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: BSC (BMED) **TIME: 2 HOURS**

DAY/DATE: FRIDAY 06/12/2019 **8.30 A.M. – 10.30 A.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)

1. With reference to figure 1.

a. Define attenuation **(2 marks)**

b. Explain the difference between 60 keV gamma ray and 60 kVp X-ray beam. **(2 marks)**

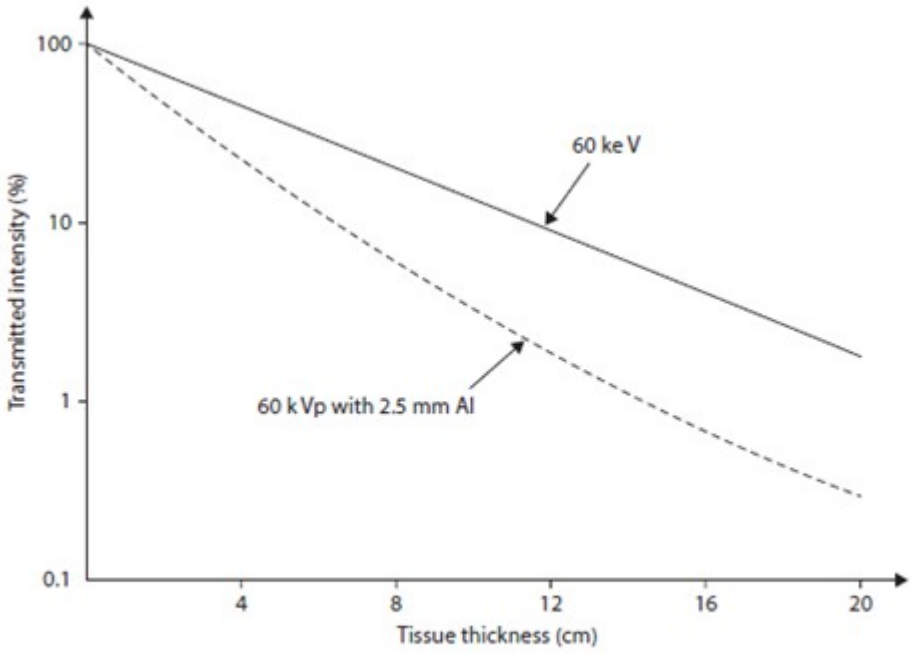

FIGURE 1. Attenuation in soft tissue for a 60 keV gamma ray and for a 60 kVp X-ray beam.

2. Discuss briefly the ALARA principle **(6 marks)**
3. If a 2 mm thick of material transmits 40% of a monenergistic photon beam, calculate the half value layer of the beam. **(4 marks)**
4. List five indications that Angiography can identify. **(5 marks)**
5. Differentiate between MRI and CT scan in terms of;
   a. Production of imaged by radiation **(2 marks)**
   b. Utility of room shielding **(2 marks)**
   c. Materials used for shielding **(2 marks)**
6. Draw the X-ray tube spectrum, i.e., the intensity distribution of X-rays as a function of the frequency of emitted X-ray photons (1) at the exit of the X-ray tube before any

filtering takes place, and (2) after the filter but before the X-rays have reached the patient. **(5 marks)**

QUESTION TWO (20 MARKS)

a. Explain how radiation energy is attenuated while passing through a medium. **(3 marks)**

b. A beam of X-rays, consisting of 10^9 photons, passes through a 5 cm thick slab (medium) where there are two attenuation processes taking place. Using linear attenuation coefficient $\mu_1 = 0.02\ cm^{-1}$ and $\mu_2 = 0.04\ cm^{-1}$, respectively:

   i. Calculate how many photons are transmitted. **(2 marks)**

   ii. Calculate how many photons are absorbed by each process in the slab. **(3 marks)**

c. Why are computed radiography (CR) systems considered to have better dynamic range compared to screen film (SF) systems? Use Figure 3 to explain your answer. **(3 marks)**

