**Georgia Institute of Technology**

The George W. Woodruff School of Mechanical Engineering

Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Fall Semester 2015

\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Your ID Code

**Radiation Transport (Day 2)**

Instructions

1. Use a separate page for each answer sheet (no front to back answers)
2. The question number should be shown on each answer sheet

3. **ANSWER 4 OF 6 QUESTIONS ONLY**

4. Staple your question sheet to your answer sheets and turn in

**NRE/MP Radiation Transport**

**Answer any 4 of the following 6 questions**.

**Question 1**.

Consider energy-dependent transport equation.

1. Write the time-independent form, for general 3D geometry, non-multiplying medium. Define all terms.
2. What is the transport operator in this case? Write the equation in operator form.
3. What is the corresponding adjoint equation in operator form? What is the requirement defining the adjoint operator, and what is the resulting expression for the operator?
4. Our objective is to calculate a detector response. The detector is located at the position rD, has a small volume VD, and response characteristic given by σD(E). The fixed source distribution S(r,E) is assumed given. How would you use the forward transport equation (b) to calculate detector response?
5. How would you use the adjoint equation (c) to calculate the same response?

**Question 2.**

Assume you are using discrete ordinates method for solving monoenergetic 1D transport equation,

* 1. Explain truncation error due to spatial differencing, specifically for the diamond difference (DD) equations. For simplicity, you may consider the within group source being zero.
  2. Show that DD is second order accurate method.
  3. What is step differencing? Qualitatively show/plot and discuss behavior of diamond and step differencing schemes.
  4. What is one important DD issue related to the mesh size? Does using higher quadrature order by itself alleviate it?
  5. How is that issue treated when using the step differencing scheme?

**Question 3.**

Suppose you are given the reciprocity relation below for two transport problems having the same geometry and cross section but different sources and different incident flux boundary conditions.



For the special case of no incident neutrons, using the above reciprocity relation derive the relation between first flight collision probabilities (PAB and PBA) for two homogeneous regions (A and B) in the problem/system, where the sources are assumed spatially uniform and isotropic in angle.

**Question 4.**

Derive the dispersion relation for the asymptotic relaxation length (1/*k*) of the adjoint transport equation with isotropic scattering in slab geometry where distance is measured in MFP (see below).

Note:

**Question 5.**

Assume there is a point source located at the center of a homogeneous sphere of radius . The angular distribution of the point source is

* 1. Write down the uncollided flux transport equation and the corresponding vacuum boundary condition;
  2. Compute the escape probability and first-flight collision probability if cm and .

**Question 6.**

Suppose there is surface source locate in a 1D homogeneous slab ). Note:

* 1. Write down the equation and the corresponding vacuum boundary condition;
  2. Use the above equation to derive the total partial current at if the slab is a purely absorbing medium.