## QUESTIONS

REACTOR DYNAMICS PRACTICE PROBLEMS FOR TECHNICAL MAJORS

The DOE Fundamentals Handbook: *Nuclear Physics and Reactor Theory, Volume 2 of 2*, provides a general overview of some of the important concepts of reactor theory. It is written to cover a generic commercial nuclear reactor whose primary purpose is electric power generation, and not a Naval reactor whose main purpose is propulsion. Consequently, not all of the concepts presented and terminology used will be identical to what you will see at Nuclear Power School (NPS). Nevertheless, the DOE Handbook provides a good background and preparation for the Reactor Dynamics subject at NPS. The time and effort you devote to this prep material will make your learning process easier while in class at NPS.

### Topic 1 – "Neutron Life Cycle" Questions

**1. Define the following terms:**

**a. Infinite multiplication factor ($k_\infty$):**

**b. Effective multiplication factor ($k_{eff}$):**

**c. Subcritical:**

**d. Critical:**

**e. Supercritical:**

**2. Name and define each factor in the six factor formula using the ratio of the number of neutrons present at different points in the neutron life cycle.**

**3. Calculate the thermal utilization factor, f, for a homogeneous reactor. The macroscopic absorption cross section of the fuel is 0.2028 $cm^{-1}$, the macroscopic absorption cross section of the moderator is 0.0110 $cm^{-1}$, and the macroscopic absorption cross section of the poison is 0.0218 $cm^{-1}$.**

4. Twenty thousand (20,000) neutrons exist at the beginning of a generation. The values for each factor of the six factor formula are given below. Calculate the number of neutrons that exist at the points in the neutron life cycle as listed below and the single value of the effective multiplication factor.

a. Number of neutrons that exist after fast fission
b. Number of neutrons that start to slow down in the reactor
c. Number of neutrons that reach thermal energies
d. Number of thermal neutrons that are absorbed in the reactor
e. Number of thermal neutrons absorbed in the fuel
f. Number of neutrons produced from thermal fission.

$\varepsilon = 1.028$ $\mathcal{L}_f = 0.886$ $f = 0.754$

$p = 0.813$ $\mathcal{L}_{th} = 0.955$ $\eta = 2.021$

5. Explain the effect that temperature changes will have on the following factors:

a. Thermal utilization factor

**b. Fast non-leakage probability**

**c. Resonance escape probability**

**d. Reproduction factor**

**<u>Topic 2 – "Reactivity" Questions</u>**

**1. Using the data from Problem 4 in the previous topic, find the reactivity.**

**2. If a neutron population doubles in 50 generations, calculate the reactivity.**

3. Can the reactivity and the effective multiplication factor be positive? Negative? Zero?

4. For a reactivity of $40x10^{-4}$, calculate the effective neutron multiplication factor.

5. List at least three parameters that affect the core's reactivity.

6. If the temperature coefficient of reactivity is $-0.90x10^{-4}\ \frac{\text{reactivity units}}{^{o}\text{F}}$, and the moderator temperature increases by 10 degrees F, will the reactivity increase, decrease, or remain the same? Will the effective multiplication factor increase, decrease, or remain the same?

## Topic 3 – "Reactivity Coefficients" Questions

1. List three properties of a good moderator.

2. For an under-moderated reactor that uses ordinary water as the moderator, compare and explain the signs of the pressure and temperature coefficients of reactivity.

**3. Why can changes in reactivity due to pressure usually be neglected in a reactor that is cooled and moderated by subcooled water?**

**<u>Topics 4, 5, & 6 – "Neutron Poisons", "Xenon", and "Samarium and Other Fission Product Poisons" Questions</u>**

**1. Explain the use of burnable neutron poisons in a reactor core.**

**2. What is the equation for equilibrium xenon-135 concentration?**

**3. How does the equilibrium xenon-135 concentration vary with reactor power level?**

**4. Describe how xenon-135 concentration changes following a decrease in the power level of a reactor.**

**5. How is samarium-149 produced and removed from the reactor core during reactor operation?**

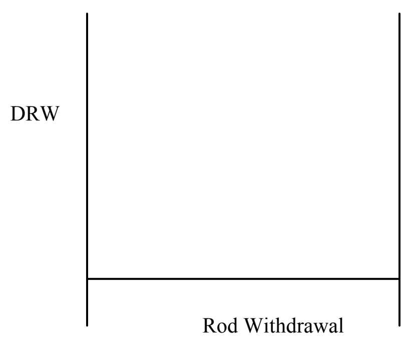
Topic 7 – "Control Rods" Questions

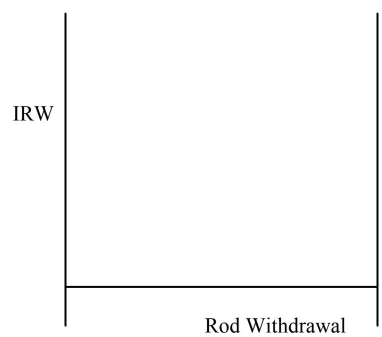
1. What are the qualities of a good control rod material?

2. Define Integral Control Rod Worth and Differential Control Rod Worth.

3. For a rod located at the center of the core, draw a sketch of Differential Rod Worth vs Rod Withdrawal and a sketch of Integral Rod Worth vs Rod Withdrawal.

4. On the same axis, complete question 3 for a rod located near the edge of the core. (Hint: for any given rod height, neutron flux is always lower at the edge than it is in the center.)




5. If a rod is currently 15-inches withdrawn, how much farther would it have to be withdrawn to add and additional 40 pcm of reactivity? Use the graphs from Example 1 on page 53 of the DOE Handbook: "Nuclear Physics and Reactor Theory, Volume 2 of 2; Module 3 – Reactor Theory (Nuclear Parameters)".