HW6

22.211 Nuclear Reactor Physics I

Due date 4/26/2023

Question 1: Finite Difference code

Write a 1D Finite Difference diffusion solver to solve the 5 1D slab problems listed in Table 2.

- 2 group materials cross-section for 7 materials in Table 1
- Geometrical layout in Table 2
- Left/Right vacuum boundary conditions
- Constant mesh spacing
- Convergence criteria (1e-7) on the RMS fractional change in successive iteration of the fission sources (integrated over energy in each mesh)
- Convergence criteria (1e-5) on the RMS fractional change in successive iteration of the total flux (sum of both fluxes in each mesh)

$$RMS = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(\frac{x_n^{l+1} - x_n^{l}}{x_n^{l+1}}\right)^2}$$

- Use the power iteration method described in class
- For the linear solver, it is ok to just use the matrix inverse

a) Produce a table of results for all 5 problems with the following
    a. k_{eff}
    b. Peak value of normalized fission source (ratio of peak to average)
    c. Location of the peak fission rate (cm from the center)
    d. Number of power iterations required for convergence
b) Produce a plot of the group 1 and 2 flux for each problem (normalized to a single value for both fluxes so that we can see the difference in magnitude between the fluxes)
c) Produce a table with baffle thickness changes (change of full cm, keep core the same size, only change baffle and reflector widths)
    a. Report k_{eff} and peak value of normalized fission source

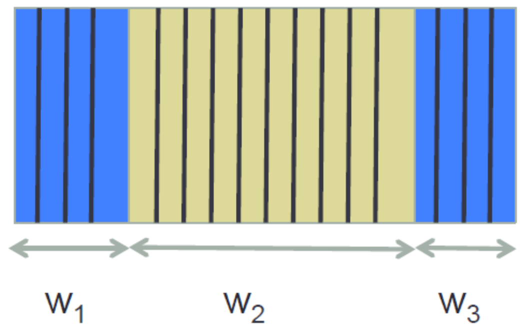


Table 1: Material Data

Material #	Description	D1	D2	A1	A2	S1-->2	NF1	NF2
1	1.60%	1.4300	0.3700	0.0079	0.0605	0.0195	0.0034	0.0711
2	2.40%	1.4300	0.3700	0.0084	0.0741	0.0185	0.0054	0.1000
3	2.4% 16 BP	1.4300	0.3700	0.0089	0.0862	0.0178	0.0054	0.1000
4	3.10%	1.4300	0.3700	0.0088	0.0852	0.0188	0.0062	0.1249
5	Baffle/Reflector	1.2600	0.2700	0.0025	0.0200	0.0294	0.0000	0.0000
6	Baffle	1.0000	0.3400	0.0054	0.1300	0.0009	0.0000	0.0000
7	Reflector	1.5500	0.2700	0.0010	0.0286	0.0450	0.0000	0.0000

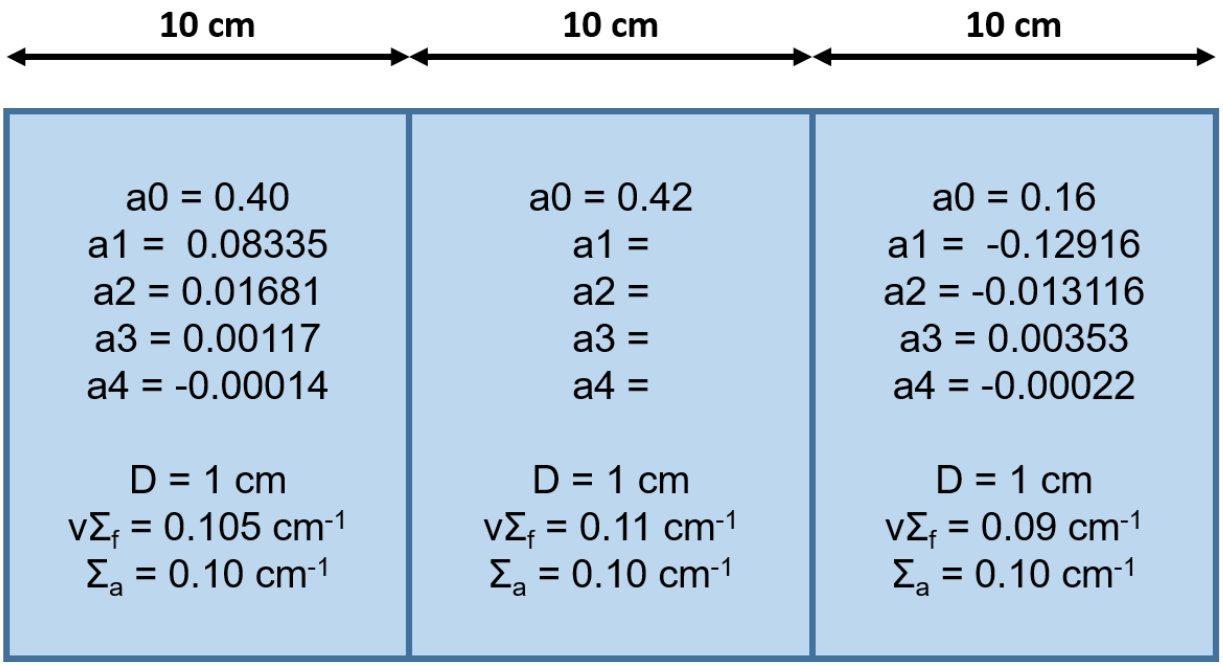
Table 2: Geometrical layout

Problem	Zone	1	2	3	4	5	6	7
1	Width	300.0						
BC Left = Vacuum	Spacing	5.0						
BC Right = Vacuum	Material ID	1						
2	Width	25.0	250.0	25.0				
BC Left = Vacuum	Spacing	5.0	5.0	5.0				
BC Right = Vacuum	Material ID	5	2	5				
3	Width	25.0	250.0	25.0				
BC Left = Vacuum	Spacing	1.0	1.0	1.0				
BC Right = Vacuum	Material ID	5	2	5				
4	Width	25.0	15.0	220.0	15.0	25.0		
BC Left = Vacuum	Spacing	1.0	1.0	1.0	1.0	1.0		
BC Right = Vacuum	Material ID	5	4	3	4	5		
5	Width	23.0	2.0	15.0	220.0	15.0	2.0	23.0
BC Left = Vacuum	Spacing	1.0	1.0	1.0	1.0	1.0	1.0	1.0
BC Right = Vacuum	Material ID	7	6	4	3	4	6	7

Problem 1: Homogeneous slab, simple cosine shape, compare with analytical
Problem 2: Reflector, thermal flux peak on the edges, reflector flattens the flux shape
Problem 3: Same as 2, except smaller mesh spacing, was the solution of 2 spatially converged?
Problem 4: Enrichment zoning to flatten power shape
Problem 5: Explicit reflector model, compare eigenvalue between 4 and 5, play with the thickness of the baffle, what happens to the reactivity of the core

Question 2: Nodal Methods

You are provided with the one group NEM nodal solution for the three nodes illustrated in Figure 1. However, some of the NEM coefficients for the center node are no longer readable. Knowing that the 4th order expansion (those in lecture 20) were used and that the reactor was critical, calculate the following:



a) Calculate the net current on the left surface of the center node.
b) Calculate the net current on the right surface of the center node.
c) Calculate the missing coefficients for the center node using the NEM expansion method.
d) Calculate the center node peaking factor (peak-to-average).