Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2016/2017

COURSE NAME	:	MEDICAL IMAGING
COURSE CODE	:	BEU 40403
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	DECEMBER 2016 / JANUARY 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) State **FOUR (4)** advantages of ultrasound imaging.

(2 marks)

(b) Find out on why the ultrasound wave is classified as a longitudinal wave.

(2 marks)

(c) Generalise the idea of the characteristic acoustic impedance, Z of tissue as an important parameter in ultrasound imaging.

(2 marks)

(d) Describe on how the axial dan lateral measures influence the spatial resolution of ultrasound image.

(4 marks)

(e) Apply the correct term in each of the blanks in the following statements:

(i) A highly compressible medium such as.....(1)....., has a .....(2)..... speed of sound, while a less compressible medium such as bone has a .....(3)..... speed of sound.

(3 marks)

(ii) .....(4)..... is independent of the passed through medium, while.....(5)..... is dependent of the medium that makes the.....(6)..... changes when it changes.

(3 marks)

(iii) A high.....(7)..... of the ultrasound wave gives superior .....(8)....., but reduces the.....(9).....of the wave and increase the.....(10).....

(4 marks)

(f) By referring to **Table Q1(d)** and related formulas given, solve the following problems given:

(i) The relative intensity of reflected ultrasound wave that is perpendicular to the interface of fat/air.

(3 marks)

(ii) The relative intensity of transmitted ultrasound wave with the angle of the incidence of the ultrasound beam being 30°. Determine whether the transmitted ultrasound wave is refracted or not.

(7 marks)

(g) Intensity of ultrasound is measured in decibels as a relative intensity.

(i) Calculate the remaining intensity of a 75-mW ultrasound pulse that loses 50 dB while traveling through tissue.

(5 marks)

(ii) The intensity of a 10 MHz ultrasound beam entering tissue is 30 mW/cm^2. Determine the intensity at a depth of 20 cm. (Hint: the attenuation coefficient for soft tissue is 1 dB cm^{-1} MHz^{-1})

(5 marks)

Q2 (a) Referring to **Figure Q2(a)**, describe briefly the principle of X-ray imaging.
(4 marks)

(b) Apply the correct term in each of the blanks in the following statements:

(i) X-ray imaging or known as ……(1)…... provides a ……(2)…… 'screening' for both acute injuries and suspected chronic diseases.
(2 marks)

(ii) The basis of both medical X-ray imaging is the differential …..(3)…. .of X-rays by various ……(4)……
(2 marks)

(iii) ……(5)……absorb X- rays more effectively than soft tissue, thus appears ……(6)…… in the X-ray image.
(2 marks)

(c) (i) Draw a schematic diagram of an X-ray tube which consists of its major components.
(2 marks)

(ii) With the aid of illustration(s), propose a design of an anode in the X-ray tube in order to produce an effective focal spot of the X-ray beam.
(4 marks)

(d) The X-ray tube produces X-rays with a wide range of energy spectrums and there are two separate mechanisms by which X-rays are produced. Referring to the part marked with circle in **Figure Q2(d)**, identify the mechanism of the X-rays production involved and how this type of energy spectrum is produced.
(4 marks)

(e) (i) List **TWO (2)** major mechanisms by which X-rays interact with tissue. Then, point out which mechanism minimizes a contrast in an X-ray image.
(4 marks)

(ii) If the thickness of the stomach area is 25 cm, determine the percentage of X-rays that are transmitted through the area at an incident X-ray energy of 70 keV. By assuming HVL values of 4.0 cm and 3.5 cm for fat and muscle, respectively, and the muscle thickness 15 cm and the fat thickness 10 cm.
(6 marks)

(g) The linear attenuation coefficient of a gadolinium-based phosphor in Computed Radiography (CR) used for detection of X-rays is 450 cm^{-1} at an X-ray energy of 80 keV.

(i) Calculate percentage of X-rays absorbed by the gadolinium-based phosphor layer with the thickness of 5 μm and 60 μm.
(6 marks)

(ii) Evaluate on how the thickness of the X-ray detector can affect the quality of the diagnostic image.
(4 marks)

Q3 (a) According to **Figure Q3(a)**, describe in brief the principle of imaging with Computed Tomography (CT).

