AS551 General Plasma Physics 1
Jan. 13, 2003

Problem Set # 9 (due Tuesday Jan 21, 2003)

G&R refers to Goldston and Rutherford's textbook.

1. G&R problem 11.4. (describe process of approaching thermal equilibrium

2. G&R problem 12.1. (solutions to diffusion equation)

3. G&R problem 12.6. (Effect of ions with charge Z on transport coefficients)
(Approximate answers using scalings from random-walk arguments are sufficient here.)

For a plasma in a stationary equilibrium ($d/dt = 0$), with an isotropic pressure, the MHD equilibrium relation is:

$$\nabla p = \frac{\vec{j} \times \vec{B}}{c}$$

In the following problems, you will explore some of the properties of equilibria implied by this equation.

4. Goldston and Rutherford problem 9.1 (plasma hole)

5. Goldston and Rutherford problem 9.2 (pinch equilibrium)

6. Bennett pinch condition. Consider a standard z-pinch equilibrium configuration (current in the z-direction, magnetic field only in the θ direction). The plasma is uniform in z and θ, and is confined to $r < a$ by the magnetic field. Calculate the volume integrated plasma energy (per length in z):

$$W = \int_0^a dr 2\pi r \frac{3}{2} p$$

Integrate this by parts (assuming $p = 0$ at $r = a$) to express this in terms of $\partial p/\partial r$, and use the MHD force balance equation to show that W can be expressed in terms of the total current carried by the plasma. (This is known as the Bennett pinch condition.)