GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff School of Mechanical Engineering

Ph.D. Qualifier Exam

Fall Semester 2002

________________ Your ID Code

Fusion

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.

FUSION

1. Formally derive the first two fluid moment equations (particle balance and momentum balance) from the Boltzman transport equation for charged particles.
2. Prove that both the current and the magnetic field in a magnetically confined plasma both lie within the isobaric (constant pressure) surfaces; i.e. have no component normal to the surfaces of constant pressure.
3. Discuss the various drift motions in a tokamak and their effects on particle confinement.
4. A 5 keV deuterium ion is born at the center of a simple magnetic mirror with a pitch angle $\theta = 15^\circ$. If the magnetic field at the center of the mirror is equal to 1 Tesla, what is its value at the location where the ion is reflected? What is the gyroradius of the deuterium ion there?
5. For a large aspect ratio tokamak plasma with circular cross section, assume that the toroidal current density is given by:

$$j_\phi(r) = j_{\phi 0}\left(1-\frac{r^2}{a^2}\right)^\nu.$$

   where a is the minor radius and ν an arbitrary exponent. Evaluate the radial profiles of the poloidal magnetic field $B_\theta(r)$ and safety factor $q(r)$. What is the value of the safety factor at the origin ($r = 0$)?

6. Show that the MHD equilibrium equation for an arbitrary 3-dimensional geometry can be written as:

$$\nabla_\perp\left(p+\frac{B^2}{2\mu_0}\right)-\frac{B^2}{\mu_0}\boldsymbol{\kappa}=0$$

   where $\boldsymbol{\kappa} = \mathbf{b}\cdot\nabla\mathbf{b}$ is the field line curvature and $\mathbf{b} = \mathbf{B}/B$.