MAJOR TEST

EPL 208 : Principles of Electrodynamics & Plasmas

April 30, 2008
Time : 2 hrs
M. Marks : 50

Attempt all problems.

1) An em wave is normally incident on free space – magnetoplasma interface ($z=0$) with $\vec{B}_s \parallel \hat{z}$. The fields of the incident and reflected waves are: $\vec{E}_{inc} = \hat{x}\, A\, e^{-i(\omega t - \omega z/c)}$
$\vec{E}_{ref} = -\frac{i}{2}\hat{y}\, A\, e^{-i(\omega t + \omega z/c)}$. Estimate ω_c/ω (ω_c being the electron cyclotron frequency). Neglect ion motions & collisions. (8)

2A) An electric field $\vec{E} = \hat{\phi}\, E_0 \cos\omega t$ is induced in a tokamak plasma via transformer action. Treating plasma as a resistive inductor of inductance $L \simeq \mu_0 \pi R$, where R is the major radius, plot qualitatively the time average heating rate of plasma as a function of electron temperature. (5)

2B) Explain the phenomenon of resonance mode conversion of laser into a plasma wave. (3)

3) A hot plasma, placed in a static electric and magnetic fields $E_0\hat{y}$, $B_s\hat{z}$ has equilibrium density $n_0 = n_0^o(1 + y/L_n)$. Obtain the equilibrium drift velocity of electrons. The equilibrium is perturbed by an electrostatic wave $\phi = A\cos(\omega t - k_x x - k_z z)$. Obtain the density perturbations. (8)

4) A hydrogen ion beam of density n_{ob} and drift $v_{ob}\hat{z}$ is launched in a doubly ionized helium plasma of ion density $n_{oi} >> n_{ob}$, ion temperature $T_i \simeq 0$, electron temperature T_e. Obtain the growth rate of ion acoustic wave. (9)

5A) An antenna array has antennas placed at $(m d_1, n d_2, 0)$ with currents $I_0 e^{-i(\omega t - m\psi_x - n\psi_y)}$ and length $d\vec{l} \parallel \hat{z}$; $m = 0, 1, 2 \ldots M$, $n = 0, 1, 2, \ldots N$. Estimate the requisite values of ψ_x, ψ_y so that the radiation is maximum along $\hat{n} = \left(\frac{1}{\sqrt{5}}\hat{x} + \frac{1}{\sqrt{5}}\hat{y} + \frac{1}{\sqrt{2}}\hat{z}\right)$. (5)

5B) An em wave propagating in a weakly collisional plasma has $\vec{E} = \hat{y}\, A\, e^{-\frac{\omega}{c}(1 - i\,0.07)x}\, e^{-i(\omega t - \frac{\omega}{c}z)}$. Estimate ν/ω. Write the equations of the plane of constant amplitude and the wavefront. (4)

6) Derive the dispersion relation for a surface plasma wave over an interface between two conductors. Plot the dispersion relation. (8)