(3 marks)

(b) Analyse the slip-ring function in helical CT.

(4 marks)

(c) Image reconstruction in CT is performed using filtered backprojection technique where it is preceded by a series of corrections. One of the corrections is made for the effects of beam hardening.

(i) Describe the phenomenon of beam hardening.

(3 marks)

(ii) Considering the effects of beam hardening, illustrate the final image formed from series of one dimensional projections in **Figure Q3(c)(ii)**. Assume that the sample is homogeneous and a darker image corresponds to a higher signal intensity detected.

(3 marks)

(iii) By specifying your answer, predict whether the CT number increase or decrease due to the beam hardening.

(3 marks)

(d) Radiation doses are relatively high in CT in which the effective dose is a factor of 10 to 100 and more, higher than a radiographic image of the same region. Identify on how the radiation dose in the CT is higher compared to the conventional X-ray imaging.

(4 marks)

– END OF QUESTIONS –

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Table Q1(d)

Biological Tissue	Characteristic Acoustic Impedance $x10^5$ (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

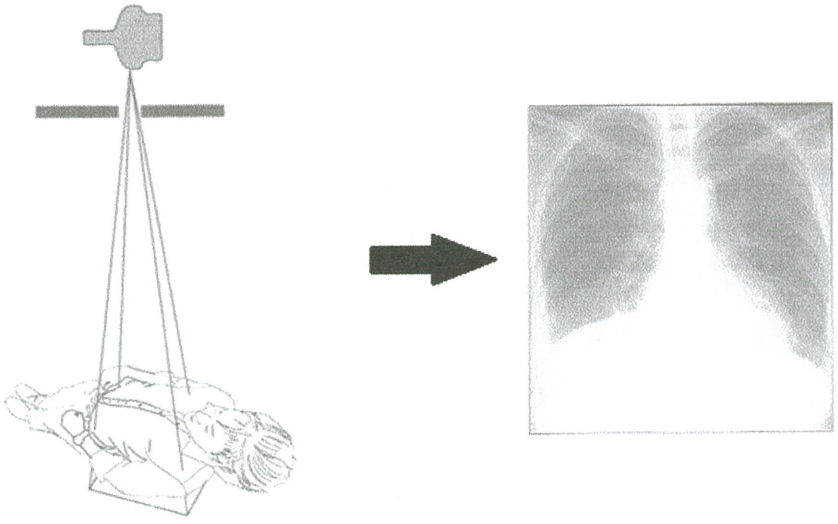

Figure Q2(a)

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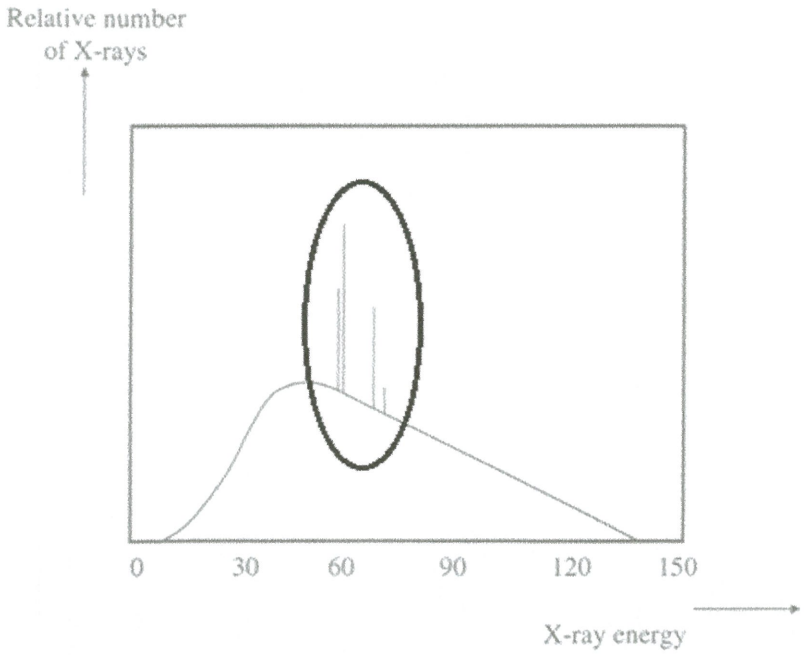

