UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020

COURSE NAME : MEDICAL IMAGING

COURSE CODE : BEU 40403

PROGRAMME CODE : BEJ

EXAMINATION DATE : JULY 2020

DURATION : 3 HOURS

INSTRUCTION : ANSWER **ALL** QUESTIONS
         OPEN BOOK EXAMINATION

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THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Find the reflected intensity of ultrasound beam that travelled from soft to hard tissue. Given the values of acoustic impedance of soft and hard tissue are 1.4 and 7.8 $kgm^{-2}s^{-1}$, respectively, and the incident intensity is 35 mW. The incident wave and transmitted wave angle are 30° and 60°, respectively.

(5 marks)

(b) The speed of ultrasound wave (c) and the acoustic impedance (Z) of hard tissue is comparably higher than those of soft tissue. Explain the reason(s) for these differences.

(5 marks)

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

(4 marks)

(d) Nowadays, there are many breakthroughs and advancements on ultrasound imaging technology.

(i) Describe the difference among 2D, 3D, 4D, 5D, and 6D ultrasound.

(5 marks)

(ii) Explain in details the application of ultrasound imaging for cancer or tumor treatments and identify the challenge(s) and solution(s) of this technique.

(6 marks)

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Q2   (a)   The X-ray tube produces X-rays with a wide range of energy spectra and there are two separate mechanisms by which X-rays are produced.

(i)   By referring to the part marked with circle in **Figure Q2(a)(i)**, identify the mechanism of the X-rays production involved and describe the production of this energy type.
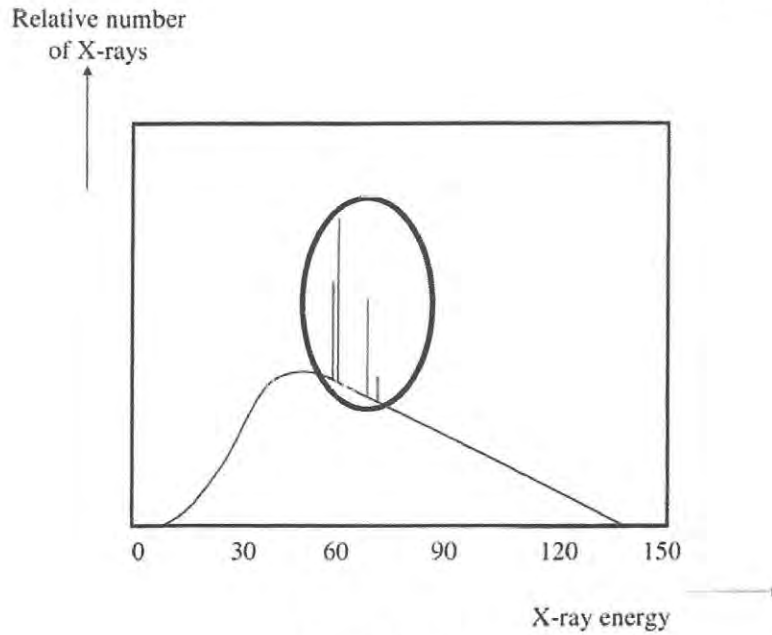
(4 marks)

Figure Q2(a)(i)

(ii)   Calculate the characteristic of x-ray released from a transition of an electron from L- to K-shell of a Tungsten target. Given the binding energies of electrons for L- and K- shell are 10.2 keV and 69.5 keV, respectively.

(1 marks)

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(b)   **Figure Q2(b)** shows the energy of a scattered x-ray as a function of the scatter angle for a 70 keV incident.
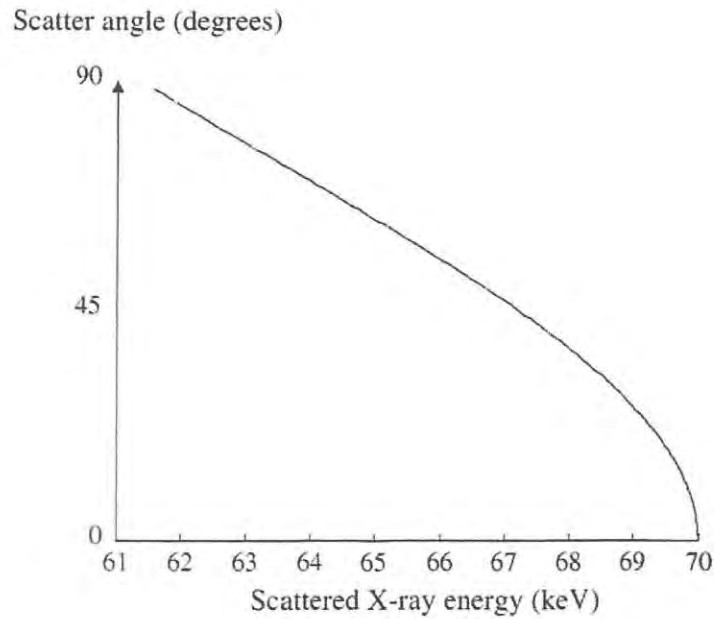
Scatter angle (degrees)

Figure Q2(b)

(i)   Identify and define the type of mechanism as the x-rays interact with tissue as shown in the figure.

