Oct. 18, 2004 Name: ______________________________

Midterm Examination

NE-630: APPLIED REACTOR THEORY

PART A: Closed books and notes. Hand in before beginning Part B.

1. Define in words the physical meaning or interpretation of the following quantities. *[3 points each]*

   (a) the one-speed flux density, $\phi(\mathbf{r})$

   (b) the total macroscopic cross section, $\Sigma_t(\mathbf{r})$

   (c) neutron lethargy, u

   (d) the y-component of the neutron current density vector, $J_x(\mathbf{r})$

   (e) the slowing down density, $q(\mathbf{r}, E)$

2. Recall, that for isotropic scattering in the center of mass, the probability $P(E \to E')dE'$ that a neutron of initial energy E ends up with an energy in dE' about E' is

$$P(E \to E') = \begin{cases} \dfrac{1}{(1-\alpha)E}, & \alpha E \le E' \le E \\ 0, & \text{otherwise} \end{cases} .$$

Derive the corresponding expression for $P(v \to v')$ where $P(v \to v')dv'$ is the probability that a neutron of initial speed v ends up with a speed in dv' about v'. *[15 points]*

Oct. 17, 2003 Name: ____________________________

Part B: Open books and notes. Begin only after handing in Part A.

3. For each of the following one-speed, steady-state diffusion problems (i) sketch the problem geometry showing your choice of coordinate system, (ii) write the appropriate form of the diffusion equation for each diffusing region in which this equation holds, (iii) write the general solution for each region including any particular solution, and (iv) write the boundary/source conditions you would use to determine the values of the arbitrary constants in your general solution.

   (a) A bare homogeneous infinitely-long cylinder of radius R contains a central cylindrical region of radius $R_o < R$ that is filled with a perfect absorber. In the outer diffusing medium of the cylinder is a uniformly distributed source of strength S cm^{-3} s^{-1}. *[15 points each]*

   (b) A bare, homogeneous sphere of radius R contains a volumetric source of strength S_o neutrons cm^{-3} s^{-1} in a central spherical region $0 \leq r \leq R_o < R$. Surrounding the sphere is a thin layer (thickness T) of a perfect absorber. The sphere with its absorber layer is placed in an infinite diffusing medium of a material different than that of the sphere. *[20 points each]*

   (c) An infinite, bare, homogeneous slab of thickness T contains a distributed volumetric source of strength $S(x) = xe^{-\alpha x}$ where α is a positive constant and x is measured from the left surface of the slab. The slab is also irradiated with a beam of neutrons of intensity I_o cm^{-2} s^{-1} that is normally incident on the left surface. *[20 points each]*

4. In a bare infinite homogeneous slab of diffusing material there is a volumetric source of strength $S(x)$ neutrons cm^{-3} s^{-1}, where x is measured from the left face of the slab. This sources produces a flux profile $\phi(x)$ in the slab. The source neutrons are eventually either absorbed by the slab material or leak from the slab. Derive an expression for the probability a source neutron leaks from the slab. *[15 points]*