ENGINEERING PHYSICS 4D3/6D3

DAY CLASS Dr. Wm. Garland

DURATION: 50 minutes

McMASTER UNIVERSITY MIDTERM EXAMINATION October 18, 1996

Special Instructions:

1. Open Book. All calculators and reference material permitted.
2. Do all questions.
3. The value of each question is as indicated.
   TOTAL Value: 100 marks

THIS EXAMINATION PAPER INCLUDES 1 PAGE AND 3 QUESTIONS. YOU ARE RESPONSIBLE FOR ENSURING THAT YOUR COPY OF THE PAPER IS COMPLETE. BRING ANY DISCREPANCY TO THE ATTENTION OF YOUR INVIGILATOR.

1. [30 marks] Consider an infinite planar source of neutrons in an infinite absorbing medium. The source strength is S neutrons/cm^2/sec. Given the resulting flux distribution as derived in class, determine the absorption rate at any point in space and show that the total absorption rate of neutrons equals the production rate of neutrons.

2. [30 marks] A bare, homogeneous cubic reactor can be characterized by one group neutron diffusion, D = 10 cm., Σ_a = 0.1 cm.$^{-1}$, height = width = length = 100 cm. What is the neutron non-leakage probability, P_{NL}? [Hint: $P_{NL} = 1 / (1 + B_g^2 \; L^2)$]

3. [40 marks] For an infinite cylindrical reactor (radius a) with a reflector boundary (outside radius b):
   a) State the 1 group steady state neutron diffusion equations for the core and reflector regions.
   b) State and justify your boundary conditions.
   c) Outline the procedure for analytically solving the above equations. Don't solve the equations; it is quite time consuming. Indicate how you would find the criticality equation. Assume trial solutions of the form:

   N_C ' $A_C J_0(\mu r)$ % $C_C Y_0(\mu r)$
   N_R ' $A_R J_0(\mu r)$ % $C_R Y_0(\mu r)$

   J_0 is the 0th order Bessel function of the first kind. Y_0 is the 0th order Bessel function of the second kind and goes to 4 at r=0.
   d) Sketch the flux distributions. Explain any significant features.

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Midterm 96

1. $\phi = \frac{SL}{2D} e^{-x/L}$ (10)

Absorption rate at $x = \Sigma_a \phi(x)$ (10)

Total abs. rate for $x > 0 = \int_0^\infty \Sigma_a \phi(x) dx$

$$= \frac{\Sigma_a SL}{2D} \int_0^\infty e^{-x/L} dx = \frac{\Sigma_a SL}{2D} \cdot (-L) e^{-x/L} \Big|_0^\infty$$

$= \frac{S}{2}$ = production rate for R.H.S. (10)

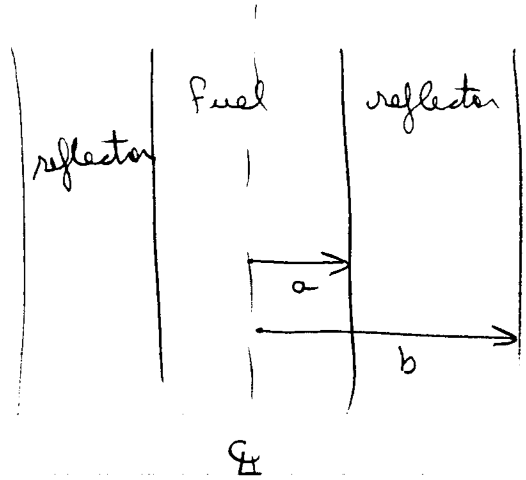
2. $B_g^2 = \left(\frac{\pi}{H}\right)^2 + \left(\frac{\pi}{L}\right)^2 + \left(\frac{\pi}{W}\right)^2 = 3\left(\frac{\pi}{H}\right)^2$ for a cube.

Non-leakage probability $= \frac{1}{1 + B_g^2 L^2}$, $L = \frac{D}{\Sigma_a} = \frac{10}{.1}$

$= 100 \text{ cm}^2$

$$= \frac{1}{1 + 3\left(\frac{\pi}{100}\right)^2 \cdot 100} = \frac{1}{1 + \frac{3\pi^2}{100}} = 0.772$$

3.



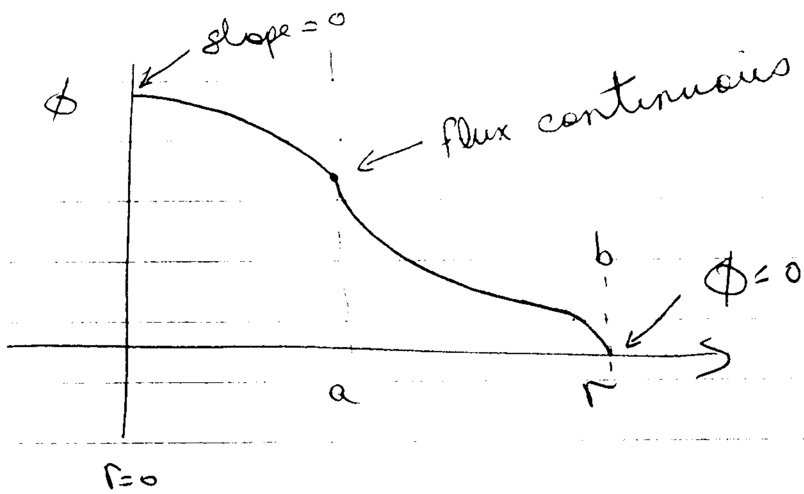
a) Fuel: $\frac{D_c}{r}\frac{\partial}{\partial r} r \frac{\partial \phi_c}{\partial r} + (\nu_c \Sigma_{f_c} - \Sigma_{a_c})\phi_c = 0$

Reflector: $\frac{D_R}{r}\frac{\partial}{\partial r} r \frac{\partial \phi_R}{\partial r} - \Sigma_{a_R}\phi_R = 0$

b) B.C.: 1. $\phi_c(a) = \phi_R(a)$ } Interface current & flux
2. $J_c(a) = J_R(a)$ } continuous
flux vanishes outside reactor
3. $\phi_R(b) = 0$ (assume b = extrapolated length)
4. Symmetry or flux gradient at $r=0$ is 0.
or flux finite

c) Assume trial solution forms
(eg $\phi_c = A_c J_0(\mu r) + C_c Y_0(\lambda r)$ $= 0$ (B.C. 4)
$\phi_R = A_R J_0(\mu r) + C_R Y_0(\lambda r)$)

Apply B.C. 1 & 2 & divide equations to get one criticality equation. The A's & C's cancel out.
Assume Value of ϕ known at $r=0$ (arbitrary).
Use B.C. 1 to relate A_c to A_R & C_R.
Use B.C. 3 to Relate A_R to C_R


slope = 0
ϕ
flux continuous
b
$\phi = 0$
a
r
r=0