EE356 Elementary Plasma Physics H.O. #21
Inan 26th April,2002
Spring 2002

HOMEWORK ASSIGNMENT #4

(Due Friday, May 3rd)

1. **Short Review Questions:**

a. *Low frequency phenomena in MHD.* Explain why the MHD treatment of a plasma is only suitable for analyzing relatively low frequency phenomena?

b. *MHD versus multi-fluid*. What is the primary advantage and disadvantage of using the MHD formulation, rather than a multi-fluid treatment?

c. *Diamagnetic drift*. Why does the diamagnetic drift not show up when we do a particle-orbit theory analysis?

d. *Generalized Ohm's law (i)*. The next 3 questions deal with equation [8.30] in the lecture notes. In the absence of a magnetic field, in a steady state situation with no collisions, explain how a pressure gradient can be maintained. How might this situation physically arise in a plasma?

e. *Generalized Ohm's law (ii).* If we now "switch off" the electric field - with the pressure gradient still present as before - how would the plasma react according to equation [8.30]?

f. *Generalized Ohm's law (iii).* How would the response in part (e) be different if the collision frequency was non-zero?

2. **Diamagnetic drift.** An isothermal plasma is confined between the planes $x = \pm a$ in magnetic field $\mathbf{B} = \hat{z} B_0$. The density distribution is $N = N_0(1-x^2/a^2)$. (a) Derive an expression for the electron diamagnetic drift velocity v_{De}, as a function of x. (b) Draw a diagram showing the density profile and the direction of v_{De} on both sides of the midplane if **B** is out of the paper. (c) Evaluate v_{De} $x = a/2$, $B_0 = 0.2$ T, $k_B T_e = 2$ eV, and $a = 4$ cm.

3. **Beta parameter.** Bittencourt, p. 323, Problem 12.4

4. **Perfectly conducting fluid.** Bittencourt, p. 323, Problem 12.7. Before starting, derive equation (4.1) in Bittencourt, from equation [8.29] in the lecture notes noting any assumptions that you made.

5. **Earth's magnetopause.** Bittencourt, p. 324, Problem 12.8. When doing this problem, bear in mind that a current sheet is established at the magnetopause that causes the magnetic field outside the magnetopause to vanish completely. The Earth's magnetic field is inversely proportional to distance cubed.

6. **Confined plasma.** Bittencourt, p. 324, Problem 12.9. After doing this problem, sketch how this configuration might look, including current flow, magnetic field lines, and surfaces of constant pressure.