Figure Q2(d)

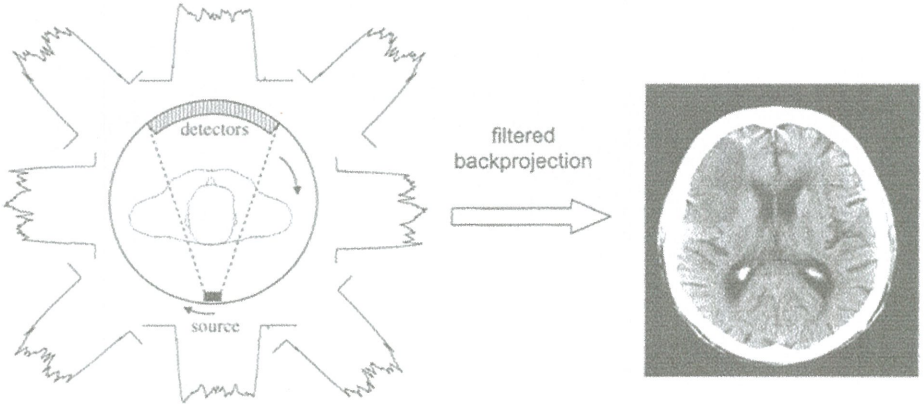

Figure Q3(a)

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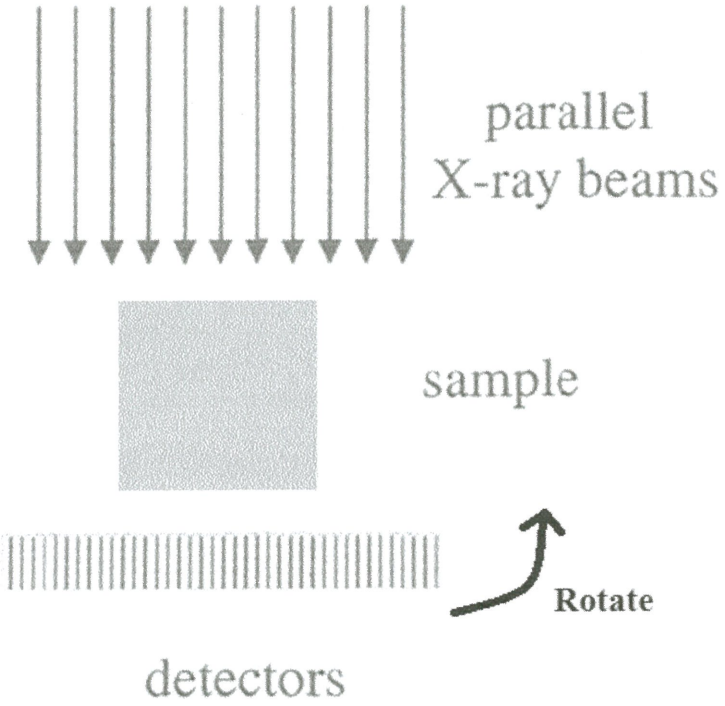

Figure Q3(c)(ii)

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RELATED FORMULAE

$$R_P = \frac{p_r}{p_i} = \frac{Z_2 \cos\theta_i - Z_1 \cos\theta_t}{Z_2 \cos\theta_i + Z_1 \cos\theta_t}$$

$$\frac{\sin\theta_i}{\sin\theta_t} = \frac{c_1}{c_2}$$

$$T_I + R_I = 1$$

$$T_P - R_P = 1$$

$$I \propto P^2$$

Where;

R_P	: the pressure reflection coefficient of ultrasound wave
θ_i	: the angle of incident ultrasound wave
θ_t	: the angle of transmission ultrasound wave
c_1	: the speed of ultrasound wave in tissue 1
c_2	: the speed of ultrasound wave in tissue 2
R_I	: the intensity reflection coefficient of ultrasound wave
T_I	: the intensity transmission coefficient of ultrasound wave
T_p	: the pressure transmission coefficient of ultrasound wave
I	: the intensity of ultrasound wave
P	: the pressure of ultrasound wave