HW5

22.211 Nuclear Reactor Physics I

Due date 4/10/2023

Question 1

Write a 1D MOC transport code to solve the problems listed in Figure 1 using the 2 group data provided in Figure 2. Use 2 polar angles:

w1 = 0.5 mu1 = +0.57735027

w2 = 0.5 mu2 = -0.57735027

- Plot k as a function of mesh spacing to determine mesh convergence

Problem												
1												
BC Left = Reflective	**Width**	1	1	2	1	2	1	2	1	2	1	1
BC Right = Reflective	**Material**	2	1	2	1	2	1	2	1	2	1	2
2												
BC Left = Reflective	**Width**	1	1	2	1	2	1	2	1	2	1	1
BC Right = Reflective	**Material**	2	1	2	1	2	3	2	1	2	1	2
3												
BC Left = Reflective	**Width**	1	1	2	1	2	1	2	1	2	1	1
BC Right = Reflective	**Material**	2	3	2	1	2	3	2	1	2	3	2

Figure 1: Problem layout

Material		Sigma_t1	Sigma_t2	Sigma_a1	Sigma_a2	nuSigma_f1	nuSigma_f2	Chi1	Chi2	Sigma_s11	Sigma_s12	Sigma_s21	Sigma_s22
1	Fuel 4%	0.416	0.821	0.032	0.421	0.028	0.795	1.000	0.000	0.383	0.001	0.000	0.400
2	Moderator	0.886	2.762	0.000	0.026					0.844	0.042	0.000	2.736
3	Fuel + Gd	0.432	3.473	0.041	3.059	0.028	0.392	1.000	0.000	0.390	0.001	0.000	0.414

Figure 2: 2 group cross-sections for Q1

Question 2

A bare critical spherical reactor with an **infinite absorber inner cavity** (in both groups) has an outer layer made of a homogeneous material that can be represented with the following two group data:

Table 1: 2 group data for Q2

$\nu\Sigma_{f1} = 0.04\ cm^{-1}$	$\nu\Sigma_{f2} = 0.4\ cm^{-1}$
$\Sigma_{a1} = 0.03\ cm^{-1}$	$\Sigma_{a2} = 0.3\ cm^{-1}$
$\Sigma_{s1\to2} = 0.02\ cm^{-1}$	$\Sigma_{s2\to1} = 0.0\ cm^{-1}$
$D_1 = 1.5$ cm	$D_2 = 1.2$ cm
$\chi_1 = 1.0$	$\chi_2 = 0.0$

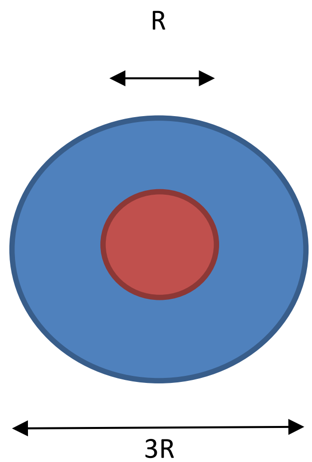

Figure 3: Bare spherical reactor with inner cavity

a) Find the geometrical buckling relation
b) Determine the critical radius (R) of this reactor
c) Compute the dominance ratio

<u>Neglect extrapolated distances.</u>

Question 3

You are in charge of designing a homogeneous solution critical reactor that operates at an average temperature of 600K as illustrated below in Figure 4. The core has a radius of 1m. Using 2 group diffusion theory with data provided in Table 2, answer the following questions:

Figure 4: Core

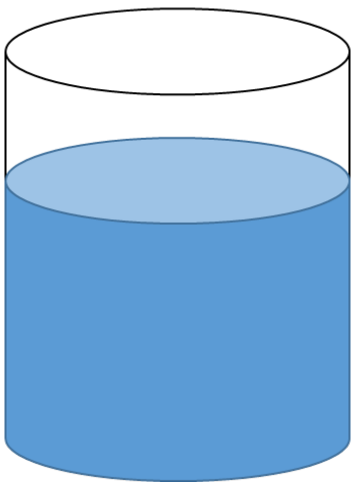

Table 2: 2 Group data for Q3

Quantity	Units	Fuel 1
D_1	cm	1.300
D_2	cm	0.400
Σ_{a1}	1/cm	0.006
Σ_{a2}	1/cm	???
Σ_{f1}	1/cm	0.004
Σ_{f2}	1/cm	???
$\Sigma_{s1\to2}$	1/cm	0.020
$\Sigma_{s2\to1}$	1/cm	0.002
χ_1	None	1.000
χ_2	None	0.000
ν	n / fission	2.5

Assume that thermal group fission and absorption vary linearly with enrichment according to the following relation (and that all other properties remain unchanged):

$$\Sigma_{a,2} = 0.01 + e \times 0.02$$

$$\Sigma_{f,2} = e \times 0.02$$ where *e* is the U-235 enrichment

a) **Calculate the U-235 enrichment** needed to make the reactor exactly critical if the tank is filled to a height of 2m (you can neglect extrapolation distances).

Assume that the nuclide density of the fuel varies linearly with *T* from its equilibrium temperature according to the following relation:

$$N = 5 \times 10^{22} - 1 \times 10^{20}(T - 600)$$ where *T* in in Kelvins

b) **Calculate the solution height** associated with a 50K increase in solution temperature (assuming that core radius remains unchanged).

c) Using 1 group diffusion theory, **approximate** the thermal expansion reactivity coefficient (pcm/K).