Due : Sept. 22, 2005

22.251 Systems Analysis of the Nuclear Fuel Cycle
Fall 2005
PROBLEM SET #2

1) An SB thesis by Chad Bollman at MIT (1998) investigated the optimization of using uranium or thorium in CANDU reactors. It was shown that the discharge burnup of the CANDU uranium fuel can be related to its initial enrichment as follows:

$$B_d = 50\,(X_p - 0.11)^{0.5} - 31.25 \qquad (0.711 < X_p < 1.5)$$

where B_d is the discharge burnup in MWd/kg and X_p is in wt%

What is the uranium fuel enrichment that will maximize the natural uranium resource utilization in this reactor?

2) It is proposed to use a 13 x 13 internally and externally cooled annular fuel assembly design to replace the 17 x17 externally cooled fuel assembly in a typical Westinghouse PWR reactor. If the power density in the original core is 100 kW/liter, and the new core is to run at 150 kW/liter, what is the internal diameter of the annular fuel that is required to maintain the same heat flux at the internal cladding as that of the original solid fuel pin. For simplicity, you may assume that the new fuel removes 40% of the heat through the internal channel.

Table 1: Assembly parameters for a Westinghouse 17X17 assembly

Assembly pitch (cm)	21.5
Lattice pin pitch (cm)	1.26
Fuel pellet radius (cm)	0.4096
Gap thickness (cm)	0.0082
Clad thickness (cm)	0.0572