Anthony Bommarito

Antenna Theory involves the process of radiation, so I thought it would be a good idea to read a bit of Griffiths chapter 11, on radiation. Radiation is an irreversible transfer of energy due to accelerating charges. Considering a sphere, one could find the power radiated by taking the surface integral of the Poynting vector, where the Poynting vector is just E x B. We know also know that this radiation would have to travel at the speed of light so the radiation must have left at some time before t, t1. This t1 is nothing more than t-r/c, where r is the radius of the sphere and c is the speed of light. The limit of the surface integral as r tends to infinity is the power radiated. There is an important point to make and that is in order to have radiation, the Poynting vector must tend to zero for large values of r, no faster than 1/r^2, or else our limit diverges. We also know that E and B fall off like 1/r^2 or even quicker, which means that this vector we need must go like 1/r. This also sheds some light on why static charges do not radiate. We know that E and B for static situations go like 1/r^2, which means that the Poynting vector would go like 1/ r^4, which could never radiate.

An example of this radiation could be caused by the Electric dipole field. Imagine two charges +q and -q situated on the z axis separated by a distance d. Now to make this a dynamic situation, connect these two charges by a metal rod that allows the charge to oscillate as a function of time. The charge at any time t is given by qcos(wto), where w is the frequency of oscillation and to is the same time discussed above. From this we can find the potential of the field like we normally would. The key difference is the approximations that must be made. The first on is that the separation distance between the charges, d, is much smaller than the distance from the origin to the point of interest, r. We also want d to be much less than the ratio c/w, which basically says that we want the separation between the two charges to be less than the wavelength emitted. The final approximation is that we want r to be much greater than c/w or the wavelength. This is referred to as the radiation limit. This limit will give us the fields that survive at very large distances, which as antennas are concerned, are very useful.

We can also find the vector potential using similar methods, and from these two potentials we may construct the E and B fields using maxwells equations. Once we know E and B we can get the Poynting vector and the power radiated. If I had time to do this in latex I would be writing out more equations so it could be seen what I am referring to(instead I am just following along with the book while using a whiteboard). The resulting Poynting vector goes like 1/r^2 and its intensity has the interesting property that there is no radiation along the Z axis, rather it is in the radial direction around the dipole, forming something like a donut of radiation.

To expand on these ideas I did some reading from lecture notes found on this website: http://www.crectirupati.com/sites/default/files/lecture_notes/AWP%20Lecture%20Notes-final.pdf

Antennas consist of a bunch of conductors connected to a receiver or transmitter. Only a fraction of the electromagnetic wave is intercepted by a receiving antenna. The type of antenna I am most interested in is the wire antenna which are used in phones and TVs. The type of radiating that is received is usually from a dipole or monopole. As discussed before, in order to have radiation there must be some time varying charge distribution or current. If there is no movement of charge there is no radiation. More interesting is the fact that if there is a straight wire with some current moving through it at a constant velocity there too will be no radiation. If this wire is bent or has some nonuniform geometry, this constant current will indeed cause some radiation. This is because we will have some accumulation of charge and thus some electric field.

In order to excite these charges, people tend to use a transmission line or a waveguide. Most transmitting antennas have a length l, equal to half the wavelength. This is because half wave dipoles are resonant. This ensures that the current is at its maximum at the center of the conductor and falls to zero at the ends. The main difference between receiving and transmitting antennas is their power source. Most receiving antennas require a small energy source, where as a transmitting antenna maybe carrying megawatts of instantaneous power.

Hertz antennas are typical dipole antennas, that operate on the half wavelength principle, they radiate either horizontally or vertically. These antennas usually operate at 2MHz or above. Regardless of their size or weight, these antennas can be characterized by their directivity, gain ,reciprocity and polarization. The directivity is just the direction the antenna is able to transmit or receive some wave. Reciprocity is the ability for the same antenna to both transmit and receive. This usually means that the better a antenna is at receiving a certain frequency, the better it is at transmitting that same frequency. Usually maximum radiation for transmitting or receiving occurs at right angles to the antennas axis. The electric field is polarized in the direction of the current. This allows people to chose the direction of polarization for the wave of interest. In antennas waves are usually circularly polarized, this insures minimum loss in intensity of the radiated wave. The gain of the antenna is a measure of how well it radiates in a certain direction ie the ratio of the intensity of the wave in the direction of maximum output to that of some arbitrary isotropic (ideal) antenna.

I still plan on digging deeper on various parameters of antennas and hope to explore some other mathematical ideas using griffiths, but as of now I have a better understanding of antennas than I did. I hope to find some more reader friendly articles to aid in my quest of knowledge.