22.06 ENGINEERING OF NUCLEAR SYSTEMS - Fall 2010

Problem Set 1

Nuclear Power Intro + Reactor Physics Review

Reference Textbooks:

[RAK] = Knief, R. A. *Nuclear Engineering: Theory and Technology of Commercial Nuclear Power*. 2nd ed. La Grange Park, IL: ANS, 2008. ISBN: 9780894484582.

1) [RAK] Chapter 1, Problems 1-10

2) [RAK] Chapter 1, Problem 1-11

3) On average, how many neutrons are born per second by fission in a reactor that is a cube 3 m on a side and that operates at 4000 MW? (Assume it is a thermal reactor fueled with U-235) Does the physical size of the reactor matter in this problem?
(Adapted from Henry text.)

4) What is the probability per centimeter of travel that a neutron having energy 0.025 eV and moving in pure Pu-239 (which has a density of 19.6 g/cm^3) will be absorbed? (The absorption cross section of Pu-239 for neutrons at 0.025 eV is 1011 b)
(Adapted from Henry text.)

5) In class we derived an expression ($n \cdot \sigma \cdot dx$) for the probability of interaction of a neutron with the nuclei in a slice of material of thickness dx. One might think that for dx sufficiently large, the probability of an interaction could exceed unity. Why is this an invalid conclusion?
(Adapted from Henry text.)

6) Derive an expression for the intensity vs distance of a beam of parallel monoenergetic neutrons traveling through a material of given density n and microscopic cross section σ ?

7) [RAK] Chapter 2, Problem 2-11 (Use the result from Problem 6 above)

8) Consider a mixture of 10% (by volume) Pu-239 and 90% C (graphite). Relevant densities are 19.6 g/cm^3 and 1.6 g/cm^3, respectively. Assuming the neutron flux is 10^{14} n/cm^{2}s, calculate the rate (per unit volume) at which the following reactions occur within the mixture:

   i) Fission
   ii) Absorption by Pu-239
   iii) Absorption by graphite
   iv) Scattering by graphite

   The relevant neutron cross sections for this problem are as follows:
   Pu-239: 743 b (fission), 1011 b (absorption), 10 b (scattering)
   C: 0.0034 b (absorption), 5 b (scattering)
   (Adapted from Henry text.)

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