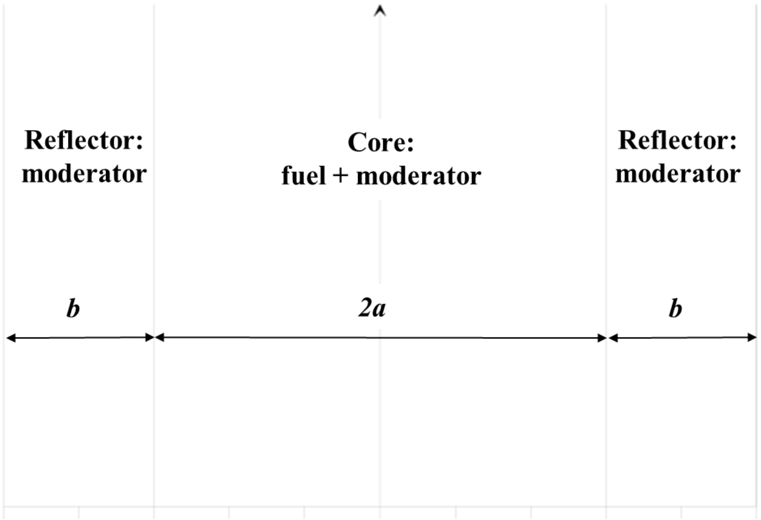
Modeling a more realistic planar reactor in two groups

We now consider a “realistic” 1D infinite slab reactor using a three batch loading scheme. Each assembly is 20cm wide, there are 4 fresh (ID 1), 4 once burned (ID 2) and 4 twice burned (ID 3) fuel assemblies. The reflector assembly has the ID 4. The loading pattern is [3 3 2 2 1 1 4] from the core center to the core boundary. A sketch of the core is shown below, where a=120 cm and b=20 cm. The total power generated by the core is 90 MW; the assemblies are 400cm tall. Please make use of the symmetry feature of this model.



The cross sections are represented with a two group energy structure are listed on the next page

Ass. ID	1		2		3		4	
Grp. ID	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
D	1.4824E+00	3.8138E-01	1.4854E+00	3.7045E-01	1.4850E+00	3.6760E-01	1.2000E+00	4.0000E-01
Σ_a	9.6159E-03	8.2153E-02	1.0577E-02	9.5616E-02	1.1109E-02	9.3004E-02	1.0000E-03	2.0000E-02
$\upsilon\Sigma_f$	7.1695E-03	1.4038E-01	6.0022E-03	1.4267E-01	5.1128E-03	1.2765E-01	0.0000E+00	0.0000E+00
$\kappa\Sigma_f$	9.1723E-14	1.8644E-12	7.4496E-14	1.7873E-12	6.1958E-14	1.5497E-12	0.0000E+00	0.0000E+00
Scattering Matrix								
to grp	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
from 1	1.9788E-01	1.7369E-02	1.9748E-01	1.6350E-02	1.9754E-01	1.5815E-02	2.5178E-01	2.5000E-02
from 2	1.6271E-03	7.9024E-01	1.8467E-03	8.0234E-01	1.8112E-03	8.1197E-01	0.0000E+00	8.1333E-01

Questions:

We now want to write a program to solve the 2G diffusion for this problem. The scattering term is considered in the LHS of the discretized equations. The system of coupled linear equations is solved by power iteration and the mesh size is set at 1cm.

1. Report keff, peak power (relative to the average), fast flux at the core boundary for the provided core configuration (mesh size 1, conv criteria in terms of keff at 10^{-7} between consecutive iterations)
2. Plot the normalized fast and thermal fluxes as well as the relative power distribution.
3. Explain the main features of the relative power distribution

Optimize the fuel loading pattern so as to have a maximum peaking strictly less than 3.0 and a vessel fast flux < 10^{13} $n.cm^{-2}.s^{-1}$ (at the last mesh point of the reflector). There are various possible solutions…for your optimum solution (it may not be the best one!),

4. Report loading pattern, keff (5 sig digs), power peaking and vessel fast flux (2 sig digs)
5. Plot the relative power, fast and thermal flux distributions of the optimized case. What is the name of such loading pattern?

Solution Check: for the initial loading pattern, normalized to the total core power: $\phi_1(10.5) = 1.7047\ 10^{14}$ $\phi_2(10.5) = 2.8791\ 10^{13}$. The relative power at 10.5cm is: $\boldsymbol{P^{rel}}(10.5) = 5.8858\ 10^{-2}$

Excerpt of matrix A

Mesh index (starting at 1)	19	20	21	22
19	2.4260	-1.2000	0.0000	0.0000
20	-1.2000	2.5523	-1.3263	0.0000
21	0.0000	-1.3263	2.8357	-1.4824
22	0.0000	0.0000	-1.4824	2.9918

Excerpt of matrix F

Mesh index (starting at 1)	21	301
21	0.0072	0.1404