

# Nuclear Reactor Dynamics

2006 년 2 학기

## Midterm Examination

Nov. 2, 2006

1. Give the rationale for the following arguments and answer the associated questions. Support your answer with proper numbers, formula, or graph if necessary. (20 points)
  - a. After shutdown of a reactor, the neutron flux level can not vanish at least for tens of seconds.
  - b. The fast reactors respond more sensitively to a reactivity insertion (of the same absolute magnitude) than the thermal reactors.
  - c. After a step increase of reactivity, the neutron flux level changes to a higher value almost immediately and then stays constant there for tens of milliseconds. What is this phenomenon called?
  - d. The one group approximation of the point kinetics equation results in a faster rise of the flux after a step reactivity insertion into a critical core than the six group solution.
2. Explain the physical significance of the following quantities or formula with proper definitions if necessary. (15 points)
  - a. Neutron generation time
  - b. Beta-effective
  - c. Adjoint flux
  - d. Generalized source multiplication formula
3. Derive the following and answer the subsequent questions. (20 points)
  - a. First order perturbation theory formula for the reactivity change.
  - b. Inhour equation. Plot the prompt and stable branches.
  - c. Stable inverse period in one group formulation for a small reactivity insertion. You can use any proper approximation in the derivation.
  - d. Number of precursors produced per fission chain at a non-critical state.
4. Describe the derivation process of the exact point kinetics equations in four steps. Work through only on the left hand side (LHS) of the neutron balance equation. For the RHS, give only the initial balance equation in the operator form. Just give the final definition of reactivity. You need to give the proper rationale for each step except for the last step. What are the approximations needed for the practical point reactor model? (15 points)
5. Simplify the inhour equation for the two extreme cases of  $\alpha \gg \lambda_k$  and  $\alpha \ll \lambda_k$ . Show that these simplified inhour equations can be obtained from the one group point kinetics equations but with different definitions of one group decay constants. (15 points)
6. Answer the following. (15 points)
  - a. Consider a cylindrical reactor having uniform composition. Suppose that the absorption cross section of a thin annular region in the lower part of the core is changed slightly. Let the annular region restricted by  $r_1 \leq r \leq r_1 + \Delta r$ ,  $\Delta r \ll R$ ;  $0 < z < \Delta z \ll Z$ . How would you evaluate the reactivity change for this perturbed core. Give your answer in an explicit, form involving integrals.
  - b. Suppose that a reactivity of  $-3\beta$  was inserted to a critical core to make it subcritical. Sketch the flux level change with proper indication of key parameters. You can use semilog scale if necessary. Use the value of the one group decay constant obtained by harmonic averaging.