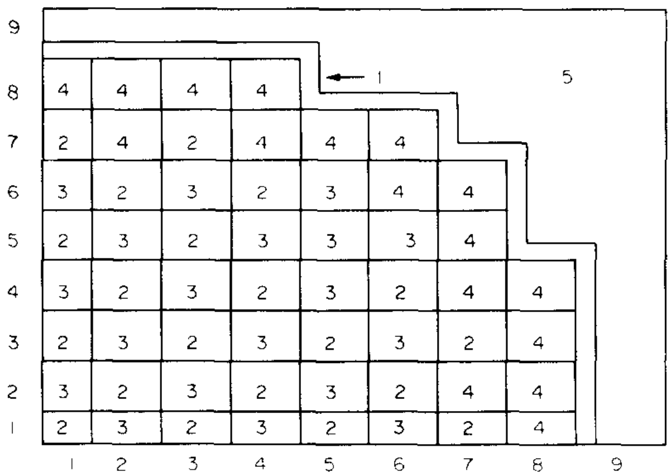
NUEN 629, Homework 3

Due Date Oct. 23

Solve the following problem and submit a detailed report, including a justification of why a reader should believe your results and a description of your methods and iteration strategies.

1 Goth and Hammer

(150 points + 50 points extra credit) The Zion PWR Benchmark (K.S. Smith, NSE, 1986), is a 2-D, two-group, reactor benchmark calculation where a quarter reactor is specified by the following figure:



Composition	Group, g	D_g	Σ_{ag}	$\nu\Sigma_{fg}$	$\Sigma_{gg'}$
1	1	1.02130	0.00322	0.0	0.0
	2	0.33548	0.14596	0.0	0.0
2	1	1.47160	0.00855	0.00536	0.01742
	2	0.37335	0.06669	0.10433	0.0
3	1	1.41920	0.00882	0.00601	0.01694
	2	0.37370	0.07606	0.12472	0.0
4	1	1.42650	0.00902	0.00653	0.01658
	2	0.37424	0.08359	0.14120	0.0
5	1	1.45540	0.00047	0.0	0.02903
	2	0.28994	0.00949	0.0	0.0

$X_1 = 1.0$, $X_2 = 0.0$.
Assembly pitch: 21.608 cm. Baffle thickness: 2.8575 cm.
Boundary condtions: reflective: left, bottom, zero flux: top, right.
$\Sigma_{tr,g} = 1/3D_g$ **for isotropic scattering, transport problem.**

Figure 1: Zion PWR benchmark from K.S. Smith, NSE, 1986.

A quarter of the reactor is a square that is divided in the figure into a 9 x 9 grid of 21.608 x 21.608 cm squares (i.e., the quarter reactor size is 194.472 x 194.472 cm). At the midline there are 8 assemblies in the x and y directions. In the problem specification there is only downscattering and what we have called Σ_{rg} is called Σ_{ag}. Also, note that all fission neutrons are born fast.

Your tasks are to:

1. Solve this problem using the finite difference method. In solving the problem you should find k_{eff} and the fission power in each assembly. Indicate what mesh resolution you need to converge k_{eff} to 1 pcm (10^{-5}). What is the time to solution for this problem?

2. Repeat part 1 using the nodal method we derived in class.

3. A critical buckling search is a method for finding the reactor height needed to make the reactor critical. We do this by adjusting the removal cross-section as

$$\Sigma_{rg} \to \Sigma_{rg} + D_g \frac{\pi^2}{H^2},$$

and iterating on the value of H until $k_{\text{eff}} = 1.$. Using either the finite difference or nodal method, estimate the critical height of this reactor.

4. (Extra Credit) Repeat part 2 using CMFD acceleration. How does the time to solution change?

2 250 points extra credit

(150 points + 50 points extra credit) The HAFAS BWR Benchmark, say it out loud (K.S. Smith, NSE, 1986), is a 2-D, two-group, reactor benchmark calculation with pin-level homogenization where a quarter reactor is specified by different assemblies as shown in the following figure:

In the problem specification there is only downscattering and what we have called Σ_{rg} is called Σ_{ag}. Also, note that all fission neutrons are born fast.

