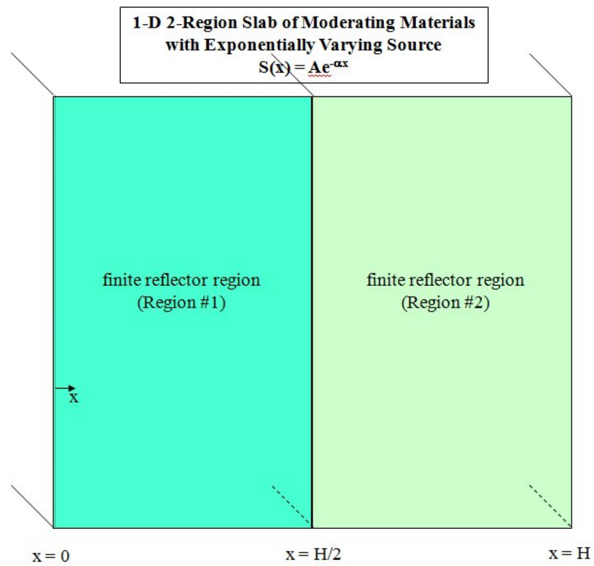
ENGY.4340 Nuclear Reactor Theory

Optional Extra Credit Project #1 -- Fall 2016

Neutron Diffusion in Moderating Media

1-D 2-Region Slab with an Exponentially-Varying Distributed Source

Consider the ***semi-infinite 2-region bare slab*** of total thickness H shown in the sketch. Both sides of the slab have vacuum boundaries (at x = 0 and at x = H). The interface between the two material regions is located at x = H/2, and the standard interface boundary conditions apply here. Neither region contains any fissionable material. There is an exponentially-varying distributed source within the slab which is given by



$$S(x) = Ae^{-\alpha x} \qquad \text{for} \quad 0 \le x \le H$$

where A and α are known constants.

a. Assuming 1-group theory, formally develop analytical expressions for the flux distributions, $\phi_1(x)$ and $\phi_2(x)$, throughout the 2-region slab. Denote the material properties and fluxes in the two regions with a '1' or '2' subscript, respectively, to denote the region of interest. Clearly identify your logic and state any assumptions that may be needed.

   For this part of the problem, **do not** attempt to algebraically solve for the unknown coefficients. Instead, simply set up the matrix equations needed to solve for these quantities (numerical values will be inserted in a latter part of the problem and the resultant matrix equation will be solved in Matlab or some other suitable software).

   Also, since the value of H may be quite small, **do not ignore** the extrapolation distances in this problem.

b. Within the context of an overall neutron balance for this system, develop formal expressions for the following quantities:

   1. Leakage rate per unit area across the yz plane at x = 0.
   2. Leakage rate per unit area across the yz plane at x = H.
   3. The absorption rate per unit area in the yz plane within the full volume for $0 \le x \le H$.
   4. The total source production rate within the full volume for $0 \le x \le H$.

c. Using the parameters given below, use Matlab (or any other suitable software package of choice) to evaluate the expressions derived in Parts a and b for the flux distribution throughout the 2-region slab and for the individual components of the global neutron balance equation. Formally plot the flux profiles and tabulate the components of the neutron balance for the following four cases:

Case 1: Region 1 is graphite, Region 2 is water, and the source decay α is α_1 (slow decay)

Case 2: Same material arrangement as Case 1, but $\alpha = \alpha_2$ (fast decay)

Case 3: Region 1 is water, Region 2 is graphite, and the source decay α is α_1 (slow decay)

Case 4: Same material arrangement as Case 3, but $\alpha = \alpha_2$ (fast decay)

d. Briefly discuss the overall results of this analysis -- does everything behave as expected? Explain...

Data for the Problem

source magnitude: $A = 1$ n/cm^3-s

size of slab: $H = 50$ cm

source decay rates: $\alpha_1 = 0.001$ cm^{-1} (slow decay) and $\alpha_2 = 0.1$ cm^{-1} (fast decay)

water properties: $D = 0.16$ cm, $L^2 = 8.1$ cm^2

graphite properties: $D = 0.84$ cm, $L^2 = 3500$ cm^2

Note: This Extra Credit Project will be worth up to **50 extra points** towards your HW grade in this course. Parts a-c are worth 15 points each and the remaining 5 points will be associated with the quality of your work and the discussion of your results. As in other homeworks, a **2-person team effort** is encouraged here, with only one project submission per team. Also please be aware that there is a fairly substantial amount of work needed to be fully successful with this problem -- thus, if you elect to do this optional exercise, be sure to get started early to give yourself plenty of time to do a good job...

Good luck...