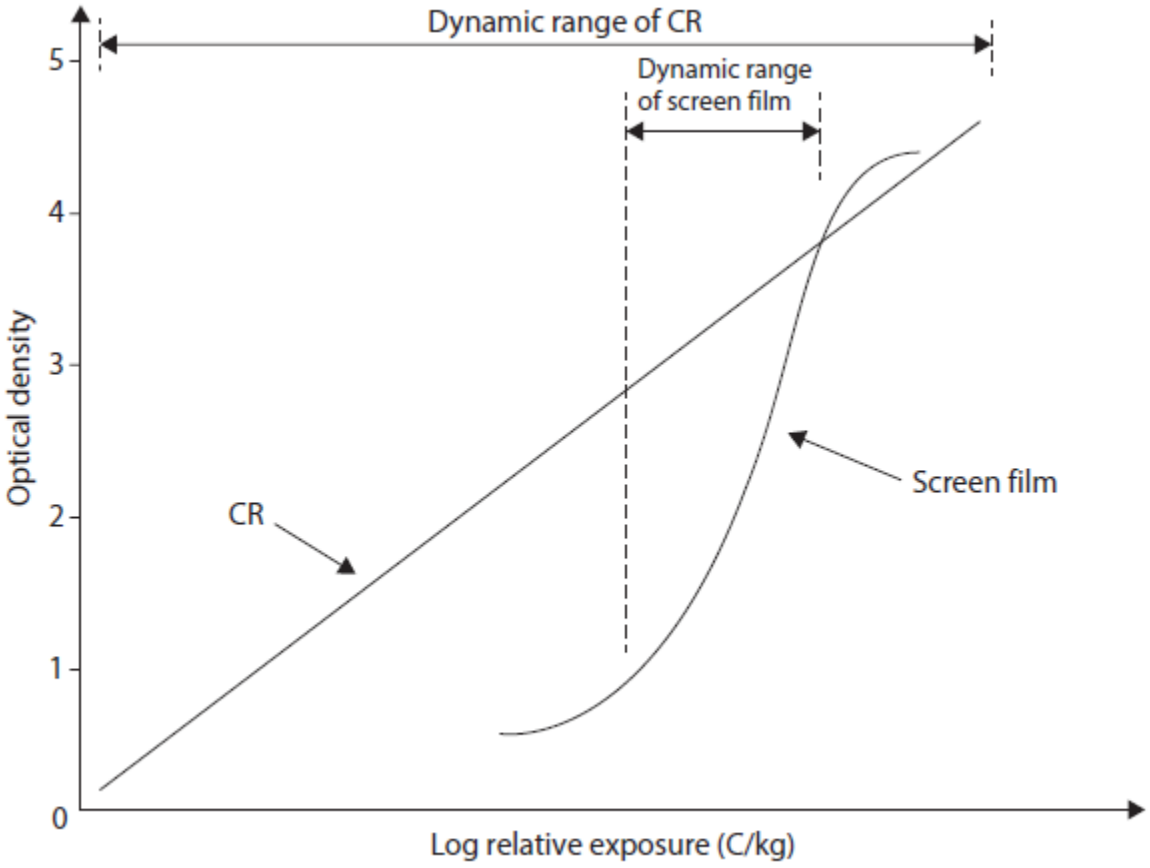

FIGURE 3. Characteristic curves of a CR and a SF system.

d. (i) Calculate the required storage capacity (in megabytes, MB) to store an uncompressed 10 seconds, 8-bit grayscale ultrasound video file of 512 × 512 pixel dimensions, given that the frame rate for the video is 30 frames/seconds. **(3 marks)**

(ii) What would be the new required storage if the video were in RGB colour format instead? **(3 marks)**

e. 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. What is the pixel size? The CR image is stored with 10 bit/pixel. What is the bit depth for this image? **(3 marks)**

QUESTION THREE (20 MARKS)

a. What is spiral (or helical) CT scanning? **(2 marks)**

b. Explain briefly the technology that enables spiral CT scanning. **(3 marks)**

c. List the advantages of Multidetector spiral CT over single slice scanning. **(4 marks)**

d. The main advantage of spiral scanning is the reduction of image acquisition time. State four possible advantages related to this. **(4 marks)**

e. Contrast between the tissues of the body can be improved by the use of contrast agents. What are contrast agents? (1 mark)

f. Differentiate between oral contrast and intravenous contrast. **(3 marks)**

g. Discuss four drawbacks of CT **(4 marks)**

QUESTION FOUR (20 MARKS)

a. Explain briefly the terms 'axial resolution' and 'lateral resolution' in ultrasound imaging. **(2 marks)**

b. Describe briefly how axial and lateral resolution vary with transducer frequency and penetration depth. **(4 marks)**

c. 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)**

d. 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)**

e.

1. Explain the physics behind the use of contrast agents in ultrasound. **(2 marks)**
2. What physical property and type of interaction does a contrast-enhanced ultrasound make use of? **(1 mark)**
3. State one example of an element which can be used as a contrast agent in ultrasound imaging. **(1 mark)**
