PHY 3107, Spring 2018, Homework #7

due Friday, March 9 (before Spring Break?)

1.) Cadmium is often used in nuclear reactors for the control rods. Let's see why. A) What is the nuclear radius of $^{113}_{48}Cd$? B) Now use that radius to find the geometrical cross-sectional area (or cross section) of $^{113}_{48}Cd$. C) In the reaction $p + {}^{113}_{48}Cd$, the cross section is on the order of a milli-barn. Based on the geometric cross section from part (B), does that makes sense? D) At very low energy (~ 0.001 eV), the neutron scatters from the entire atom. At larger energies, the neutron is probing the nucleus. We expect this from the de Broglie wavelength's momentum dependence. Now: in the reaction $n + {}^{113}_{48}Cd$, for neutrons of energy $E_n < 0.5\ eV$ (e.g., low energy or thermal neutrons), the average cross section is 2450 barns. Does that make sense?

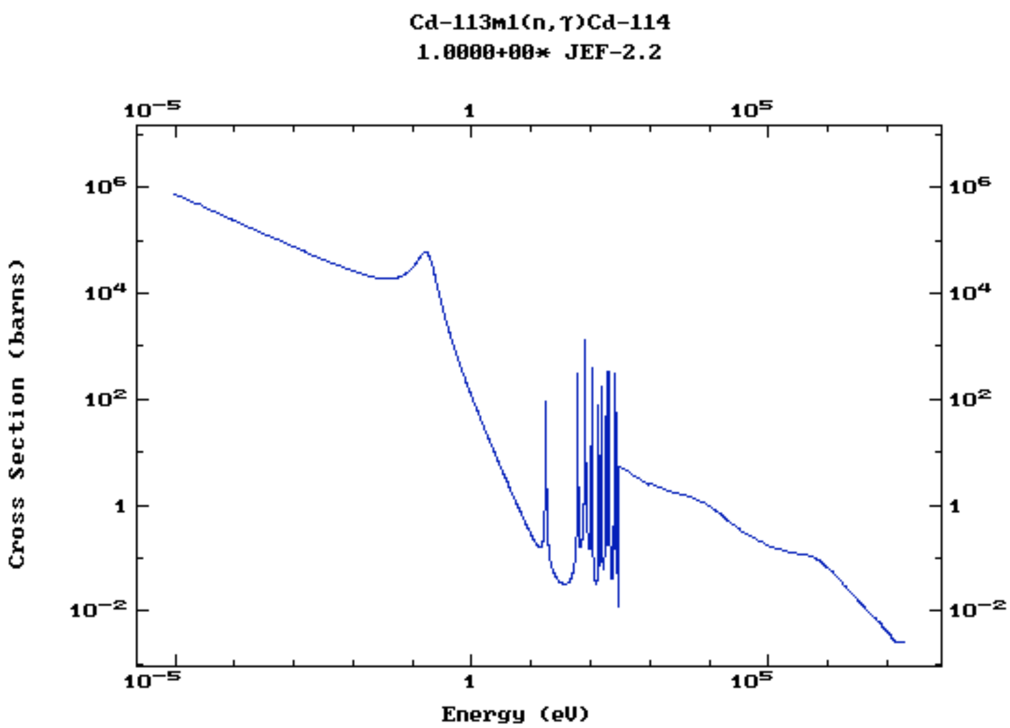
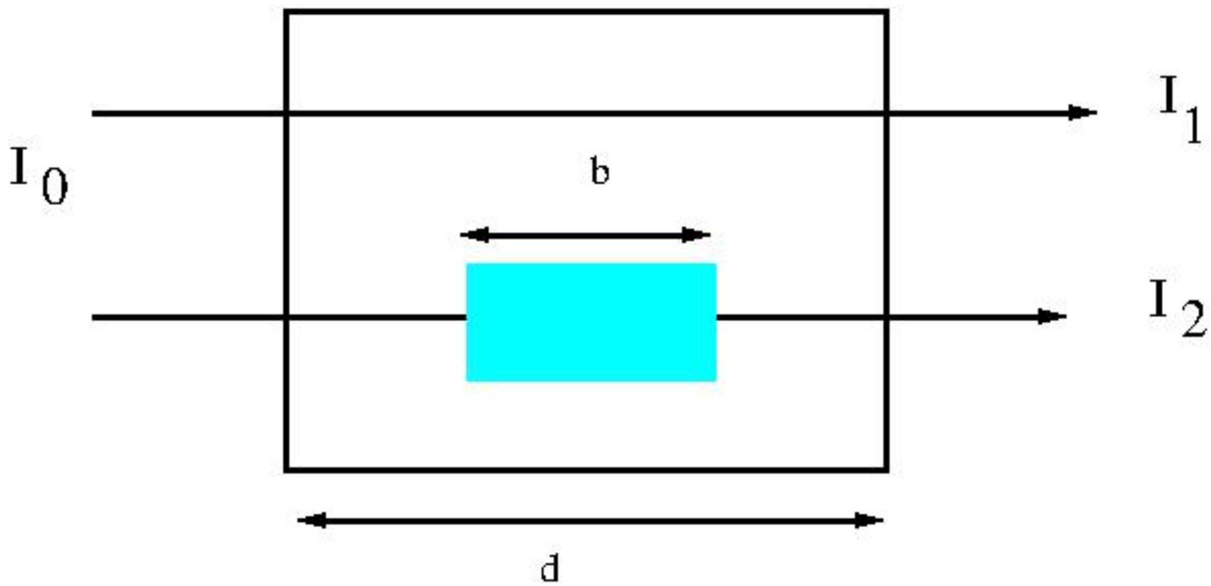


Figure 2.3: Energy dependence of the cross section of ^{113}Cd

Figure from Neutron Capture Cross Sections of Cadmium Isotopes, A. Gicking. Senior thesis, Oregon State University, 2011. (unpublished)

2.) A fission reactor uses ^{235}U, which yields about 208 MeV per decay. A) If we want to provide 100 MW of power, approximately how many uranium fissions must occur each second? B) How many kilograms of uranium would have to fission in one year?

3.) The sketch is a (poor) schematic representation of a piece of bone (in blue) surrounded by tissue irradiated with γ rays. I_1 is the transmitted γ-ray intensity through tissue and I_2 through tissue-plus-bone. The table lists the mass attenuation coefficients, μ, in units of inverse centimeters. A) If the ratio of the transmitted γ-ray intensities I_1 (through tissue) to I_2 (through tissue-plus-bone) is 2 for 60-keV γ-rays, calculate the thickness of the bone. B) Using the information in the table, find the ratio I_1/I_2 for a γ-ray energy of 364 keV.



Material	E_γ (keV)				
	60	140	159	364	511
Tissue	0.20	0.15	0.15	0.11	0.097
Bone	0.58	0.29	0.27	0.18	0.16

4.) A neutron beam is produced using the fusion reaction $d + d \rightarrow {}^3_2He + n$. Assuming the kinetic energy was very small (i.e., negligible) before the fusion, calculate the kinetic energy of the neutron after the fusion. [Hint: The two final particles must have zero net momentum, and the energy released, or the Q value, must be that of both particles combined.]