Solution

ENGINEERING PHYSICS 4D3/6D3

DAY CLASS Dr. Wm. Garland
DURATION: 20 minutes
McMASTER UNIVERSITY QUIZ #2 October 23, 2001

Special Instructions: Closed Book. All calculators and up to 6 single sided 8 ½" by 11" crib sheets are permitted.

THIS EXAMINATION PAPER INCLUDES 2 PAGES AND 2 QUESTIONS.

1. [10 Marks] Briefly:

a. distinguish between neutron flux and neutron current

(1) $\phi \equiv nv$ (scalar), $\bar{J} \equiv n\bar{v}$ (vector)

b. distinguish between reactivity, ρ, and multiplication factor, k

(1) $k = \frac{\text{production rate}}{\text{loss rate}}$ or $\frac{\text{\# in generation } n}{\text{\# in generation } n-1}$, $\rho \equiv \frac{k-1}{k}$

c. describe ϵ of the four factor formulae

(1) fast fission factor $= \frac{\text{total \# of fissions from fast + thermal}}{\text{\# of fissions from thermal neutrons}}$ (~ 1.03)

d. describe η of the four factor formulae

(1) $\frac{\text{average \# neutrons produced}}{\text{\# neutrons absorbed in fuel}} \simeq \frac{\nu \sigma_f}{\sigma_a}$ (~ 2.0)

e. describe f of the four factor formulae

(1) thermal utilization $= \frac{\Sigma_a^{\text{fuel}}}{\Sigma_a^{\text{fuel}} + \Sigma_a^{\text{rest}}}$ (~ 0.7)

f. describe p of the four factor formulae

(1) resonance escape probability (~ 0.9)

g. distinguish between geometric buckling and material buckling

(2) for 1 speed case, $\underbrace{B_g^2 \simeq \left(\frac{\pi}{a}\right)^2}_{\text{geometric buckling}} = \underbrace{\frac{\nu\Sigma_f - \Sigma_a}{D}}_{\text{material buckling}} = B_m^2$ $B_g^2 = B_m^2$ in critical reactor

h. describe fission product poison.

(1) Some fission products, like Xe & Sm, have high absorption cross-sections ∴ act like "poisons" in that they absorb neutrons.

i. describe xenon over-ride.

(1) Xe builds up when a reactor shuts down. If want to start up during this build up period, need to have excess reactivity available.

2. [10 marks] What is the obvious error in the following expressions? Explain briefly.

a. Steady state one-group neutron balance equation:
$D(r)\nabla^2\phi(r) - \Sigma_a(r)\phi(r) - \nu\Sigma_f(r)\phi(r)$

(2) We have $\frac{1}{v}\frac{\partial\phi}{\partial t} = \nabla\cdot D\nabla\phi - \Sigma_a\phi + \nu\Sigma_f\phi$.
In SS: $-\nabla\cdot D\nabla\phi + \Sigma_a\phi = \nu\Sigma_f\phi$ Also, if $D = fn(r)$ can't take D outside of $\nabla\cdot(\ \ )$

b. $\Sigma_{total} < \Sigma_{absorption}$

(1) $\Sigma_{total} = \Sigma_{abs} + \Sigma_{scattering} \therefore \Sigma_{total} \geq \Sigma_{abs}$

c. The gradient of the flux is continuous at an interface

(1) The current is continuous at an interface

d. $\rho = 2$

(1) $\rho \equiv \frac{k-1}{k}$. $0 \leq k \leq \infty \Rightarrow -\infty \leq \rho \leq 1$
ie ρ cannot be > 1.

e. For a reactor operating at constant power, as the fuel is burned up, the flux remains constant over time

(1) Power $\propto \Sigma_f\phi = \sigma_f N_f \phi$. As $N_f \downarrow$, ϕ must $\uparrow$ to keep power constant.

f. I^{135} decays with a half life of 9.17 hours to Xe^{135} which decays with a half life of 6.58 hours

(1) I^{135} decays faster than Xe^{135}
$\uparrow T_{\frac{1}{2}} = 6.58$ hr. $\uparrow T_{\frac{1}{2}} = 9.17$ hr.

g. Neutron current is defined as: $\underline{J} = -D\nabla\phi$

(2) $\underline{J} \simeq -D\nabla\phi$. This is an approximation, not a definition. Also $\underline{J}$ is the current density

h. For the same power, the smaller the reactor, the lower the flux.

(1) $P \propto \text{Volume} \times \Sigma_f\phi$
$\therefore$ As Volume $\downarrow$, ϕ must $\uparrow$ for same Power.