**CSE 4215 :: Problem Set 1**

1. For an arbitrary signal x(t), demonstrate (with equations) the operations of modulation and demodulation by a carrier frequency $f_c$. Explain, making reference to the Fourier transform, why low-pass filtering is required as part of the demodulation procedure.

2. Suppose there exists a device called a "squarer", which accepts a real-valued signal x(t) as input, and produces $x^2(t)$ as output.
   a. If $x(t) = \sin(2\pi ft)$, for any frequency f, what is the output of the squarer? What is the bandwidth of the resulting signal?
   b. Using your result from part a, if an arbitrary signal with bandwidth B is applied to the squarer, what is the maximum bandwidth of the output signal?

3. Signals $x_1(t)$ and $x_2(t)$ are modulated with carrier frequencies $f_1$ and $f_2$. Assume $f_2 > f_1$, and $f_2 - f_1 << f_1$. What is the largest allowed bandwidth of either signal so that they do not interfere with each other?

4. The received power of a signal is measured as 5W, 0.04W, and 0.005W at distances of 1m, 5m, and 10m from the receiver, respectively. What is the path loss exponent?

5. Suppose a sinusoid with frequency f = 1 GHz is sent from a transmitter to a receiver. The transmit antenna is located 10m above the ground, and the receive antenna is located 2m above the ground. The two antennas are 200m apart. The power in the direct path is 1 μW at the receiver. Assume the ground is a good conductor and that the reflection coefficient is R = -1. Find a simplified expression for the signal observed at the receiver.

6. In Rayleigh fading, a sinusoidal signal with average power 1W is transmitted. What is the probability that the amplitude at the receiver is less than 0.5?