**Georgia Institute of Technology**

The George W. Woodruff School of Mechanical Engineering

Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Fall Semester 2015

\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Your ID Code

**Reactor Physics (Day 3)**

Instructions

1. Use a separate page for each answer sheet (no front to back answers)
2. The question number should be shown on each answer sheet

3. **ANSWER 4 OF 6 QUESTIONS ONLY**

4. Staple your question sheet to your answer sheets and turn in

**NRE/MP Reactor Physics**

**Answer any 4 of the following 6 questions**.

**Question 1.**

Consider a critical reactor with thermal spectrum utilizing HEU operating in a steady state with power level Po.

* 1. A control rod worth $0.40 is withdrawn. What is the prompt-jump power level after this reactivity insertion? (List your assumptions, i.e. approximate value(s) that you used, in case some data is needed but not given here.)

* 1. Explain prompt jumps approximation and sketch the power level as a function of time for case (a).
	2. Also sketch/explain power behavior if starting with a critical rector a very high worth (say $50) control rod is inserted.

**Question 2.**

Consider two very large but relatively thin metal slabs, each of thickness *t*, placed in parallel at distance from each other, separated by vacuum, and surrounded by vacuum. Distance *d* is comparable with thickness *t.* Assume that the slabs are made of pure 239Pu metal, density 17.0 g/cm3. Calculate the thickness *t* that will make this system critical by using the following (fast) one-group data: ν = 2.98, σf = 1.85 b, σγ = 0.26 b, and σtr = 6.8 b. How does this critical thickness *t* depend on distance *d*?

**Question 3.**

Describe the physics of Doppler broadening of resonances and why it leads to increased neutron absorption. Describe how resonance integrals would be calculated for resolved resonances and used to construct multigroup cross-sections in a homogeneous mixture of uranium and graphite.

**Question 4.**

Write the 2-group (fast and thermal) neutron flux and adjoint diffusion equations and use them to develop an expression for the reactivity worth of a change in the group 1 (fast) to group 2 (thermal) slowing down cross section.

**Question 5.**

Assuming the one-speed diffusion equation is valid in a thermal homogeneous slab (1-D) reactor with vacuum boundary conditions on both sides:

$$ϕ\left(x=\frac{\tilde{a}}{2}\right)=ϕ\left(x=-\frac{\tilde{a}}{2}\right)=0$$

Where $\frac{\tilde{a}}{2}$ and $-\frac{\tilde{a}}{2}$ are the extrapolated right and left boundaries, respectively.

The reactor is made of a uniform material with: $Σ\_{a}=1.0 cm^{-1}, and υΣ\_{f}=1.2 cm^{-1}$, and the differential scattering cross section is given as:

$$Σ\_{s}\left(μ\right)=\frac{2+μ}{4π} cm^{-1}$$

Where $μ$ is the cosine of the scattering angle. The thermal neutron speed $v=2200 m/sec$.

Calculate the following:

1. Diffusion coefficient *D*
2. Diffusion length *L*
3. Reactivity $ρ$
4. Mean neutron life time

**Question 6.**

Given the one delayed group point kinetics equations:

  

Apply the “Prompt Jump” approximation using the following ramped reactivity insertion parameters given below to estimate the near instant change in power attributed to prompt neutrons after the reactivity is inserted:

Initial Reactor State: Stable, Critical at 20,000 Wt

*  s-1
* 
* +0.0010
*  s