CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

FOURTH YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN BIOMEDICAL SCIENCES

BMET 452: MEDICAL IMAGING TECHNIQUES

STREAMS: **TIME:2 HOURS**

DAY/DATE: THURSDAY 13/04/2023 **11.30 A.M. –1.30 P.M.**

INSTRUCTIONS

- Answer Question One in Section A and any other Two Questions in Section B
- Do not write anything on the question paper
- This is a closed book exam, No reference materials are allowed in the examination room
- There will be No use of mobile phones or any other unauthorized materials
- Write your answers legibly and use your time wisely

QUESTION ONE (30 MARKS)

a) Sketch the X-ray spectrum at the following locations:

i. After the X-ray target, before any filter

ii. After the filter, before reaching the patient (3 marks)

b) Describe the production of X-rays by means of bremsstrahlung interaction. (2 marks)

c) PM was told that he needs to perform an angiogram due to his chest pains. After the test, he was told that he requires coronary angioplasty.

i. What is an angiogram? Explain briefly. (2 marks)

ii. What may be the diagnosis for this patient? (1 mark)

iii. What is coronary angioplasty? Explain. (2 marks)

d) Identify which two statements are true regarding basic radiation protection principles

A. When deciding on whether an examination is justified, the ALARA principle should be taken into account

B. The recommendations of the International Commission on Radiological Protection introduced three basic principles of radiation protection: justification, optimization and diagnostic reference levels

C. Justification can be made where the medical benefit does not exceed the risk

D. Radiation protection is considered appropriate if exposure is kept within the required limits

E. Dose limits do not apply to patients (2 marks)

e) Explain why the three statements you have left out in (d) above are incorrect. (3 marks)

f) A 5 MHz ultrasound beam incident perpendicularly onto a patient body, traversing 2 cm of muscle tissue, 3 cm of fat, and 4 cm of liver. The tissue properties are given in Table 1., and

$$R = \frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$$

Table 1

Tissue Type	**Characteristics Acoustic Impendence $Z(Kg\ m^{-2}s^{-1})$**	**Attenuation Coefficient α $(dB\ cm^{-1}\ MHz^{-1})$**
Muscle	$1.70\ x\ 10^{-6}$	0.6
Fat	$1.38\ x\ 10^{-6}$	1.0
Liver	$1.60\ x\ 10^{-6}$	0.4

i. Calculate the reflection index of the signal at the two interfaces. (4 marks)

ii. Give a conclusion to your calculation in (i) above (1 mark)

iii. Calculate the total energy loss of the ultrasound signal. (2 marks)

iv. Give a conclusion to your calculation in (iii) above (1 mark)

g) Using sketch diagrams, explain how Time-Domain Optical Coherence Tomography (TDOCT) is achieved. (4 marks)

h) A computed radiography (CR) image with an image matrix of 2048 × 2500 was used to image a field of view of 35.56 × 43.18 cm^2.

a. What is the pixel size? (2 marks)

b. The CR image is stored with 10 bit/pixel. What is the bit depth for this image? (1 mark)

QUESTION TWO (20 MARKS)

Today's medical imaging is incredibly advanced and sophisticated. They have been invented all by physicists, utilizing the latest physics principles and technologies. Let's explore five important three-dimensional scanning:

a) X-ray CT scan,
b) MRI,
c) PET (Positron Emission Tomography),
d) OCT(Optical Coherent Tomography), and
e) Ultrasound.

Explain briefly the physical principle concisely. Try to address five key points:

(1) What kind of particles/waves is used? (5 marks)
(2) What wavelength and energy? (5 marks)
(3) How deep can it penetrate in human body? (5 marks)
(4) What is the most useful application(s)? (5 marks)

QUESTION THREE (20 MARKS)

a) In the context of Ultrasonic waves, what are reflection, refraction, scatter and absorption? What is their effect on an ultrasound image? Put your response in a table form. (8 marks)
b) Calculate the angle of transmission for ultrasound striking the interface between fat and muscle at an incident angle of 25°. Given the speed of sound for fat and muscle is 1450 ms^{-1} and 1590 ms^{-1}, respectively. (4 marks)
c) The intensity of a 3 MHz ultrasound beam entering tissue is 10 $mWcm^{-2}$. Calculate the intensity at a depth of 4 cm. (The attenuation coefficient is 1 dB cm^{-1} MHz^{-1}.) (6 marks)
d) What is the physical reason to avoid an air gap between the transducer and the patient? How can it be avoided? (2 marks)

QUESTION FOUR (20 MARKS)

a. Using illustration figures, explain how digital subtraction angiography (DSA) works (7 marks)
b. Give examples where this technique is used clinically. (2 marks)
c. Comment on how digital image subtraction affects quantum noise and structure noise in a digital image. (3 marks)
d. Suggest a method to reduce quantum noise in DSA images. (2 marks)

e. What are potential complications of angiograpy? (3 marks)

f. Angiographic procedures use contrast media in order to make fine blood vessels visible. What are the main requirements of the contrast media? (3 marks)

QUESTION FIVE (20 MARKS)

A 42 year old female presents to your office. After reviewing the medical history and gathering her vital signs questions are asked about her dental history. The patient reveals she has not been to the dentist for 4 years. She states she has had fillings and thinks she had a root canal and crown but can't remember which tooth. She currently has some sensitivity on a maxillary molar tooth when she drinks cold beverages.

a) Explain what you would say to the patient about the need for x-rays or radiographs. (4 marks)

b) Identify and briefly describe three types of dental X-ray radiographs (6 marks)

c) Which of the three types of radiographs in (b) would you recommended for this patient and why. (3 marks)

d) Identify any one risks concern that you may have for this particular patient. (1 mark)

e) Discuss the safety measures taken so the patient will not be exposed to unnecessary radiation. (3 marks)

f) What is ALARA? (3 marks)
