Nuclear Reactor Theory

2008 년 1 학기

Midterm Examination 2

May 15, 2008

1. Explain the following. (25 points)
   a. Doppler effect and its consequence
   b. Undermoderation and its significance
   c. Geometrical buckling and material buckling (use 1 group xsec for definition)
   d. Neutron current and Ficks' law.
   e. The reason why the spherical reactor has the smallest peaking factor.
   f. Eigenvalue in neutron diffusion equation

2. Consider a unit cell consisting of fuel and coolant regions. The fuel-to-coolant volume ratio is given as α. The energy range is divided into three intervals (fast, intermediate, and thermal) and proper average macroscopic cross sections and fluxes are given for each material. For example, Σ_{aI}^{f} represents macroscopic absorption cross section of fuel for intermediate range is ϕ_T^m is the thermal flux in moderator. (15)
   a. Define the four factors in terms of these parameters
   b. What is the factor among the four which would be affected mostly by the radius of the fuel? Explain the reason.
   c. If the geometrical buckling and migration area are given, how can you determine the effective multiplication factor

3. Derive the following. (15):
   a. The flux distribution for a point source in which the one group approximation is applied.
   b. The mean squared distance of a neutron to be absorbed at *r* from the origin where the neutron is born. Note that the probability of absorption between r and $r+dr$ is $\frac{\Sigma_a \phi(r) 4\pi r^2 dr}{\int_0^\infty \Sigma_a \phi(r) 4\pi r^2 dr}$. What is the physical meaning of the diffusion length?
   c. The effective multiplication factor in terms of 4 factors and the groupwise-nonleakage probabilities. Note that the Laplacian term can be replaced with $B^2\phi_g$ in the two group neutron diffusion equation.

4. For the following one-dimensional problem, $-D\frac{d^2\phi}{dx^2} + \Sigma_a \phi = \frac{1}{k}\nu\Sigma_f \phi;\ \ \phi(0) = 0, \phi(H) = 0$, answer the following: (15)
   a. Find the flux distribution.
   b. The effective multiplication factor in terms of H
   c. Determine the peaking factor.

5. A planar source of $s''[n/cm^2 - sec]$ is located at the left of a semi-infinite plane consisting of sub-productive material. (15)
   a. Solve this one-dimensional neutron diffusion problem with two different boundary conditions imposed on the left. First use $J(0) = s''$, then use $J^+(0) = s''$.
   b. For each solution, determine the absorption rate over the whole problem domain and consider the balance between the given source and the absorption rate.

c. Based on the consideration above, which one should be the correct boundary condition?

6. Consider now a slab of sub-productive medium ($k_\infty < 1$) with properties D and L and a thickness of a. Again there is a source of $s''[n/cm^2 - sec]$ enters the slab from the left. (15)

a. Give proper boundary conditions at each side of slab boundary (use your solution for Prob. Then, derive flux solution.

b. Calculate the fraction of neutrons that generated from the fission reaction in slab.

c. Calculate leakage of this medium? Is it positive of negative? And explain physical meaning.