MAJOR TEST

EPL 208: Principles of Electrodynamics & Plasmas

May 5, 2007

Attempt Six problems.

Time: 2 hrs

M. Marks: 50

1. A cold collisionless plasma in equilibrium has crossed dc electric and magnetic fields $E_s \hat{x}$, $B_s \hat{z}$ and non-uniform density $n_0(x)$. Obtain the electron dc drift. This equilibrium is perturbed by an electrostatic perturbation of potential $\phi = A e^{-i(\omega t - ky)}$. Obtain the perturbed electron density. (8)

2A) An em wave is propagating in a plasma along dc magnetic field $B_s \hat{z}$. At $z = 0$, $\vec{E} = (2\hat{x} + i\hat{y}) A e^{-i\omega t}$. Write the field at $z = L$ when $\omega_c = \omega_p = 0.5\omega$, $\nu = 0$. (5)

2B) Deduce the Lawson criterion. How could it be achieved in Laser driven fusion? (4)

3. Using a simple model deduce the breakdown voltage for avalanche breakdown in a discharge tube. How does it scale with plasma pressure? (8)

4A) The field of an electromagnetic wave in a dielectric is $\vec{E} = A(\hat{x} + \alpha \hat{z}) e^{-2\omega x/c} e^{-i(\omega t - 3\omega z/c)}$

Deduce i) α, ii) ϵ_r, iii) $\vec{S}_{av}$. (4)

4B) An em wave of frequency ω and amplitude 10 V/m is reflection with a phase change of $\pi/3$. Estimate ω_p/ω and deduce the field amplitude at a depth of $5\,c/\omega$ inside the plasma. (4)

5A) Obtain an expression for dielectric susceptibility at frequency ω. Hence explain the $1/\lambda^4$ dependence of Rayleigh scattering of light in the atmosphere. (5)

5B) Two crossed dipoles of lengths $dl\,\hat{z}$ and $dl\,\hat{y}$ are placed at $(0,0,0)$ and $(0,0,d)$. They carry currents $I_0 e^{-i\omega t}$ and $I_0 e^{-i(\omega t - \pi/2)}$. Obtain $\vec{S}_{av}$. (4)

6. Obtain ∇B and curvature drifts of electrons at distance r from a long wire carrying dc current I_0 along $\hat{z}$. (8)

Or

6. Discuss physically the mechanism of radiation generation in a Cerenkov FEL. Deduce an expression for its operating frequency. If the perturbed beam velocity due to a TM mode in CFEL is $\vec{v}_1 = \hat{z}\, eE_z/(m i \gamma_0^3 (\omega - k_z v_0))$, obtain the dispersion relation. (8)