The Royal Australian and New Zealand College of Radiologists®

e-AIT
(Applied Imaging Technology)
Paper 1 Exam

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Case 1- Radiation Biology and Safety

Question 1

(a) Starting with the definition of absorbed dose indicate how the estimated effective dose may be calculated and indicate in what context it may be regarded as a useful dose metric. **(4 marks)**

(b) Why is it inappropriate to use the effective dose as an individual risk estimate for a specific patient undergoing a diagnostic imaging procedure? **(2 marks)**

(c) In the context of biological effects of radiation describe what is meant by:

(i) the Genetically Significant Dose (GSD) and **(2 marks)**

(ii) the latent period. **(2 marks)**

Question 2

(a) A female patient of child bearing age presents at a small medical clinic with clinical indications of renal colic. She undergoes three AP abdominal X-rays on the basis that she is not pregnant. She subsequently undergoes an ultrasound examination which reveals that she was 7 weeks pregnant at the time of the examination.

The referring doctor wants to know what he can tell his patient about any possible concerns for the foetus. An entrance skin dose of 4 mGy is posted as the local diagnostic reference level for an abdominal X-ray in the clinic.

Given that the patient was of average size, outline your response to this situation beginning with an approximate estimate of the foetal dose. **(6 marks)**

(b) As a general rule, at what radiation dose limit to the foetus would the possibility of therapeutic abortion be considered? Discuss whether it is conceivable that this limit could ever be approached or even exceeded with routine diagnostic examinations before the pregnancy is actually identified. **(4 marks)**

Question 3

Discuss measures that may be taken to minimise staff exposure to secondary radiation during fluoroscopically guided interventions. Specifically, address the disadvantages of using an over table versus an under table X-ray tube from the perspective of radiation protection of the operator. **(10 marks)**

Case 2 - Basic Physics & Technology including Mammography, Fluoroscopy & DSA

Question 1

(a) Name two quantities with appropriate units used when plotting X-ray spectrum? **(2 marks)**

(b) Distinguish between the physical processes happening in the anode material that give rise to the Bremsstrahlung and Characteristic Radiation features of an X-ray spectrum. **(2 marks)**

(c) Compare the appearance of X-ray spectra of a typical clinical beam generated with a tungsten anode when the kV applied to the X-ray tube is changed from 60 kV to 80 kV. **(2 marks)**

(d) Explain what happens to the above spectrum when a 2.5 mm aluminium filter is added to the output of the X-ray tube. **(2 marks)**

(e) Explain the differences between two 70 kV clinical spectra of the same filtration, one generated with a single phase x-ray generator, the other generated with a medium frequency generator. **(2 marks)**

Question 2

(a) Identify the three major interactions of diagnostic energy X-rays with matter. **(1 mark)**

(b) Describe what happens at the atomic level in each of these interactions. **(3 marks)**

(c) For tissue, how would you expect the probability of each of these interactions to change with increasing X-ray energy? **(3 marks)**

(d) What is meant by the K-edge and how does it arise? **(1 mark)**

(e) An angiogram acquired at 100 kV, 250 mA with tight beam collimation displays poor image contrast in the blood vessels of interest. What change in X-ray factors would you suggest to improve the situation? **(2 marks)**

Question 3

(a) Describe the construction and operation of an indirect digital radiography (DR) image receptor. **(3 marks)**

(b) Different types of phosphors (composition and structure) can be used in such receptors. What two materials are generally used in these phosphors? **(1 mark)**

(c) How do these two materials differ in their structure and performance? **(2 marks)**

(d) What is meant by the modulation transfer function (MTF) of an image receptor? **(2 marks)**

(e) How do the phosphor structures alluded to in (b) and (c) above affect the MTF of the overall image receptor? **(2 marks)**

Case 3 - CT, MRI, US & Nuclear Medicine

Question 1

(a) Noise in a CT image is an important determinant of the image quality. Describe the main source of noise in the CT image. **(2 marks)**

(b) Also describe four (4) operator controlled factors that will directly affect the noise in a helical CT scanning image. For each factor detail what effect changing the factor will have on both the image noise and patient dose assuming all other factors remain unchanged. **(8 marks)**

Question 2

(a) Contrast in a spin echo MRI image depends on three (3) parameters intrinsic to the tissue being imaged. Name these three parameters. **(2 marks)**

(b) Also explain what operator adjustable factors are required to cause each of them to predominate in a spin echo sequence, giving reasons for your selected factors. **(6 marks)**

(c) In the sequences where relaxation times give the most contrast, tissues with what values of the intrinsic parameters will appear brightest? **(2 marks)**

Question 3

(a) In real time ultrasound imaging the Pulse Repetition Frequency (PRF) is a fundamental instrument factor in image formation.

(i) Briefly explain the definition of PRF **(1 mark)**

(ii) State and explain the effect of increasing the PRF on the maximum imaging depth in tissue **(2 marks)**

(b) In duplex Doppler imaging pulsed Doppler is utilized to determine Doppler shifts within a user specified sample volume.

(i) Briefly explain how pulsed ultrasound is used to determine Doppler shift. Include in your answer any implications around the PRF of the Doppler pulses and define the Nyquist frequency limit **(3 marks)**

(ii) What occurs in pulsed Doppler if the PRF is too low? **(1 mark)**

(c) The image provided shows an example of an artifact posterior to a fluid filled cyst. Name the artifact and explain the cause of this artifact. **(3 marks)**

Question 4

a) In diagnostic nuclear medicine imaging increasing the activity administered to the patient allows image acquisition time to be reduced.

Discuss why this is true and any drawbacks associated with using this as a strategy to reduce acquisition time. **(3 marks)**

b) (b) In a gamma camera an array of photomultiplier tubes (PMTs) are positioned at the back of the camera's NaI crystal and a parallel hole collimator is normally fitted to the front of crystal facing the patient.

Explain the role of the PMTs and the collimator in gamma camera image formation. **(4 marks)**

c) (c) In contrast to gamma cameras, PET cameras utilise a ring of detectors and do not require collimation. Explain the principles behind why PET cameras do not need collimators to form an image. **(3 marks)**