Problem 1:

a.) What is the minimum Eb/Ieff (bit energy over effective noise energy) to yield P(e)<1% in the asynchronous CDMA system (additive white Gaussian noise, no multipath)?

b.) If the spectral efficiency is 1chip/sec/Hz, bandwidth is 3MHz, chip energy Ec=0.1No, data rate per user=10kbit/sec/user, and P(e)<1%, how many users can be supported in a single cell?

(Note that No is noise power spectral density (unit is Energy per sec per Hz) and therefore its unit is energy.)
(Hint: if processing gain is N, for each bit, after the despreader,
the desired signal energy is N*N*Ec
the energy for one interferer is N*Ec
the noise energy is N*No)

Problem 2:

The minimum Eb/Ieff (bit energy over noise energy) per user in the uplink of an asynchronous CDMA system is 2. The spectral efficiency is 1chip/sec/Hz. The bandwidth of the available spectrum is 2MHz. Data rate per user 10kbit/sec/user. The received chip energy at the base station for a user is Ec=No(10^9)/(r^3) where r is the distance (in meters) between the user and the base station.

(Note that No is noise power spectral density (unit is Energy per sec per Hz) and therefore its unit is energy.)

Consider the case that all users have the same distances from the base station.

1) What is the maximum range of coverage, if the number of user Nu=100?

2) What is maximum number of users Nu and the corresponding processing gain N for r=100m?

3) What is maximum number of users Nu and the corresponding processing gain N for r=1km?

4) What is maximum number of users Nu and the corresponding processing gain N for r=3km?

5) What is maximum number of users Nu and the corresponding processing gain N for r=5km?

Problem 3:

The minimum Eb/Ieff (bit energy over noise energy) per user in the uplink of an asynchronous CDMA system is 2. The spectral efficiency is 1chip/sec/Hz. The bandwidth of the available spectrum is 2MHz. Data rate per user =1kbit/sec/user. The received chip energy at the base station for the j-th user is Ec=No(10^9)/(r(j)^3) where r(j) is the distance (in meters) between the j-th user and the base station. Consider the case that r(j)=100+(j-1)*30. Want is maximum number of users Nu and the corresponding processing gain N?

(Note that No is noise power spectral density (unit is Energy per sec per Hz) and therefore its unit is energy.)

(hint: The users with larger distances from the base station have smaller Eb/No. Therefore, make a reasonable guess of Nu and calculate the Eb/No for the farthest user to check the minimum Eb/No requirement. By trial and error, you will be able to derive the correct value of Nu.)

Problem: 4 (CDMA_asynchronous_cross_correlation)

$$Y^{(m)} = \sum_{n=1+mN}^{(m+1)N} y_n^{(m)}, \quad y_n^{(m)} = \sqrt{E_c} \sum_{k=-\infty}^{\infty} x_k b_k a_n^* e^{j\theta_i} \int_{mNT_c}^{(m+1)NT_c} g(t-nT_c)g(t-kT_c+\tau_i)dt$$

Part a: Let m=0, N=3 (i.e., the sum for n is from 1 to 3). Expand the above equation for k=1 to 3 (i.e., you will have 9 terms). Simplify the expression by combining the terms with similar integrals (combine terms with n=k=1,2,3; (n-k)=1; (n-k)=2; (n-k)=-1; (n-k)=-2). Leave the integral intact (don't perform the integral). Find the expectation and variance for each term.

Part b: Repeat Part a by letting x_k=d, b_k=a_k, θ_i=0, τ_i=0. (Now, combine terms with n=k=1,2,3; (n-k)=1 or -1; (n-k)=2 or -2).