ECE 604 Electromagnetic Field Theory

Spring 2020

Homework No. 8. Due Date: Apr 3, 2020.

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Read lecture notes 1-28.

1. (i) Following the method, where the Green's function has been derived for Poisson's equation, show that the Green's function for Helmholtz equation is in fact

$$g(\mathbf{r}-\mathbf{r}') = \frac{e^{-j\beta|\mathbf{r}-\mathbf{r}'|}}{4\pi|\mathbf{r}-\mathbf{r}'|}$$

(ii) Show that in the far field, the ratio of $|\mathbf{E}|/|\mathbf{H}| = \eta$. Give the physical reason for this.

(iii) In Lecture 26, it was shown that

$$\mathbf{A}(\mathbf{r}) \cong \frac{\mu e^{-j\beta r}}{4\pi r}\mathbf{F}(\boldsymbol{\beta})$$

Explain why when we are in the far field, in the neighborhood of an observation around $\mathbf{r}$, the variation of the field is dominated by $e^{-j\beta r}$, and hence, why we can make a local plane wave approximation.

2. (i) Go through the Lecture 27 and derive the expression (27.1.6).

(ii) Repeat Case II of the same lecture notes, but with N=5, and plot the far field pattern of this new array.

(iii) Find the leading order approximation, up to the quadratic term, of the expression $|\mathbf{r}-\mathbf{r}'|$ when $r' << r$. In other words, rederive equation (27.2.7) and reconfirm the definition of Rayleigh distance in (27.2.10). Also, derive the Rayleigh distance defined in (27.2.12).

3. (i) Explain why a folded dipole has a lower resonant frequency.

(ii) Explain how a cavity backed slot antenna work.

(iii) Explain why the corrugated horn antenna produce an axially symmetric radiation pattern.

(iv) Explain how a lens antenna work.

(v) Explain why PIFA is smaller than a half-wave dipole.

(vi) Explain how you would made the current uniform on a large loop antenna.