The Royal Australian and New Zealand College of Radiologists®

Applied Imaging Technology (AIT) Paper 1 Exam

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Case 1

Section 1 (Radiation Biology and Safety)

Question 1

a. Define absorbed dose (3)

b. Describe how effective dose is derived from absorbed dose (3)

c. A patient having a screening mammogram is calculated to have an effective dose of 0.2 mSv.

   i) Calculate the theoretical potential risk of cancer mortality from this imaging examination? (2)

   ii) What are the potential errors that exist in estimating cancer risk from the calculated effective dose? (2)

Question 2

a. The tissue weighting factor of the breast has increased from ICRP 60 (1990 Recommendations) to ICRP 103 (2007 Recommendations).

   i. State the breast tissue weighting factor, according to ICRP 103. (1)

   ii. Explain why the breast tissue weighting factor has changed. (1)

   iii. What is the typical effective dose for a CT chest scan (include units)? (1)

   iv. For a CT chest scan, what is the impact on the effective dose due to the revisedtissue weighting factor? (1)

b. Explain the ALARA principle in diagnostic radiology. Provide one example in terms of patient exposure. (2)

c. In relation to Diagnostic Reference Levels (DRLs):

   i. Explain what a national DRL is and how it is determined. (3)

   ii. In Australia, have national DRLs been established for all CT procedures? Explain why or why not. (1)

Question 3

a. A pregnant patient in their first trimester presents for a clinically justified Abdominal X-ray exam. The exam is usually carried out using Automatic Exposure Control (AEC) in the AP projection.

   i. Estimate the expected fetal dose for this examination (1)

   ii. The patient requests a lead apron to reduce fetal dose. What advice would yougive? (4)

   iii. How could you modify the examination technique to reduce fetal dose? Give abrief explanation for your answer (2)

b.

   i. Why is it important to establish paediatric protocols for X-ray imaging? (1)

   ii. Briefly describe TWO dose reduction strategies you might employ when taking a projection X-ray of a 3 year old child (2)

Case 2

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

Question 1

You are undertaking a fluoroscopically guided interventional procedure on a large patient.

a. Whilst advancing the catheter the movement appears “stepped” or “jerky”.

   i. State which user-accessible technical factor is likely to be directly related to this image quality problem. (1)

   ii. Describe the physical principle that creates this problem (2)

   iii. Describe the system setting adjustment that may be made by you or the radiographer to alleviate this issue. (2)

   iv. Describe and quantify the main negative impact of the above setting adjustment. (2)

b. The X-ray tube/image receptor orientation is changed from a PA projection to a steep angulation for best visualization of a particular blood vessel. The fluoroscopic images in the new orientation consequently appear excessively “grainy” or “noisy”. Describe the physical principle that creates this problem. (3)

Question 2

a.

   i. Briefly describe how characteristic X-rays are produced in an X-ray tube. (1)

   ii. Briefly describe how characteristic X-rays are produced during photoelectric absorption of X-rays in tissue. (1)

   iii. Identify the key differences between the characteristic X-rays produced by these processes. (1)

b. A number of elements and their corresponding K-edge are listed below, grouped by their medical imaging application.

Group 1: Iodine (I) 33 keV and Barium (Ba) 37 keV
Group 2: Caesium (Cs) 36 keV and Iodine (I) 33 keV

For each group, identify the application and explain why the K-edge makes these elements well-suited to the application (4)

c. The intensity of a radiation beam (I) transmitted through a thickness of material (x) is described by the relationship $I = I_0e^{-\mu x}$

i. Identify and define the quantity denoted by "μ" (2)

ii. Is this relationship more likely to apply to a radiation beam used in X-ray ornuclear medicine imaging? Justify your answer. (1)

