Analysis of Reactor Static Characteristics

Fall 2008

Final Examination

Dec. 11, 2008

Closed Book Questions

1. Define the following term in words and give then associated mathematical form. (12)
   a. Transport kernel used in collision probability method (CPM), T_{ij}
   b. Resonance integral
   c. Intermediate resonance approximation

2. Explain the following conceptually. (16)
   a. White boundary condition and the need for it.
   b. The most important assumption lying in the integral transport equation and the correction introduced in the cross section in order to practically satisfy the assumption.
   c. The significance of the addition theorem in the treatment of anisotropic scattering.
   d. The need for the B_1 calculation and its usage.

3. Derive the following. (16)
   a. The contribution of the first moment of the differential scattering cross section onto the anisotropy of the scattering sources for an angle of interest, namely, $\frac{3}{4\pi}\tilde{\Sigma}^{(1)}_{g'g}\vec{J}_{g'}\cdot\hat{\Omega}$.
   b. The probability for a neutron to move horizontally by τ in optical distance without any collision.
   c. The reciprocity relation between collision probability kernel (or flux-to-collision conversion factor), P_{ij}.
   d. The leakage term in 1-D P_L equation given that $(2l+1)\mu P_l(\mu)=(l+1)P_{l+1}(\mu)+lP_{l-1}(\mu)$.

Open Book Questions

4. Derive the relation between the first collision escape probability and the first flight blackness for an interior region: $\gamma_i = 4\frac{V_i}{S_b}\Sigma_i p_i$.

5. Answer the following questions regarding the solution of resonance self-shielding in the lattice of a heterogeneous fuel cell. (12)
   a. Give the slowing down equation in terms of collision probabilities defined for the lattice employing the intermediate resonance approximation and explain each term.
   b. Derive the expression for the fuel flux rigorously starting from the slowing down equation assuming that $P_{FF}=\frac{x}{x+\alpha}$ where $x=\bar{l}_f\Sigma_f$.
   c. From this result, explain the equivalence between heterogeneous and homogeneous systems in resonance treatment.

6. The multigroup diffusion equation can be derived from so called inconsistent P_1 formulation. Explain the need for inconsistency concentrating on the second P_1 equation. Discuss then the validity of this inconsistency. (8)

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7. Give the P_1 equation in a 0-D problem in which the leakage term is presented in terms of buckling. Explain why B_1 would give a better solution despite that both P_1 and B_1 use the same first order expansion of the angular flux. (8)

8. Answer the S_n related questions. (11)
   a. Assume a neutron moving left. Show from the analytic solution of the 1-D transport equation that the average angular flux within the node should be obtained with more weight to the exit angular flux.
   b. The disadvantage of the diamond differencing is the possibility of negative flux. Explain the condition for positivity and the method for negative flux fixup.

9. Supposing that $AV_m = V_m H_m + \tilde{v}_{m+1} e_m^T$ is valid, show that $V_m^T A^2 V_m e_1 = H_m^2 e_1$. Explain the implication of this property in the solution of the depletion equation using the matrix exponential method. (7)