Nuclear Engineering 180
Fall Semester 2001
First Midterm Examination

SEVENTY-FIVE MINUTES, CLOSED BOOK. ONE: $8\frac{1}{2}'' \times 11''$ SHEET OF NOTES ALLOWED.

1. A tokamak reactor has $< \beta_{pol} >= 1$ and an aspect ratio $A = R/a$ of 3.0, and a safety factor at the edge $q(a) = 2.5$. The toroidal magnetic field in the center of the plasma is 4.0T. The plasma cross section is circular. Assume that $< n^2 >=< n >^2$ and that $Z_{eff} = 2.0$. The machine is designed to produce 1000 megawatts of electric power to the grid. The design Q is 25, and the efficiency of the thermal converter is 0.33, and the efficiency of the injector is 0.8. The plasma is a 50-50 D-T mixture.
   a. Find the plasma poloidal magnetic field at the edge, $B_\theta(a)$.
   b. Find the average density $< n >$ if $T_e = T_i = 15.0$ KeV everywhere.
   c. Find the net power produced in the machine.
   d. Find the volume of the machine.
   f. Find the major radius R of the machine.
   f. Find $n\tau_E$.
2. A plasma has a $D-T$ total fuel density of 10^{20} m^{-3}. Molybdenum ($Z = 42$) is present as an impurity at concentration of 0.1 percent of the $D - T$ fuel density.
   a. At a region near the edge, the temperature is 100 eV. Is the molybdenum fully stripped here ? Give a formula to justify your answer.
   b. In the center of the plasma, the electron temperature is 30 keV. Do you expect the molybdenum to be fully stripped here?
   c. Suppose that the molybdenum were fully stripped in the center of the plasma. Find the increase in the plasma radiation loss through bremsstrahlung compared to a clean plasma with the same $D - T$ fuel density.
3. A laser fusion target is compressed to 100× the liquid density of $D - T$ ($\rho_{liq}(DT) = 0.25$ g cm^{-3})
   a. Find the minimum energy per photon of light which will penetrate this density.
   b. Find the associated wavelength of this photon energy.
   c. Suppose that this density of DT was at a temperature of 15 keV and that the plasma had the same electron density as ion density at this same temperature. What value of magnetic field, in tesla, has a magnetic pressure which corresponds to this kinetic pressure?