EE101 Homework 2

Please submit it via Blackboard. MATLAB and Python are allowed.
Due：October.30th 23：59
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Your name: _____ **Student ID:** _____

Question 1 (20 pts)

For a 18F PET scan, if an initial dose of $1.5\,mCi$ is injected, please calculate the total number of γ-rays that are detected during a scan time of 50 minutes. Assume the scanning starts immediately after injection, and only True Coincidence (no other coincidences) will happen. (Half-life of 18F is $109.7\,minutes$.)

Question 2 (20 pts)

Isosensitive imaging is a technique that acquires nuclear medicine scans from opposite sides of the patient, and then combines the signals to remove the depth dependence of the signal intensity. By considering the attenuation of \gamma-rays in the patient, using the following figure as an example, show how this technique works, and what mathematical processing of the two scans is necessary.

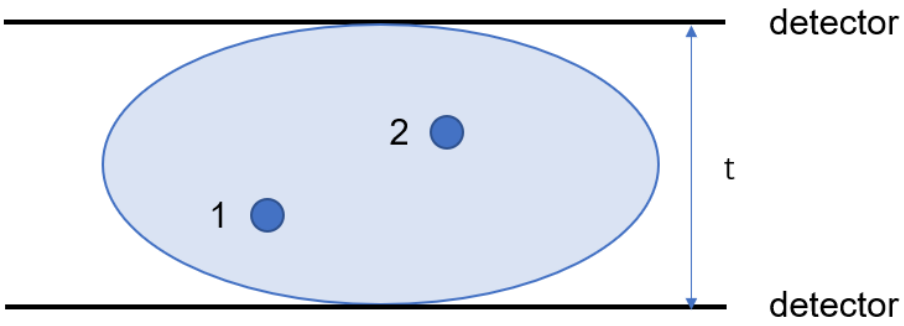

Fig.1

Question 3 (30 pts)

(1) 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. Suppose the linear attenuation coefficient of lead septa is μ, and $L \gg t, d$. Please use Fig.2 to show that the thickness is given by the formula below with appropriate approximation. (Hint: Assuming that in tiny triangle, hypotenuse can be approximated by the longer right-angle side.)

$$t = \frac{6d}{\mu L - 3}$$

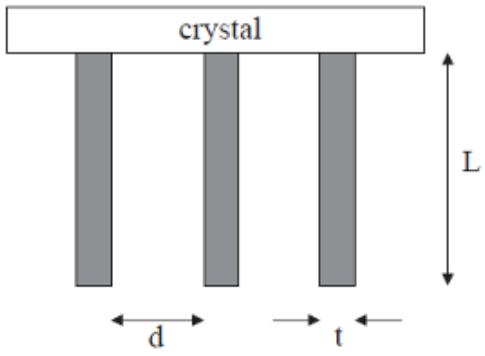

Fig. 2

(2) Calculate the septal thickness required for γ-rays of 140 keV and lead collimators with a hole diameter of $0.25\ cm$ and a length of $3\ cm$. The attenuation coefficient for lead is $30\ cm^{-1}$ at 140 keV.

Question 4 (30 pts)

(1) In a sample of 39,600 atoms, if 660 of these atoms decay in 5 seconds. What is the radioactivity measured in mCi of this sample?

(2) In order to produce a level of radioactivity of $5\ mCi$, how many nuclei of 99mTc ($\lambda = 3.21 \times 10^{-5}\ s^{-1}$) must be present? And what mass of the radiotracer does it correspond to? ($N_A = 6.022 \times 10^{23}\ mol^{-1}$)

(3) A dose of $5\ mCi$ of 99mTc (Half-life: 6 hours) is administered to a patient at 9 a.m. Please calculate the dose of radioactivity in the patient, measured in mCi, at 11 a.m. on the same day if the biological half-life of the radiotracer in the body is 2 hours.