Homework 2 (EAS 8803: OBS. SEISMOLOGY - SPRING SEMESTER 2011)
Total points: 100. Due 03/09/2011

1. The most critical specification of a data logger is its dynamic range, which is defined as the ratio of the largest on-scale measurement divided by the smallest resolvable measurement. Modern seismometers record on digital recorders, which convert the analogue voltage seismometer output to digital counts. The nominal dynamic range is determined by the number of bits used to characterize the voltage. Please compute the dynamic range in terms of both decibels ($dB = 20 \log_{10} (A_1/A_2)$) and orders of magnitude for the following types of digitizers: 8, 12, 16, 20, 24 bits. (Note: One bit is used to determine whether the signal is positive or negative, and each additional bit represents a factor of 2 in dynamic range). (15 point)

2. Consider a system with a pole and a zero on the real axis of the s-plane. Let the pole position be (-6.28318, 0), and the zero position (0.628318, 0). Please plot the amplitude part of the frequency response function. What is the contribution of the pole and zero to the frequency response function? (15 point)

3. Please plot the amplitude and phase spectra of the instrument responses for the following types of seismometers. In addition, please obtain the normalization factor at 1 Hz and plot the pole and zeros on the *z*-plane for each seismometer (20 point):

Name	Natural Freq.	Damping	Zeros	Poles
Streckeisen STS2	0.0083 Hz (120 s)	0.707 critical	Two at zero	$-0.037 + 0.037i$ $-0.037 - 0.037i$ $-118.752 + 423.4880i$ $-118.752 - 423.4880i$ -251.3270
Guralp CMG-3 ESP	0.033 Hz (30 s)	0.707 critical	Two at zero	$-0.147 + 0.147i$ $-0.147 - 0.147i$
Mark Products L-4C3D	1 Hz	0.707 critical	Two at zero	$-4.44 + 4.44i$ $-4.44 - 4.44i$
Mark Products L-22D	2 Hz	0.707 critical	Two at zero	$-8.88 + 8.88i$ $-8.88 - 8.88i$

4. Please download the instrument response information from the following website (30 points):
http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/RESP.BK.PKD..HHZ
The original data (counts) in SAC format can be downloaded from the following website:
http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/BK.PKD.HHZ.SAC

   The original data (counts) in ASCII format can be downloaded from the following website:
   http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/BK_PKD_HHZ_SAC.dat

   (a) Verify that the Stage O (field B058F04) sensitivity is a multiplication of the gain of previous stage (5 point).

(b) Please use evalresp command to extract, then plot the amplitude and phase spectra of the instrument response (5 point).

(c) Please write your own code to remove the instrument response based on the either the pole-zeros, or the evalresp output to obtain the true velocity in the unit of m/s. Please compare with your results with those obtained using the SAC or GSAC transfer function (20 point).

5. Please download the SAC data for an M6.6 earthquake offshore Maule, Chile on 2011/02/14 and recorded by the station NARJ installed during our Nicoya Peninsula field trip. The time has been shifted so that the reference time corresponds to the origin time of the Chile event. The predicted *P* and *S* wave arrival times are 508.77 and 919.38 s, and are also marked as *a* and *t0* in the SAC header. The station coordinates are longitude −85.5437°, latitude 9.97205°, and the event location and depth are longitude −72.739°, latitude −35.433° and 25.4 km depth. The source-receiver distance is 5202.87 km.

http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/Chile_02142011_M66_NARJ.BHZ.SAC

http://geophysics.eas.gatech.edu/people/zpeng/Teaching/ObsSeis_2011/misc/Chile_02142011_M66_NARJ_BHZ_SAC.dat

(a) Please use a window starting at a time that corresponds to a surface wave velocity of 4.5 km/s, with a total length of 512 s as the signal window, and use the same window immediately before the *P* wave arrival as the noise window. Please compute the FFT for both windows, and plot the amplitude spectra together. (5 point)

(b) If the first step is done properly, you will find that there are some differences in the spectra level at longer period for both the signal and the noise windows, but the high-frequency signals (> 5 Hz) are similar. We suspect that some high-frequency signals higher than expected are produced at this site. Please recall what you have seen at this site, and propose at least one possible source of such high-frequency signals. For those who did not go to the field trip, please come up with at least one likely source. In addition, please suggest ways to either reduce such high-frequency signals if man-made, or prove their existence if they occur naturally.

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. 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/