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) Define the following dose terms and indicate their units: absorbed dose, equivalent dose and effective dose. **(3 marks)**

(b) Briefly discuss and compare the linear no-threshold (LNT) and linear-quadratic (LQ) dose response models in the context of the biological effects of Ionising radiation.
(4 marks)

(c) What are the dose limits that apply for the prevention of stochastic effects to:

i. Occupationally exposed individuals **(1 mark)**
ii. Members of the general public **(1 mark)**

Why is there a difference in these values? **(1 mark)**

Question 2

The ICRP system of radiation protection is founded on the twin tenets of Justification and Optimization backed up by the application of dose limits

(a) In the specific context of the medical use of ionising radiation discuss what is meant by Justification and Optimisation and give examples of how these principles might be applied in practice. **(6 marks)**

(b) (Dose limits do not apply to patient exposures but increasingly Diagnostic Reference Levels (DRLs) do. What are DRLs, how are they established and how can they be used to optimise imaging procedures in diagnostic radiology? **(4 marks)**

Question 3

(a) What is the magnitude of the effective dose that an average sized patient might expect from:

i. PA chest X-ray;
ii. mammography (4 views);
iii. a CT head examination; and
iv. a nuclear medicine ^{99m}Tc-MDP bone scan. **(2 marks)**

(b) (b) A fixed under-table X-ray system is used for general purpose fluoroscopy on adult patients. The X-ray unit has automatic brightness control (ABC) with a range of dose rate options, including pulsed fluoroscopy and an image intensifier with variable field size. Discuss practical procedural measures that you might implement to ensure that the patient dose is minimised without compromising the diagnostic information obtained. Supplement your answer with reasons for your actions. **(8 marks)**

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

Question 4

(a) What is the reason that image acquisition takes a couple of milliseconds for a chest X-ray and 15 to 20 minutes for a nuclear medicine chest image? **(1 mark)**

(b) Describe 2 ways that scatter radiation can be removed from a chest radiographic image. **(2 marks)**

(c) Outline the materials and construction of a typical focused grid. What is the approximate increase in patient dose when a grid is used for an abdominal radiograph, assuming kV is held constant? **(3 marks)**

(d) In order to maintain the required spatial resolution of a chest radiographic image a large image matrix is required. What is the limiting spatial frequency that can be displayed with an acquisition del size of 200 microns x 200 microns? **(2 marks)**

(e) If the pixel size needed to be reduced to 140 microns x 140 microns for better resolution, what would be the impact of patient dose if the same image noise is maintained? **(2 marks)**

Question 5

(a) What is meant by a k edge, and how is this principle used to increase image contrast in radiological procedural work? **(2 marks)**

(b) In order to maximize the visibility of iodine contrast material during fluoroscopy, how would you choose the optimum tube potential and filtration for operation? **(2 marks)**

(c) What are the clinical uses for exposure acquisition and fluoroscopy modes in angiographic procedures? How does this affect the radiographic characteristics of each mode? For an average sized patient, what is the approximate ratio of the dose rates between the two modes? **(3 marks)**

(d) What is meant by the dose area product (DAP) also called kerma area product (KAP)? What units can it have? How can it be used to monitor skin dose in angiography?
(3 marks)

Question 6

(a) Scanning mammography systems are a low-dose alternative to full-field digital mammography (FFDM). What are the possible advantages and disadvantages of a scanning mammographic system compared to a typical area acquisition system?
(2 marks)

(b) Different types of digital image receptor (excluding CR) designs can be used in mammography area receptors. What are these designs called and what materials are generally used for X-ray capture in these receptors? **(3 marks)**

(c) How do these two image receptor types differ in X-ray capture and image formation processes? **(3 marks)**

(d) How do the X-ray capture and image formation processes affect the resolution of these two types of detector? **(2 marks)**

Case 3 - CT, MRI, US & Nuclear Medicine

Question 7

(a) Briefly describe the following CT scanning techniques with particular emphasis on the differences between them and any advantages or disadvantages of each of the techniques over the others:

i. Sequential (axial) CT **(2 marks)**
ii. Helical (spiral) CT **(2 marks)**
iii. Multislice (multidetector) CT **(2 marks)**

(b) Describe features that affect individual patient dose, which have arisen specifically as a result of the introduction of multislice CT. **(4 marks)**

Question 8

Describe briefly the following components of an MRI scanner, their effect on the protons and the role of each component in creating an MR image.

(a) Fixed magnetic field **(3 marks)**

(b) Radiofrequency field **(3 marks)**

(c) Each of the applied magnetic field gradients **(4 marks)**

Question 9

(a) Discuss the factors affecting the axial and lateral spatial resolution in real-time ultrasound imaging. **(4 marks)**

(b) Lateral resolution in real time ultrasound imaging can be improved over a range of depths by using multiple focal zones. If 2 focal zones are set and the line density and maximum depth of imaging are unchanged, explain what will happen to the frame rate and why. **(2 marks)**

(c) Blood flow can be assessed using Doppler ultrasound and instruments can use either continuous wave Doppler or pulsed Doppler.

i. Describe the basic differences in operation between pulsed and continuous wave Doppler units (note you do not need to describe the Doppler effect). **(2 marks)**
ii. Give 1 advantage and 1 disadvantage of continuous wave and pulsed Doppler **(2 marks)**

Question 10

(a) SPECT imaging is most often performed with a dual head gamma camera fitted with parallel hole collimators. Briefly describe the principles of SPECT image acquisition and reconstruction. (Note you do not need to describe the operation of a gamma camera detector). **(5 marks)**

(b) A CT acquisition is often performed as part of SPECT imaging (for a SPECT/CT examination). Give the two main reasons why the CT part of the examination is performed. **(2 marks)**

(c) PET imaging does not require the use of collimators for image formation. Discuss the elements of PET imaging that make collimators unnecessary. **(3 marks)**