The Royal Australian and New Zealand College of Radiologists®

AIT
(Applied Imaging Technology)
Paper 1

Tuesday, 10 September 2019

Please write your answers in the books provided, starting each question on a new page.

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Case 1

Section 1 (Radiation Biology and Safety)

Question 1

a) The dosimetric quantity kerma-area product (KAP, also known as DAP) can be used as the DRL quantity for general x-ray examinations. Define this quantity with units and identify two reason why this quantity is used in x-ray patient dosimetry **(4 marks)**

b) What does the mean glandular dose (MGD) to the breast indicate in the context of mammography screening? What is the maximum allowable MGD delivered to an ACR phantom for use in screening in Australia and New Zealand? **(3 marks)**

c) The dosimetric quantity cumulative air kerma (CAK) is used in interventional radiology. At what spatial point in relation to the equipment is it measured at? What practical indication does it give to the clinician and what is a limitation of this quantity? **(3 marks)**

Question 2

One of the tenets of the International Commission on Radiological Protection (ICRP) system of radiation protection in the medical use of ionising radiation is that of Justification. There are 3 levels of justification, two of these relate directly to common radiological practice

a) Discuss the principle of justification in medical imaging. **(2 marks)**

b) Give an example of a radiological examination that utilises specific procedure justification (level 2) and discuss the implications of this on clinical practice. **(3 marks)**

c) Explain what is meant by individual patient justification (level 3). Name a tool that is useful in this type of justification. **(2 marks)**

d) You are performing an abdominal angiographic investigation using a C arm unit. Name three operational practices that you can use to minimize the radiation dose to both yourself and the patient and explain how each practice reduces the dose. **(3 marks)**

Question 3

When considering the risk of cancer induction as a result of radiation exposure, the linear no-threshold (LNT) model relationship is usually applied.

a) Briefly describe the LNT model and its implications for a busy CT service. **(3 marks)**

b) What is the approximate accepted risk of cancer mortality for a 10 year old child who undergoes a complex CT procedure and receives 10 mSv of effective dose? How does this risk compare to that of an adult with the same received effective dose? **(2 marks)**

c) When considering the risk of leukemia as a result of radiation exposure sometimes a different relationship model is utilized. What is the name of this model and how does it differ from the LNT model? **(3 marks)**

d) Apart from cancer induction, identify two other broad radiation detriment effects that can occasionally be associated with interventional radiology. Why are these effects rare?

Case 2

Section 2 (Basic Physics & Technology including Mammography, Fluoroscopy & DSA)

Question 1

a) Identify and describe the principal radiation interaction in tissue responsible for x-ray absorption during a diagnostic x-ray examination **(3 marks)**

b) For a PA Chest X-ray examination, what kVp would you select and what is the rationale for your choice? **(2 marks)**

c) Refer to the diagram:

   i) Name the discontinuity labelled A and briefly explain why it arises **(2 marks**)

   ii) What element would you expect to match the data shown in the graph? Provide one medical imaging application for this element and explain how you would achieve the optimum beam quality for this application **(3 marks)**

Question 2

a) Explain how the design and operation of an automatic exposure control (AEC) system used for mammography differs from an AEC system used for general radiography **(3 marks)**

b)

   i) Briefly describe the relationship between image signal and image receptor dose for film-screen mammography and digital (DR) mammography. Your answer should include a definition of image signal for each image receptor **(3 marks)**

   ii) Explain why the dynamic range of digital mammography is considered superior to that of film-screen mammography **(2 marks)**

   iii) State what image quality metric you would use to ensure that the performance of a digital mammography system is optimised and give reasons for your choice **(2 marks)**

Question 3

Modern fluoroscopic imaging systems may use either an image intensification (II) chain or a flat panel detector (FPD). Within this context answer the following:

a) Describe why minification gain occurs within the fluoroscopy II imaging chain **(2 marks)**

b) Describe the composition of a Flat Panel Detector used for fluoroscopic imaging **(2 marks)**

c) Name and describe two factors that specifically influence the system spatial resolution in a FPD **(4 marks)**

d) Describe how these two factors directly relate to the maximum resolution of the FPD **(2 marks)**

Case 3

Section 3 (CT, MRI, US & Nuclear Medicine)

Question 1

a) Either in words or by equation, describe how the CT number (or Hounsfield Unit) of a voxel is calculated. **(2 marks)**

b) Suppose a multislice CT scanner has 100 detector rings each 1 mm in length along the z (long) axis. If all rings are fully exposed and 50 slices are acquired in a single rotation:

   i) What is the imaged slice width and the nominal x-ray beam width? **(1 marks)**

   ii) In practice, the actual beam width will be slightly longer than the nominal beam width. Explain the purpose of this. **(2 marks)**

c) To best visualise subtle differences in soft tissue, state whether you should use a relatively thick or thin reconstructed slice width and give reasons for your answer. **(3 marks)**

d) Explain the cause of the cupping artifact whereby CT numbers at the centre of the image are erroneously decreased. **(2 marks)**

Question 2

a) For a standard spin-echo pulse sequence performed with a 3T scanner: With regard to the chemical shift artefact in MRI, briefly describe:

   i) define the terms TR and TE. **(1 mark)**

   ii) Give approximate numerical values in ms required for TR and TE to produce a T1 weighted image of brain tissue. (NB: partial marks may be awarded for a qualitative description of the relative lengths of TR and TE e.g.short). **(2 marks)**

b) An artifact is present in two of the three figures, A, B and C. Identify which 2 figures, and name the artefact' **(3 marks)**

   Explain how an inversion recovery sequence could be used to suppress the signal from fat. **(3 marks)**

c) Explain why a quenching event presents a safety hazard. **(1 mark)**

Question 3

a) Lateral spatial resolution in real time ultrasound imaging can be improved at a particular depth by focusing the beam in the scan plane at that depth.

   i) Define lateral spatial resolution and discuss why the above statement is true. **(3 marks)**

   ii) Explain how beam focusing is achieved for a linear array transducer. (NB. You do NOT need to describe beam steering) **(2 marks)**

b) When using real time ultrasound imaging, explain why a lower pulse repetition frequency must be used to image to a maximum depth of 10 cm than when imaging to a maximum depth of 5 cm. **(2 marks)**

c) When performing an abdominal ultrasound imaging examination one element of the screen display is TIB: 0.8.

   i) Discuss what this parameter means and what safety implications, if any, it has for the procedure at the value displayed. **(2 marks)**

   ii) If TIB was 3.0 would the safety implications change and if so actions would you take? **(1 mark)**

Question 4

a) When performing SPECT imaging with a gamma camera a parallel hole collimator is usually fitted to the camera. What is the primary purpose of the collimator. **(1 mark)**

b) The face of the collimator is normally positioned as close as possible to the patient. What is the reason for this? **(1 mark)**

c) In PET imaging no collimator is necessary, explain why this is true. **(2 marks)**

d) Explain what implications the fact that SPECT imaging requires a physical collimator when PET imaging does not has on the relative sensitivity of PET and SPECT systems? **(2 marks)**

e) When performing whole body PET/CT the mAs selected for the CT component of the scan is normally significantly lower than would be used for a diagnostic scan. Explain why this is acceptable and what benefits there are from using a low mAs CT. **(2 Marks)**