Nuclear Engineering 180
Fall Semester 2000
Second Examination

SEVENTY-FIVE MINUTES, CLOSED BOOK. ONE $8 - \frac{1}{2}$" × 11" SHEETS OF NOTES ALLOWED.

PLASMA FORMULARY ALLOWED.

1. A tokamak plasma has an ion temperature profile and density profile given by:

$$T_i(r) = T_0(1 - (\frac{r}{a})^2)$$
$$n_i(r) = n_0(1 - (\frac{r}{a})^2)$$

where $T_0 = 15.0$ KeV, $n_0 = 2 \times 10^{20}$ m^{-3}, and $a = 2.0$ m. The magnetic field $B_\phi(r = 0)$ is 4.0 T. The major radius R of the tokamak is 6.0 m. The electron temperature $T_e = T_e(0) = 10.0$ keV everywhere.

   a. Find the classical ion heat conduction through the flux surface at $r = 0.9a$. Assume that the ions have an average mass of 2.5× the proton mass. Neglect variation in the magnetic field, and use $B = B_\phi(r = 0)$ for your calculation.

   b. Find the resistivity in ohm-meters.

   c. If the plasma carries a current of 10 MA toroidally, find the total power in ohmic heating of the plasma.

   d. Assume that a fraction f of the plasma's surface area at $r = 0.9a$ is connected to the reactor wall by parallel electron heat conduction along stochastic magnetic field lines. Assume that these field lines are 1000 meters long ($= L$) and that the electron temperature gradient is $T_e(0)/L$. Find this fraction f if the experimentally observed heat conduction is 50 MW.

2. A laser-heated ICF target has a fusion yield of 100 MJ. $\rho R = 10$ in cgs units. The internal temperature of the spherical pellet is 10 keV for both the electrons and ions. Take the burnup fraction $f_B = \rho R/(6 + \rho R)$.

   a. Find the final value of ρ and R in cgs units.

   b. Find the longest wavelength for light which will penetrate the pellet at this density.

   c. Find the hydrodynamic disassembly time $R/(4c_s)$ for this pellet.

   d. The Stefan-Boltzmann constant σ for blackbody radiation is 5.6699×10^{-8} watt m^{-2} deg C^{-4}. Find the outgoing blackbody radiation from the pellet during the fusion burn.