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 is injected, please calculate the total number of -rays that are detected during a scan time of minutes. Assume the scanning starts immediately after injection, and only True Coincidence (no other coincidences) will happen. (Half-life of 18F is .)

**Solution:**

First, we have the half-life of 18F as . Then we derive

The value of can be computed by

During the 50-minute scan, the total number of disintegrations is given by

So, the total number of -rays detected, if only True Coincidences happen, is twice the value of , namely .

**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.

图片包含 图表

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**Fig.1**

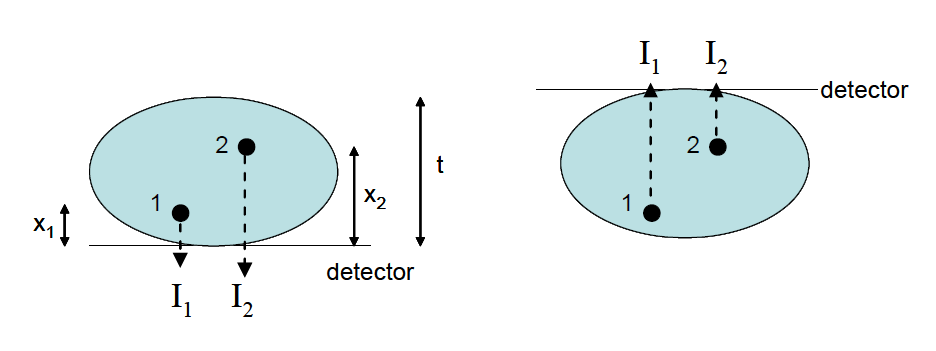
**Solution:**

Suppose that there are two sources of radioactivity, labeled 1 and 2 in the figure below. If only one scan is taken, shown on the left, then the intensity of γ-rays detected are:

If we denote the thickness of the body as t, then the intensities from the second scan shown on the right:

If the signals are multiplied together, and the square root of the product is taken, to give and then these have values:

This shows that the depth-dependence of the signals has been eliminated



**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 , and . 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.)

图示

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**Fig. 2**

(2) Calculate the septal thickness required for -rays of 140 keV and lead collimators with a hole diameter of and a length of . The attenuation coefficient for lead is at 140 keV.

**Solution:**

(1) From the figure below, we can see that the minimum path distance x for a γ-ray to pass through the collimator and be detected from the adjacent collimator hole, is related to , and by

图表

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Then, since only 5% of the -rays can penetrate, we have

Rearranging the above two equations, we derive

(2) From the above formula, we have

**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 of this sample?

(2) In order to produce a level of radioactivity of , how many nuclei of 99mTc () must be present? And what mass of the radiotracer does it correspond to? ()

(3) A dose of 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 , at 11 a.m. on the same day if the biological half-life of the radiotracer in the body is 2 hours.

**Solution:**

(1)

(2) Using formula for radioactivity, and converting Curies into Bq, we have

And convert this into mass, we have

Where is the molar mass of 99mTc, namely .

(3) We have the following equation for the effective half-life,

Thus, we have

Then, we have

So, the dose of radioactivity at 11 a.m. is .