Introduction to Plasmas
Homework Assignment #4

We will consider a stationary cylindrical plasma of infinite length. The plasma has a minor radius or radial extent of r=a=0.1 m. The plasma temperature is uniform and T_i=T_e=10 eV. There is an applied, uniform external magnetic field in the axial direction, z, of B_z=0.1 Tesla.

The central (r=0) plasma density is n_0= 10^{18} m^{-3}. The radial form of the density follows a parabolic shape, namely:
$n(r) = n_0 (1 - (r/a)^2)$.

1. What is the value of the plasma's permissivity, ε, as compared to vacuum (ε_0)?

2. Derive and calculate the direction and magnitude of the diamagnetic velocity (in m/s) of the ions and electrons.

3. Calculate the direction and magnitude of the diamagnetic current density (A/m^2).

4. Draw a fluid component in the plasma and its equilibrium force vectors in the cylindrical coordinate system for the plasma as described above.

5. Estimate the change in the axial magnetic field that can we expect from the diamagnetic current. (Hint: think of a solenoid magnetic field)

6. Doppler-shift spectroscopy of plasma emissions show that the plasma is rotating poloidally as a rigid body at 100 Hz. Derive and calculate the direction and magnitude of the electric field and potential causing this rotation.

7. What is the fractional charge imbalance needed in the plasma to sustain this potential?