Homework 1 (EAS 4803/8803: OBSERVATIONAL SEISMOLOGY - SPRING SEMESTER 2011)
Total points: 100. Due 02/10/2011

Problem 5, 6, 7, 10 of the Stein's textbook (pp 412-413). (10 point each)

Computer problem (60 point):
(Modified from C-2 of the Stein's textbook: pp 413. 35 point): Write a subroutine to prepare the following time series, then take the fast Fourier transform (FFT) and generate the spectrogram. The subroutine should call a set of separate subroutines that perform the following operation:

1. Preprocessing (10 point)
    a. Cut the data between 300 and 1800 s;
    b. Remove the mean;
    c. Apply a cosine taper of length which you input;
    d. Extend the length of time series to the nearest power of 2;

2. FFT and inverse FFT (15 point)
    e. Take the FFT using the subroutine (COOLB) provided (Box 6C-2) or another subroutine (e.g., fft command in Matlab);
    f. Plot the amplitude and phase spectrum.
    g. Invert the FFT back to the time domain and plot it together with the original data.

3. Design your own filter and filter the data (15 point)
    h. Write a subroutine to filter it in the frequency domain over the following two passband (low-pass-filtered at 30 s; band-pass-filtered at 2-16 Hz), and invert the FFT to yield two filtered time series. The subroutine should have the capability to taper in the frequency domain. Plot the original and filtered time series.

4. Compute the spectrogram (20 point)
    i. Write a subroutine to compute the FFT with a window length of 256 data points, and slide the window through the entire time series with an overlapping ratio of 50% (i.e., the time window moves forward with a step of 128 data points). Generate a plot with frequency on the y-axis, time on the x-axis, and the amplitude spectra as color to show the spectrogram of your time series. You may want to change the spectra range into log10 scale in order to show the spectrogram in a wide dynamic range.
    j. Please compare with the 2-16 Hz band-pass-filtered data (from step h) and comment on what you have found out.
    k. Bonus point (5 point): based on what you have identified in j, can you propose any approaches to resolve the issue or reduce its effect?

Note:

1. Your code can be written in any scientific languages (e.g., Fortran, C, Matlab). Please make sure that the code can be compiled under standard Linux machine.

Please submit your code electronically to zpeng@gatech.edu, and submit a write-up that includes all the figures.

2. You can use the existing FFT subroutine in the Stein's book or in other languages (e.g., Fortran, C, Matlab). But you should write your own filter subroutine, instead of using any existing subroutine.
3. The SAC binary format data can be downloaded from the following link:
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/BK.PKD.HHT.SAC.vel
   This data is generated by the 2002 Mw7.9 Denali Fault earthquake in Alaska, and recorded by the broadband station PKD around the Parkfield section of the San Andreas Fault in Central California.
4. The ASCII format data can be downloaded from the following link:
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/BK_PKD_HHT_SAC_vel.dat

   Please note that the 'instrument response' of this data has been removed, and the physical unit for the amplitude is in cm/s. The physical unit for the time is in seconds. The data started at 0 s, and with a sampling rate of 0.125 s (or 80 samples per second).
5. The MatSAC package can be downloaded from the following link:
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/MatSAC.tar.gz
   and the related examples on how to use it can be found at
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/SAC_Tutorial/