Homework 4

1. In a nuclear medicine scan using ^{99m}Tc, the image SNR for a 30 minute scan was 25:1 for an injected radioactive dose of 1 mCi. Imaging began immediately after injection.

(a) If the injected dose were tripled to 3 mCi, what would be the image SNR for a 30 minute scan?

(b) If the scan time were doubled to 60 minutes with an initial dose of 1 mCi, what would be the image SNR?

2. Do the tops of the curves in Figure 1 lie at the same values that would have been obtained if the technetium cow were not milked at all?
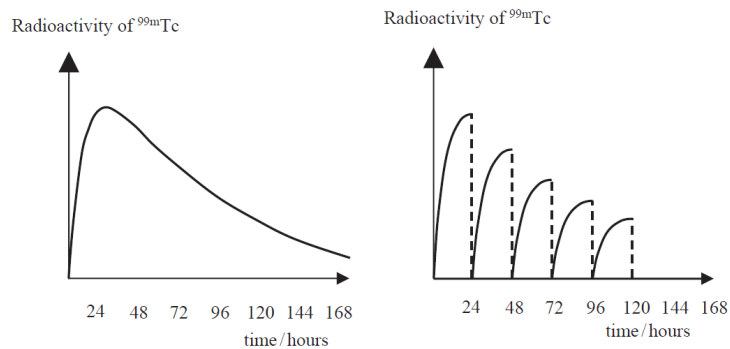

Figure 1. (Left) Theoretical plot of the radioactivity of ^{99m}Tc vs time for a generator that is not milked.

(Right) Practical radioactivity curve in which the generator is milked every 24 hours, as shown by the dashed lines.

3. (i) The thickness of the lead septa is chosen to ensure that only 5% of the γ-rays penetrate from one collimator hole to the adjacent one. Using Figure 2 show that the thickness is given by [6d/μ]/[L-3/μ].

(ii) Calculate the septal thickness required for γ-rays of 140 keV for lead collimators with a hole diameter of 0.1 cm and a length of 2.5 cm. The attenuation coefficient for lead is 30 cm^{-1} at 140 keV.
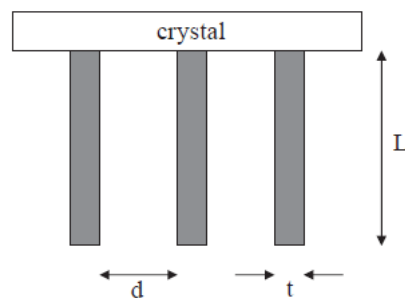

Figure 2

4. Three parameters which affect the image SNR in nuclear medicine are the thickness of the detector crystal, the length of the lead septa in the anti-scatter grid, and the FWHM of the energy window centred around 140 keV. For each parameter, does an increase in the value of the particular parameter increase or decrease the image SNR? In each case, name one other image characteristic (e.g. CNR, spatial resolution) that is affected, and explain whether this image characteristic is improved or degraded.

5. Calculate the maximum angle and corresponding energy of Compton scattered γ-rays accepted for energy resolutions of 5, 15 and 25%.

6. What timing resolution would be necessary to obtain a position resolution of 5 mm in TOF PET based only upon time-of-flight considerations?

7. Suggest why a PET/CT scanner operating in 2D mode has a relatively uniform axial sensitivity profile, whereas in 3D mode the sensitivity is much higher at the centre of the scanner.