Plasma Electrodynamics 2 **Final Exam** Dec. 17, 2009

(15점)

1. If each of the following statements is true, please mark O at the end of each statement. If false or incorrect, mark X and make corrections.

a) The *E-plane radiation pattern* of an antenna is two-dimensional plots in a spherical coordinate system by drawing the magnitude of the normalized field strength versus ϕ for $\theta = \pi/2$.

b) The *directive gain,* $G_D(\theta,\phi)$, of an antenna pattern is the ratio of the time-average power per unit solid angle in the direction (θ,ϕ) to the average radiation intensity.

c) The *radiation efficiency* of an antenna, which is defined by the ratio of the time-average radiation power to the total input power, is equivalent to the ratio of the power gain to the directivity of an antenna.

d) A *linear dipole antenna* is a center-fed thin straight antenna having a very short length compared to the operating wavelength.

e) The *E-plane pattern function* of a Herzian dipole depends on the ratio of the antenna length to the working wavelength.

f)The H-plane radiation pattern of two-element parallel linear array, which is separated by a half wavelength and fed in phase, shows a *broadside array* having a narrower main beam than that of a corresponding endfire array.

g) The *binomial array* consists of equally-spaced identical antennas fed with equal currents, and its broadside array has no sidelobes.

h) The *total array pattern function* of identical elements is described by the product of the individual source pattern function and the array factor.

i) The power received in a monostatic radar system with a given transmitted power is inversely proportional to the fourth power of the distance to the target.

j) The *backscatter (radar) cross section* is an equivalent area intercepting the incident power by a passive object, and is proportional to the square of the distance between the antenna and the object.

(28점)

2. Consider a *Herzian dipole* of length dl that carries a time-harmonic current, $i(t) = I\cos\omega t = Re[Ie^{j\omega t}]$. The phasor representation of the retarded vector potential is given as

$$\boldsymbol{A} = \frac{\mu_o}{4\pi}\int_{V'} \frac{Je^{-jkR}}{R}dv' = \hat{z}\frac{\mu_o I\,dl}{4\pi}\left(\frac{e^{-j\beta R}}{R}\right) \quad \text{where } \hat{z} = \hat{R}\cos\theta - \hat{\theta}\sin\theta.$$

   a) Find $\boldsymbol{H}$ from $\boldsymbol{A}$, and then $\boldsymbol{E}$ from $\boldsymbol{H}$.
   b) Find *far (radiation) fields* of the Herzian dipole.
   c) Find the *E-plane* pattern function and draw its pattern.
   d) Find the *H-plane* pattern function and draw its pattern.

   Next, consider *two identical linear antennas* separated by a distance *d*, which are excited with currents of the same amplitude E_m and a phase difference ξ between them. In this case, the total electric field is found as $|E| = \frac{2E_m}{R_o}|F(\theta,\phi)|\left|\cos\frac{\psi}{2}\right|$ where $\psi = \beta d\sin\theta\cos\phi + \xi$ and $|F(\theta,\phi)|$ =element factor.

   e) Find the *broadside array factor* and draw its pattern.
   f) Using the above factor, find the *broadside array pattern* for the *binary array of 3 elements*.

   Lastly, consider a *uniform linear array of 3 equally-spaced identical antennas* fed with equal currents and uniform progressive phase shift.

   g) What is the *normalized array factor*?
   And draw the *broadside array pattern*.

(10점)

3. *Two identical parabolic antennas*, each having a directive gain of $G_D = 1{,}000$, establishes a microwave link over a distance of 10 km at 300 MHz. The transmitting antenna radiates a power of $16\pi^2$ (W). Neglecting losses, find
   a) the *power received*, and
   b) the magnitude of the *electric field intensity* E_i at the receiving antenna.

   [*Notes*: $\frac{P_L}{P_t} = \frac{G_{D1}G_{D2}\lambda^2}{(4\pi r)^2}$, $\mathscr{P}_{av} = \frac{P_t}{4\pi r^2}G_{D1}$, $A_e = \frac{P_L}{\mathscr{P}_{av}}$, $\mathscr{P}_{av} = \frac{E_i^2}{2\eta_o} = \frac{E_i^2}{240\pi}$]

(7점)

4. Assume the spatial distribution of the current on a very *thin center-fed half-wave dipole* lying along the z-axis to be $I_o\cos 2\pi z$.
   a) Find the *charge distribution* on the dipole. b) What is the *wavelength*?

(6점)

5. Find the *beamwidth* of the *E-plane pattern* of a Hertzian dipole.
   (*Note*: The beamwidth of the pattern is the angle between the half-power points of the main beam of the radiation pattern)