**Q 1.** Consider a homogeneous multiplying material. We want to build a critical system (without the reflector). Neglecting the extrapolated length, find which configuration allows reaching criticality with the minimum amount of material (select between spherical, cylindrical with height equal to the diameter, cubic).

**Q 2.** Determine the critical composition and the flux of a finite slab reactor with a width of 50 cm, composed of a homogeneous mixture of $^{235}U$ and $H_2O$, surrounded by an infinite reflector made of $H_2O$. Both the reflector and the core operate at a temperature of $\bar{T}$ = 60°C. This reactor has a power density of $q''' = 25$ W/cm$^3$. Assume thermal energies only, $\nu = 2.44$ and $\rho_{H_2O} = 1$ g/cm$^3$. Use also the following data.

- $D_r = 0.16$ cm
- $B_c = 0.05624$ cm$^{-1}$

Assume also $D_c \approx D_r$ (diluted fuel).

Hint: you will need the microscopic cross sections for water and $^{235}U$. As most tables report the values at 20°C, you can use this formula (careful about the units of measure):

$$\sigma = \sigma_0 \left(\frac{T_0}{T}\right)^{1/2}$$

**Q 3.** Based on the one-speed diffusion model, derive the criticality equation for a three-region slab reactor and compute the critical width 2a. The three regions are:

- core, with the same composition as Problem 3 and operating at the same temperature (60°C);
- blanket, composed of an homogeneous mixture of natural uranium and water with a ratio $NU/NW = 0.01$, width of 5 cm and temperature of 20°C
- reflector, composed of water with infinite width and temperature of 20°C (same composition as Problem 2 but different operating temperature).

Compare the results of Problem 2 and Problem 3 and discuss.

**Q 4.** In an unsupervised room of a nuclear power plant, there is a cylindrical tank containing a mixture of Beryllium and $^{235}$U. The cylinder has a sub-critical configuration with ratio $B_m^2/B_g^2 = 0.75$, radius R = 20 cm and height H = 40 cm. Now, a person accidentally sits on top of the cylinder. Assume that:

- The person can be approximated as a cylinder with a radius R = 20 cm.
- The person is a homogeneous medium composed of water.
- Neglect all surfaces and media (floor, air, etc.) near the cylinder and all other materials contained within the cylinder and the worker.
- For both regions the one-speed diffusion model can be used, also neglecting the extrapolated length

Using the data reported below, compute the height $h$ of the person for which the system becomes critical. Repeat the procedure using $B_m^2/B_g^2 = 0.93$ and discuss the safety of the tank.

$$^{235}U \ ; \ \nu = 2.4 \ ; \ \Sigma_a^U = 0.01297cm^{-1}$$
$$Be \ ; \ D_B = 0.7cm \ ; \ \Sigma_a^B = 0.0013cm^{-1}$$
$$H_2O \ ; \ L = 2.85cm \ ; \ D_A = 0.16cm$$