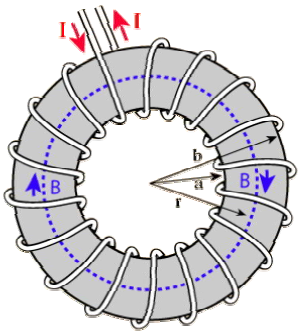
Fusion Reactor Engineering 1 (459.760)

Midterm Examination

22 April, 2009

1. (20 points) (a) A uniform solenoid *l* in diameter and *L* in length has *N* turns of wire and a current *I*. Find the magnetic field *B* at distance *r* from the axis of the solenoid.

(b) Find the magnetic field *B* at *r* in a toroid shown on the right side.



(c) Provided plasmas are formed inside the toroid, explain motions of electrons and ions.

(d) Find ways to confine the plasmas in the toroid.

2. (10 points) Explain natural processes in the universe to produce Helium from Hydrogen.

3. (20 points) (1) Write down the equation of fusion power in the D-T fusion reaction in steady state and homogeneous plasmas.

(2) Describe the Ricatti's equation which is for calculating the ion density.

4. (20 points) Derive the ignition condition of fusion reactors using the following formulae.

$$P_{br} = A_{br} N_i N_e Z^2 \sqrt{kT_e}\,, \quad P_{cyc}^{net} = A_{cyc} N_e B^2 kT_e \psi$$

5. (20 points) Answer the following questions.

(1) How one can describe the plasma configuration in a tokamak?

(2) Explain the concept of beta in the economic point of view.

(3) Explain the concept of the energy confinement time

(4) What is the meaning of $q(0)/q(a)$ in a tokamak?

6. (10 points) Explain the meaning of the following equation by term by term.

$$m_\alpha n_\alpha \left(\frac{\partial \vec{u}_\alpha}{\partial t} + (\vec{u}_\alpha \cdot \nabla)\vec{u}_\alpha \right) = n_\alpha q_\alpha (\vec{E} + \vec{u}_\alpha \times \vec{B}) - \nabla \cdot \vec{P}_\alpha + \sum_\beta R_{\alpha\beta}$$

"Look at the birds of the air; they do not sow or reap or store away in barns, and yet your heavenly Father feeds them. Are you not much more valuable than they?" (Mathew 6:26)