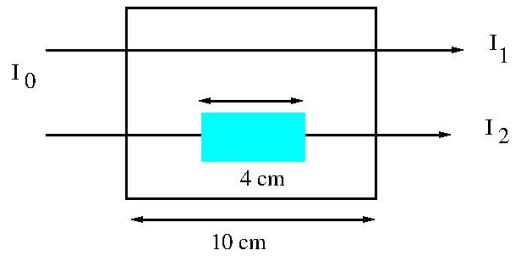
PHYS 4134, Fall 2016, Homework #8

Due Wednesday, October 26

1. X-Rays and Projection Imaging

The sketch is a schematic representation of a piece of bone surrounded by tissue irradiated with γ rays. I_1 is the transmitted γ-ray intensity through tissue and I_2 through tissue-plus-bone. Using the information in the table, find the ratios I_1/I_2 separately for γ-ray energies of: a) 140 keV and b) 364 keV. [See also problems 9.1 and 9.2.]



Material	Density ($g\ cm^{-3}$)	E_γ (keV)				
		60	140	159	364	511
Tissue	1.0	0.20	0.15	0.15	0.11	0.097
Bone	1.8	0.32	0.16	0.15	0.10	0.090
Copper	8.9	1.5	0.25	0.20	0.098	0.081
NaI(Tl)	3.67	5.7	0.66	0.52	0.13	0.090

2. Statistical Risks

A dose of post-operational X-ray therapy, given after an operation to remove cancerous breast tissue consists of daily "fractions" of 3Gy, given 4 days a week for 5 weeks. Estimate the risk of inducing breast-cancer from this treatment. [See also problem 7.14]

Tissue or Organ	**Effect**	**Probability per Sv**
Breast	Cancer	2.0×10^{-3}
Red bone marrow	Leukemia	5.0×10^{-3}
Lung	Cancer	8.5×10^{-3}
Thyroid	Cancer	8.0×10^{-4}
Bone surfaces	Cancer	5.0×10^{-4}
Other tissues	Cancer	3.4×10^{-2}
Whole body, all cancer effects		5×10^{-2}

3. Bananas!

Bananas are a great source of potassium, which we need in our diets to stay healthy. However, although naturally occurring potassium in 99.988% ^{39}K, naturally occurring potassium also contains 0.012% ^{40}K, which is a radioactive isotope of potassium with a halflife of $\tau_{1/2} = 1.25\times10^{9}$ years.

A) If a medium banana weights 118 g, with 422 mg of potassium, find the number, N_K, of potassium atoms. [Use an atomic molar mass of 40 grams/mole.]

B) Find the activity of that banana in Bequerels. [Use $\mathcal{A} = N_K \ln(2)/\tau_{1/2}$.] If each decay releases gamma or beta radiation with an average of 0.5 MeV, how much energy (in Joules) is released into the body in a year?

C) Next, calculate the absorbed does for a person who eats one banana per day, for 50 years. Assume that after one day any remaining potassium is flushed from your system.

D) Of course not all the potassium is flushed from your system. In fact, the human body is 0.27% potassium by mass. For your weight, how many grams of potassium are contained in your body? Again using the ratio that 0.012% of that potassium is radioactive ^{40}K, what is the number of ^{40}K atoms in your body?

E) Again, each decay releases an average of 0.5 MeV of beta or gamma radiation, which is absorbed by the body. Calculate the absorbed does over 50 years from this background exposure.

F) Finally, compare parts C) and E). Is eating a banana a day going to significantly increase your exposure to radiation?