THE UNIVERSITY OF BRITISH COLUMBIA
Department of Electrical and Computer Engineering

ELEC 411 - Antennas and Propagation
Fall 2016

Fundamentals Review

The purpose of these seven problems is to help you review: (1) some of fundamental concepts that you learned in previous electromagnetics courses and (2) some of the mathematical techniques that you will use during ELEC 411. Answers should be short and to the point. Clarity, conciseness, and presentation all count.

Concepts Review

1. *Transmission Line Theory.* A transmission line with characteristic impedance 50 Ω is connected to a load impedance of 75 Ω. An 1-W RF signal is applied to the input to the transmission line. How much power is actually transferred to the load? Express your result in terms of the voltage reflection coefficient Γ.

2. *Circuit Theory.* At the input terminals to an antenna with $Z_a = R_a + jX_a$, an RF current with peak value I_a is measured. What is the power dissipated in the antenna?

3. *Maxwell's Equations.*

   (a) Assuming the general case, fill in the right hand side of the equations:

   $$\begin{aligned} \nabla \cdot \mathbf{D} &= \\ \nabla \cdot \mathbf{B} &= \\ \nabla \times \mathbf{E} &= \\ \nabla \times \mathbf{H} &= \end{aligned}$$

   (b) Give the physical significance of (and units for) the following field quantities:

   E - electric field strength
   H - magnetic field strength
   D - electric flux density
   B - magnetic flux density

4. *Plane Waves.* A plane wave with frequency ω and phase constant β, and travelling in the $+z$ direction in free space, has

   $$E_y = E_0 e^{j(\omega t - \beta z)}$$

   where $|E_o| = 10$ V/m.

(a) Give an expression for the magnetic field component of the plane wave.

(b) What is the power density of the plane wave?

(c) What is the total power content of the plane wave?

(d) What is the physical significance of the quantity E_0?

Mathematics Review

5. Consider the following functions expressed in spherical coordinates:

$$F(\theta, \phi) = k \cos^2 \theta$$

and

$$G(\theta, \phi) = 1.$$

(a) Sketch $F(\theta, \phi)$ and $G(\theta, \phi)$.

(b) Find k such that

$$\int_0^{2\pi} \int_0^{\pi} F(\theta, \phi)\, r^2 \sin\theta d\theta d\phi = \int_0^{2\pi} \int_0^{\pi} G(\theta, \phi)\, r^2 \sin\theta d\theta d\phi.$$

(c) Using a sketch, explain the physical significance of the factor $r^2 \sin\theta d\theta d\phi$ in the above integral.

You will encounter expressions of this sort when we study antenna radiation patterns.

6. Evaluate and plot

$$f(\theta) = 1 + e^{j(2\pi d/\lambda)\cos\theta}$$

as a function of θ where $d = \lambda/2$.

You will encounter expressions of this sort when we study array theory.

7. Find the sum of the geometric series

$$AF = A_0 \sum_{n=0}^{N-1} e^{jn\psi} = A_0(1 + e^{j\psi} + \cdots + e^{j(N-1)\psi}).$$

You will encounter expressions of this sort when we study array theory.