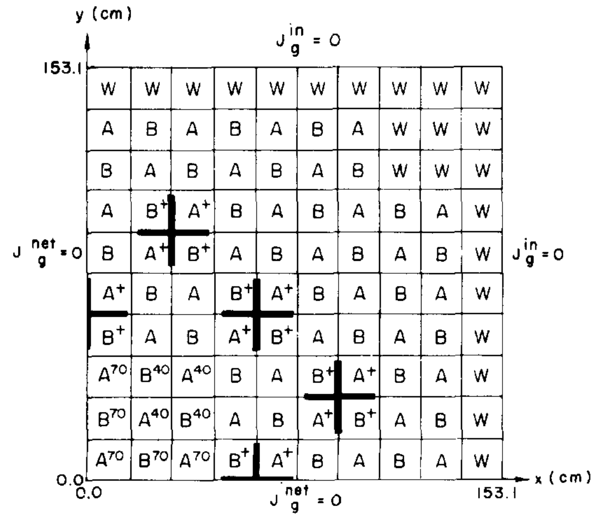
Your tasks are to:

1. (100 points) Solve this problem using the finite difference method. In solving the problem you should find k_{eff} and the fission power in each assembly. Indicate what mesh resolution you need to converge k_{eff} to 1 pcm (10^{-5}). What is the time to solution for this problem?

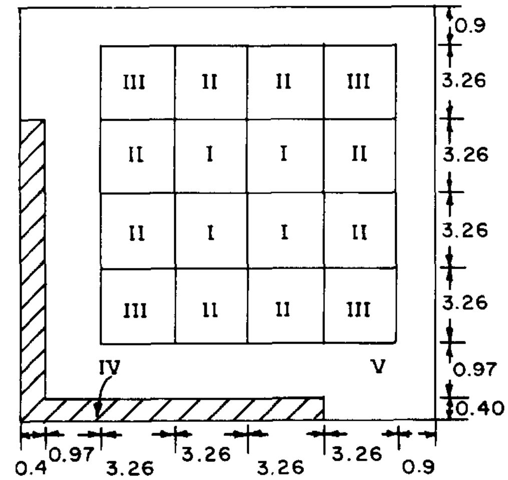
2. (100 points) Repeat part 1 using the nodal method we derived in class.

3. (50 points) Repeat part 2 using CMFD acceleration. How does the time to solution change?

Quadrant of the two-dimensional Reactor



Fuel Assembly Description



Composition-to-Zone Assignments

Zone	Assembly Type								
	A	A^{40}	A^{70}	A^{+}	B	B^{40}	B^{70}	B^{+}	W
I	1	5	9	1	2	6	10	2	15
II	2	6	10	2	3	7	11	3	15
III	3	7	11	3	4	8	12	4	15
IV	13	13	13	14	13	13	13	14	15
V	13	13	13	13	13	13	13	13	15

Cross sections

Composition	D_1	Σ_{aa1}	$\nu\Sigma_{f_1}$	$\Sigma_{1\to 2}$	D_2	Σ_{a2}	$\nu\Sigma_{f_2}$
1	1.400	0.0090	0.0065	0.0160	0.375	0.080	0.1220
2	1.400	0.0090	0.0057	0.0170	0.375	0.070	0.1000
3	1.400	0.0090	0.0051	0.0180	0.375	0.060	0.0800
4	1.400	0.0090	0.0051	0.0180	0.375	0.050	0.0700
5	1.680	0.0080	0.0063	0.0100	0.530	0.077	0.1180
6	1.680	0.0085	0.0055	0.0105	0.530	0.067	0.0960
7	1.680	0.0090	0.0049	0.0110	0.530	0.057	0.0780
8	1.680	0.0090	0.0049	0.0110	0.530	0.047	0.0680
9	2.000	0.0078	0.0061	0.0052	0.800	0.073	0.1140
10	2.000	0.0082	0.0053	0.0053	0.800	0.063	0.0920
11	2.000	0.0086	0.0047	0.0054	0.800	0.053	0.0720
12	2.000	0.0086	0.0047	0.0054	0.800	0.043	0.0620
13	1.530	0.0005	0.0	0.0310	0.295	0.009	0.0
14	1.110	0.08375	0.0	0.00375	0.185	0.950	0.0
15	2.000	0.0	0.0	0.0400	0.300	0.010	0.0

$\chi_1 = 1.0$, $\chi_2 = 0.0$, $\nu = 2.5$.
Boundary conditions: reflective: left, bottom, zero incoming flux: top, right.
$\Sigma_{tr,g} = 1/3D_g$ for isotropic scattering, transport problem.

Figure 2: HAFAS BWR benchmark from K.S. Smith, NSE, 1986.