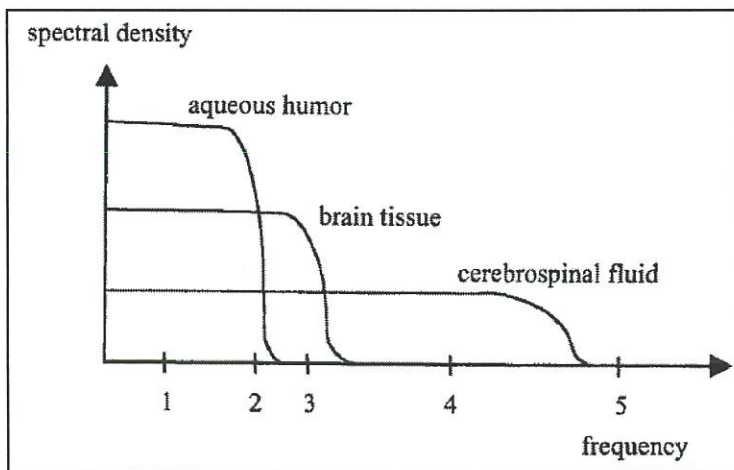


Figure Q4(d)

THESE MATERIALS ARE THE PROPERTY OF THE UNIVERSITY OF MALAYA AND ARE NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM.