ECE 123 **Assignment 1** **Spring 2009**

This problem set is due Tuesday April 7 at 11:00 AM. If you cannot finish on time, let me know in advance. Do not skip the lecture to finish the report on time.

A Matlab script to do section 1 (b)-(d) is on the web-site. You can modify it to do section 2, or, if you are familiar with Matlab, you can do the calculations anyway you prefer. The same calculations will recur throughout the course, so you should document and save the code you write for each assignment.

1. Handset Antenna Gain: You are given that a for a certain handset antenna the electric field pattern $E(\theta, \phi) \propto \sin\theta$ is independent of ϕ. (this is the pattern of a short vertical electric dipole antenna)

(a) Find the gain of the handset antenna (with respect to an isotropic radiator) analytically. Clearly it will have the form $G(\theta, \phi) = K\sin^2\theta$ so your task is to find the constant K. You can use the constraint that the integral of $G(\theta, \phi)$ over the sphere = 4π to find K.

(b) Check your analytical result in (a) by doing the integral with MATLAB.

(c) Make a 2-D "polar plot" of the gain $G(\theta)$ using the MATLAB script **polar(θ, G)**. This is the common way to display antenna patterns (a polar plot of $G(\phi)$ would simple be a circle of radius $G(\theta)$). Note that, although in polar coordinates the angle θ runs from 0 to 180°, in practice we plot $G(\theta)$ over 360°.

(d) Make a three dimensional polar plot of $G(\theta, \phi)$. One way to do this is to define a surface using the MATLAB script **sphere**. The statement **[x,y,z] = sphere(N)**; will define three 2-D arrays giving the coordinates **x,y,z** on the N x N surface of the unit sphere. You can find θ, for example, from $z = \cos\theta$, so $\theta = \text{acos}(z)$. From this you can find the gain g at each point on the surface. You can then change the radius to be equal to the gain with the statements **xx = x.*g; yy= y.*g; zz = z.*g**; and you can plot the pattern with **mesh(xx,yy,zz)** or **surf(xx,yy,zz)**. This is a convenient plot because you can do a three-dimensional rotation of the mesh or surf plot to change the viewing angle.

2. Endfire Antenna Gain: Consider a point to point link needs a beam which is directed as close as possible to the other antenna. This will minimize interference between different communications systems, as well as maximizing the power transfer on a given link. For the particular antenna of interest the electric field pattern peaks along the positive z axis with $|E(\theta, \phi)|^2 \propto \cos^8\theta$ for $0 < \theta < 90^0$ and zero for $90^0 < \theta < 180^0$. Repeat the calculations (a) through (d) of section 1 for this antenna, finding and plotting the gain. Include your matlab script with your report. Comment it carefully.

3. Synchronous Satellite Link: Consider a 2 GHz link between a synchronous satellite and a ground station on the equator. The bandwidth of the up-link and down-link are the same. The orbital radius of the satellite is 36,000 Km and the radius of the Earth is 6,400 Km. The satellite antenna beam must just cover the whole Earth; its transmitted power is 100 w; and its receiver noise temperature is 300K (because the antenna is looking at the warm Earth). The ground station antenna diameter is 64 cm; its aperture efficiency is 100%; and its receiver noise temperature is 50 K (because it is looking at the cold sky). Note that RF power is usually specified in dB with respect to a reference. The most common reference is 1 mw, which gives rise to the power unit of dBm. For example –30 dBm is 1 microwatt.

Find: **(a)** the beam solid angle of the satellite antenna; **(b)** the gain of the satellite antenna in dB; **(c)** the power received on the ground in dBm; **(d)** the bandwidth at which the SNR on the ground is 10 dB; and **(e)** the power that must be transmitted from the ground (in dBm) so the uplink channel capacity will be the same as that of the downlink. The channel capacity $C = BW*\text{Log}_2(1+SNR)$.