PHYS-E0460 Introduction to Reactor Physics, 1st mid-term exam
24 October 2017

You are allowed to use a non-programmed calculator and the document "Mathematical Tools for Reactor Physics".

1. Give a concise explanation of the following terms:
   a) radiative capture
   b) conversion ratio
   c) fissionable isotope
   d) six-factor formula
   e) multigroup diffusion theory
   f) self-shielding.

2. In 1972, uranium shipped to France from the Oklo mine in Gabon was found to contain a lesser amount of isotope ^{235}U than is usual (only 0,708 weight-%, as compared to the present day average of 0,711 weight-%). A more detailed analysis revealed signs of fission products and transuranic heavy elements. The only explanation is that at a depth of about 450 m, a natural reactor formed by a uranium and groundwater deposit had been active at Oklo in the distant past. When was the ^{235}U content of natural uranium at the level that makes this possible (about 3 weight-%), i.e. how old is the "Oklo reactor"? The half-life of ^{235}U is $7,13 \times 10^8$ a and the half-life of ^{235}U is $4,51 \times 10^9$ a.

3. Consider a homogeneous medium of volume V that absorbs neutrons and has a neutron source density s. Formulate the continuity equation describing the neutron population and derive from it the steady-state one-group diffusion equation. Under what general conditions is the diffusion model applicable to describing the neutron population?

4. The core of an infinite slab reactor is composed of a mixture of ^{235}U and graphite. There is an infinitely thick graphite reflector on both sides of the core. In the case of graphite, $\tau_T \ll L_T^2$; explain whether using more than one energy group is necessary. Starting from the reactor equation, derive expressions for the reflector savings and the critical thickness of the reflected core.

5. What kinds of reaction products are released in fission (including elementary particles and quanta), and what kinds of time scales are involved? As a consequence, what special safety consideration does this entail for nuclear reactors?