3 Questions + tables

HW 4 IJL

1. (*40 points*) Consider a critical bare slab reactor 200 cm thick consisting of a homogeneous mixture of ^{235}U and graphite. The maximum thermal flux is 5×10^{12} $neutrons/cm^2-sec$. Using modified one-group theory, calculate:

(a) the buckling of the reactor,

(b) the critical atomic concentration of uranium,

(c) the thermal diffusion area,

(d) the value of k_∞,

(e) the thermal flux and current throughout the slab,

(f) the thermal power produced per cm^2 of this slab.

2. (*30 points*) A bare thermal reactor in the shape of a cube consists of a homogeneous mixture of ^{235}U and graphite. The ratio of atom densities is $N_F/N_M = 1.0 \times 10^{-5}$ and the fuel temperature is 250 $°C$. Using modified one-group theory calculate:

(a) the critical dimensions,

(b) the critical mass,

(c) the maximum thermal flux when the reactor operates at a power of 1 kW.

3. (*30 points*) Calculate k_∞ for a hexagonal lattice of 1.4 cm radius natural uranium rods and graphite if the lattice pitch is 20 cm. [Note: The fast fission factor for this lattice is 1.03.]

* Use the table below if Needed

TABLE 6.1 NOMINAL ONE-GROUP CONSTANTS FOR A FAST REACTOR*

Element or Isotope	σ_γ	σ_f	σ_a	σ_{tr}	ν	η
Na	0.0008	0	0.0008	3.3	—	—
Al	0.002	0	0.002	3.1	—	—
Fe	0.006	0	0.006	2.7	—	—
^{235}U	0.25	1.4	1.65	6.8	2.6	2.2
^{238}U	0.16	0.095	0.255	6.9	2.6	0.97
^{239}P	0.26	1.85	2.11	6.8	2.98	2.61

*From *Reactor Physics Constants*, 2nd ed., Argonne National Laboratory report ANL-5800, 1963.

TABLE 6.2 BUCKLINGS, B^2, AND FLUXES FOR CRITICAL BARE REACTORS (ASSUMING d IS SMALL)

Geometry	Dimensions	Buckling	Flux	A	Ω
Infinite slab	Thickness a	$\left(\frac{\pi}{a}\right)^2$	$A\cos\left(\frac{\pi x}{a}\right)$	$1.57P/aE_R\Sigma_f$	1.57
Rectangular parallelepiped	$a \times b \times c$	$\left(\frac{\pi}{a}\right)^2+\left(\frac{\pi}{b}\right)^2+\left(\frac{\pi}{c}\right)^2$	$A\cos\left(\frac{\pi x}{a}\right)\cos\left(\frac{\pi y}{b}\right)\cos\left(\frac{\pi z}{c}\right)$	$3.87P/VE_R\Sigma_f$	3.88
Infinite cylinder	Radius R	$\left(\frac{2.405}{R}\right)^2$	$AJ_0\left(\frac{2.405r}{R}\right)$	$0.738P/R^2E_R\Sigma_f$	2.32
Finite cylinder	Radius R, Height H	$\left(\frac{2.405}{R}\right)^2+\left(\frac{\pi}{H}\right)^2$	$AJ_0\left(\frac{2.405r}{R}\right)\cos\left(\frac{\pi z}{H}\right)$	$3.63P/VE_R\Sigma_f$	3.64
Sphere	Radius R	$\left(\frac{\pi}{R}\right)^2$	$A\frac{1}{r}\sin\left(\frac{\pi r}{R}\right)$	$P/4R^2E_R\Sigma_f$	3.29