(2 marks)

(ii)   Examine the possibilities that this scattered x-ray can either be detected or otherwise as it passes through the body.

(3 marks)

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(c)   Digital mammography is one of the x-ray imaging applications to detect small tumors and microcalcifications in the breast. **Figure Q2(c)** shows the energy spectra of a digital mammography (molybdenum target) embedded with (solid line) and without (dotted line) molybdenum filter.
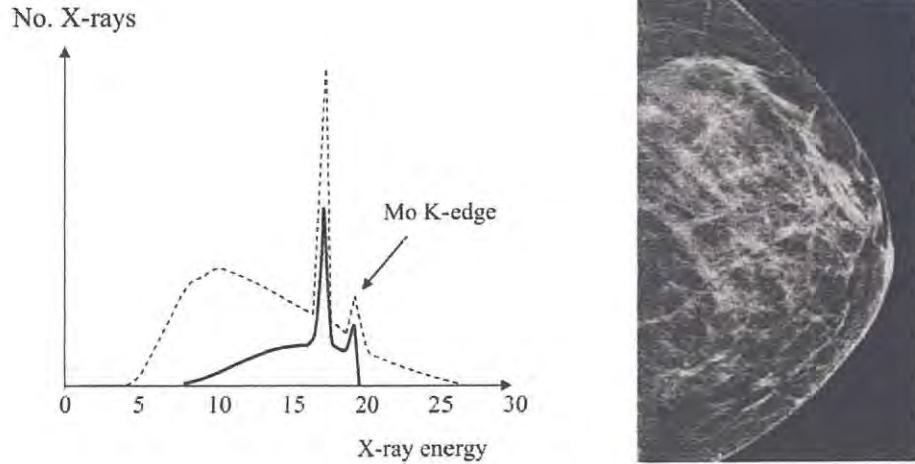

Figure Q2(c)

(i)   Based on the figure, point out the important technical and safety features of the mammography imaging instrumentations in order to reduce the exposure dosage and improve the diagnostic quality.

(6 marks)

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

(5 marks)

(d)   "It is time for radiology departments to eliminate lead shields when performing X-ray exams, medical physicists at the University of Colorado School of Medicine in Aurora contend. They explain why technological changes in X-ray equipment have negated the assumption that shielding improves patient safety and made decades-old federal regulations obsolete in the April 2019 issue of the *American Journal of Roentgenology*."

Justify the consequence of patient shielding when performing X-ray exams.

(4 marks)

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Q3   (a)   Explain the basis of success of the third-generation CT scanners over the fourth-generation CT scanners.

(1 mark)

(b)   CT is used for a wide range of clinical conditions in almost every organ of the body such as brain, lymph nodes, lung, pelvis, liver, gall bladder, spleen, kidneys, GI tract, spine, and extremities.

(i)   Lists **TWO (2)** applications of medical imaging.

(2 marks)

(ii)   Determine the optimisation in CT imaging that can be adopted in the application of cardiac imaging.

(3 marks)

(c)   In the absence of specific therapeutic drugs or vaccines for COVID 19, it is essential to detect the disease at an early stage and immediately isolate an infected patient from the healthy population. One of the practical method to diagnose this disease is by using rapid test kits. However, the clinical study has found that the sensitivity of the testing kits is between 60 to 70% in which it still can trigger a false negative results.

(i)   Based on your opinion, point out the strength and the weakness of CT imaging that can be used to diagnose COVID 19 in comparison to rapid test kits technique.

(12 marks)

(ii)   Suggest and justify another type of medical imaging device that can also be used to diagnose this disease in order to reduce the exposure of the infected patient to the hospital environment, physician and the imaging device itself.

(7 marks)

Q4 (a) Explain in details the basic principles of Magnetic Resonance Imaging based on the Quantum Mechanical Description.

(7 marks)

(b) A brain tumor has a lower concentration of water than surrounding healthy tissue. The T1 value of protons in the tumor is shorter than that of the protons in healthy tissue, but the T2 value of the tumor protons is longer.

(i) Determine the kind of weighting (values for TE and TR) that should be introduced into the spin echo imaging sequence to ensure there is a contrast between the tumor and healthy tissue.

(6 marks)

(ii) If a large concentration of superparamagnetic contrast agent is injected and accumulated only in the tumor. Formulate the optimal weighting.

(2 marks)

(c) Propose in details the major breakthrough or advancement of MRI for the future in order to achieve more comfortable MRI scans for patients, faster scan times, and clearer images. Give appropriate examples to support your arguments.

(10 marks)

– END OF QUESTIONS –

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