Question 3

a. Two different full-field digital image receptor designs (excluding CR) can be used in mammography. What are these designs called and state the material commonly used for X-ray capture in each receptor? (2)

b. Explain how these two image receptor designs differ in X-ray capture and image formation processes, including effect on spatial resolution (4)

c. Explain why dose optimisation is more important for screening mammography thanfor diagnostic mammography. (2)

d. Explain why magnification mammography requires use of a smaller focal spot than contact mammography and does not require use of a grid. (2)

Case 3

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

Question 1

a. In a multi-slice CT scanner over-beaming can occur under certain conditions.

   i. Describe this phenomenon including the conditions under which it occurs and its impact on the patient. (3)

   ii. Name a clinical CT application where over-beaming is significant. (1)

b. Many CT scanners using automatic mode for contrast chest examinations on adults select lower kVs such as 80 kV or 100 kV to perform the scan.

   i. What is the benefit of this approach? Explain the underlying physical reasons why this approach is taken. (4)
   ii. For a certain patient the above scanner selects 120 kV when the average kV used for all patients is 100 kV. What might be the reason for this? (1)
   iii. Briefly discuss whether the rationale for using lower kV for contrast scans can also be applied similarly for non contrast scans. (1)

Question 2

a.

   i) Name three properties of tissues that determine the signal intensities generated in an MR signal (and form the basis of the contrast between tissues in MRI images). (1)

   ii) In a spin echo sequence, what acquisition parameters can be manipulated to produce images that reflect the above tissue characteristics. Give examples of typical values of these parameters for one of the above tissue properties. (3)

b) An MRI scanner may ‘quench’. Explain what this means and describe hazards that can occur. (3)

c)

   i) Explain what the term ‘susceptibility’ means in relation to magnetism. (1)

   ii) How may materials be classified based on their susceptibility? How do materials in each category influence an externally applied magnetic field? (2)

Question 3

A patient presents for nuclear medicine bone scan imaging. For this study 800 MBq of ^{99m}Tc-HDP is administered and scanning commences after a 2 hour uptake period.

One element of the imaging procedure specifies that a static anterior image of the pelvic area is to be acquired for a 5 minute acquisition time with the collimator of the camera positioned as close as possible to the patient.

a. Explain the main reason for the imaging protocol specifying to position the collimators as close to the patient as possible. (1)

b. If the static image appears to have an excessive amount of noise and needs to be reacquired, discuss what element(s) of the image acquisition procedure you wouldchange to rectify the problem, giving reasons for your choice(s). (2)

c. SPECT imaging is also performed, using a dual-headed gamma camera with the detector heads oriented in a 180° geometry. Describe how SPECT images are acquired and reconstructed using this type of camera. The description should include any important technical aspects of the acquisition phase. (4)

   Note: DO NOT describe the operation or image formation processes of a gamma camera detector, e.g. details on the function of the collimator or PMT tubes in the camera head are NOT required.

d. 48 hours after the bone scan has been performed the patient is required to undergo a PICC line insertion. Staff conducting this procedure are concerned about possibleradiation exposure. Discuss whether their concerns are justified and what advice you would provide. (3)

Question 4

a. Diagnostic ultrasound imaging typically uses probes that emit sound with frequencies ranging from around 2 MHz to 15 MHz

   i. State one way in which a higher frequency probe will always be superior to a lower frequency probe in terms of image quality. (1)

   ii. Explain why this is so. (2)

   iii. Explain why high frequency probes (10 – 15 MHz) are suboptimal for imagingdeep structures. (1)

b. In an abdominal ultrasound exam, a large calcification has a dark region deep to it (as indicated by the arrow in the picture). The sonographer demonstrates that it is an artefact.

   i. Describe one way it could be demonstrated that the dark region is an artefact (1)

   ii. Name the artefact. (1)

   iii. Briefly describe how it is caused. (2)

c. You are observing an ultrasound exam of an 8-week-old fetus. For this type of exam, the following parameters displayed by the machine are of particular importance: TIS and MI.

   i. State what TIS and MI stand for. (1)

   ii. Describe the action that should be taken if the TIS is 3.5. (1)